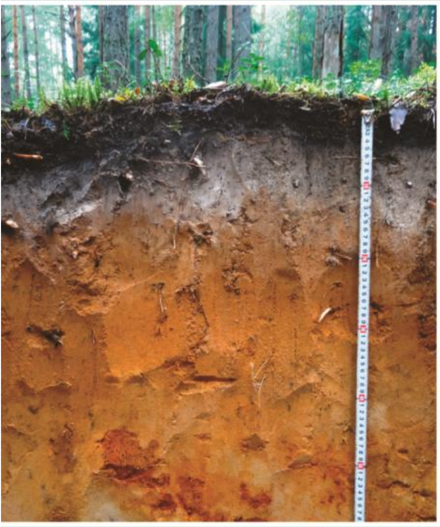
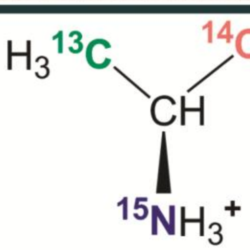
5th International SYMPOSIUM on SOIL ORGANIC MATTER

Soil Organic Matter
SOM 2015
Structure, Origin, Mechanisms





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ABSTRACTS

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O 1.1.01

Persistent soil organic carbon is thermally stable low energy organic carbon

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Determining the relative stability of soil organic carbon (SOC) is a critical step to better understanding its dynamics and vulnerability to global change. The absence of convincing physical or chemical procedures to define, characterize or isolate relatively labile versus persistent SOC pools makes it difficult to study. Long-term bare fallow (LTBF) experiments, in which C inputs have been stopped for several decades, provide a unique opportunity to study persistent SOC without the inherent artefacts induced by extraction procedures, the hypothesis being that SOC is gradually enriched in persistent C with time as labile components decompose. We determined the evolution of thermal and chemical characteristics of bulk SOC in five LTBF experiments across Europe: Askov (DK), Grignon (FR), Rothamsted (UK), Ultuna (SW) and Versailles (FR), using a multi-technique approach involving Rock-Eval pyrolysis, thermogravimetry and differential scanning calorimetry (TG-DSC), mid-infrared diffuse reflectance spectroscopy (DRIFT-MIRS), Pyrolysis Gas Chromatography Mass Spectrometry (py-GC-MS) and Near Edge X-Ray Absorption Fine Structure (NEXAFS).

Results of Rock-Eval and TG analyses showed that the temperature needed to combust the SOC increased with bare fallow duration at all sites. Conversely, SOC energy density (in mJ $mg^{-1\ C}$) measured by DSC decreased with bare fallow duration. Rock-Eval pyrolysis results showed that hydrogen index (HI) tended to decrease with bare fallow duration whereas the oxygen index (OI) did not show consistent trends across sites. NEXAFS signals presented little differences and were dominated by carboxyl peak. Nonetheless, NEXAFS results showed a trend of increasing carboxyl groups and decreasing ketone and amide groups with bare fallow duration. Due to the mineral matrix, only a reduced part of the DRIFT-MIRS signals has been used. We observed that the bulk chemistry of aliphatic SOC (CH_3 vs. CH_2 functional groups) showed different trends for the different sites. Similarly, py-GC-MS results did not present any general trend either.

Our results showed that in spite of the heterogeneity of the soils at the 5 LTBF sites, organic carbon that has persisted in soils for several decades have similar and defined thermal and energetic properties: persistent SOC burns at higher temperature and its combustion generates less energy. Persistent SOC in the studied temperate soils also shares some chemical properties: it has a lower HI values and is consistently enriched in carboxyl groups. Nonetheless, the chemical trends were less obvious than the results given by thermal techniques confirming that organo-mineral interactions are the key driver of long-term SOC stabilization. The increased burning temperature and lower energy density of persistent SOC suggest that SOC stability may be a function of the high energy cost and low energy gain from decomposition of this material. It also suggests that decomposition of the stable C pool should be more temperature sensitive and thus vulnerable to increased temperature as previously observed in several incubation studies.

O 1.1.02

Toward an accurate quantification of truly old SOC: An integration of analytical approaches to estimate pyrogenic carbon

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Pyrogenic carbon (PyC) is a ubiquitous component of soils, particularly prevalent in systems highly prone to fire, comprising between 5 and 45% of the soil organic C (SOC). Our mechanistic understanding of PyC dynamics in soils is advancing, as we now recognize its significant contribution to the most stable SOC pool and its effect on the apparent age of SOC fractions. Still, our ability to produce accurate estimates of PyC in soils remains limited by the available quantification methods.

One of the most accurate and versatile methods for PyC quantification is the benzene polycarboxylic acid (BPCA) method, which can measure PyC in deep soil horizons and from a variety of environmental matrices. BPCAs are markers for PyC, thus accurate estimation of the PyC pool via BPCA analyses remains problematic, as evidenced by the range of correction factors that have been proposed to relate BPCA-C to PyC. Additionally, determination of BPCAs is very tedious and costly. A more efficient and cost effective method is Mid-Infrared spectroscopy (Mid-IR), which allows larger-scale PyC studies. Mid-IR spectroscopy has been used to characterize PyC for over a decade, yet quantification of PyC requires a comparison to another method and a large dataset to calculate statistical significance. Thus, Mid-IR cannot be used explicitly to calibrate the BPCA method, but rather *viceversa*. As an alternative method, Hydrogen Pyrolysis (HyPy), using pyrolysis at a relatively slow heating rate coupled with high hydrogen pressures, presents a feasible quantitative approach to measuring PyC, with the potential to calibrate other less quantitative (e.g.,, Mid-IR) and/or more time-consuming analytical approaches (e.g., BPCA).

We analyzed 200 samples from a variety of matrices (i.e., plant litter, soils, coarse and fine sediments, and char) by BPCA and Mid-IR methods, and a subset (>100) also by HyPy. We will present results from these analyses to address the following questions: (1) Is there a universal relationship between the HyPy and BPCAs PyC estimates that can be used to derive a correction factor for the BPCAs PyC pool estimates? (2) Are there specific Mid-IR features that correlate to the BPCAs and HyPy PyC estimates? And eventually, (3) Can the correlation between BPCAs and/or HyPy and Mid-IR analyses be used to calibrate the Mid-IR and use it for accurate large-scale PyC pool quantification?

O 1.1.03

Near infrared fingerprint of soil organic matter as a proxy for tracking old SOM

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Introduction

For 20 years near infrared spectroscopy (NIRS) has been emerging as a powerful tool in soil science (Guerrero et al. 2010). Dozens of studies demonstrated the efficiency of the tool especially for simultaneous quantitative prediction of various soil properties (i.e; Viscarra Rossel et al.2006). The molecular vibrations produce sharp isolated peaks in the mid infrared region and their overtones in the NIR region. Because the overtones overlapped in the NIR region, the peaks measured are smoother and very difficult to correlate directly with molecular bounds as it is commonly done in mid infrared. On the other hand, the spectra give an overall signature or fingerprint (Palmborg and Nordgren 1996) of a soil sample. The O-H, N-H, C-H overtones are particularly important in the NIR region when quartz does not produce any signal. Thus the organic molecules are overweighed in the NIR fingerprint and therefore studies of soil organic matter can be carried out without chemical extraction even in soils or horizons with very low organic content (Barthes *et al.* 2008)

The rapid and easy-to-use measurement based on a reference measurement coupled with a calibration-validation step is especially adapted to large dataset. Thus high spatial resolution or high profile resolution analysis can benefit a lot from the approach. Moreover NIR spectra can be used to determine qualitative features of soil like earthworm casts (Velasquez et al. 2007 ; Zangerlé et al. 2014) or origin of soil organic matter (Roman Dobarco et al. 2014 ; Gruselle and Bauhus 2010 ; Ertlen et al. 2010)

In a previous study (Ertlen et al. 2010) we demonstrated that NIRS is able to discriminate organic matter in soil under grassland and forest. Applied ton unknown samples from subsoil, this tool may have a great potential. Among preliminar y studies we can mention the dynamic of organic matter inside the solum (Ertlen et al. 2015), the relations between vegetation and pedogenesis and the study of past vegetation (Vyslouzilova et al. 2015).

Materiel and Methods

In this paper, we tested the capacity of NIRS to discriminate soil organic matter when enlarging the dataset and its heterogeneity. Our data set grew up from 13 sites to 85 sites with a bigger variety of sites in the Alsace region (France) and other sites from temperate Europe. The number of forest and grassland sites was increased and agricultural soils were included. This third category was a greater challenge because in agricultural fields the inputs of organic matter are lower, the stability of vegetation is uncertain and more difficult to check at a century timescale. Furthermore we tested the discrimination between different kinds of forest. In the first step we separated the conifers the broadleaves forest and the mixed forest and in the second step we tested the discrimination between oak forest and beech forest

Results and discussion

The results confirm the capacity of NIRS to discriminate soil organic matter according to the vegetation covering the soils. The discrimination between forest and grassland was strengthened (Fig. 1). We also calculated the evolution of this discrimination when increasing the number of reference sites. The discrimination is stabilized over 30 sites and our referential can now be considered as representative for temperate environment.

The discriminations between different kinds of forests and between cultivated and natural soils (10 sites) and other soils are also promising but need to be enlarged to become suitable for further applications.

Our spectral library has already been used successfully to predict the soil organic matter origin from deep horizon (Ertlen *et al*. 2015) or from palaeosoil (Vyslouzilova *et al*. 2015) in the frame of specific studies. We do believe that our enlarged referential is now valid for temperate environment and we invite soil scientists interested in tracking SOM in subsoils or palaeosoils for fruitful collaborations.

Fig.1: Histograms of canonical scores after a disciminant analysis carried out on the NIR spectra. Dark grey corresponds to grassland soils (39 sites) and light grey to forest soils (35 sites).

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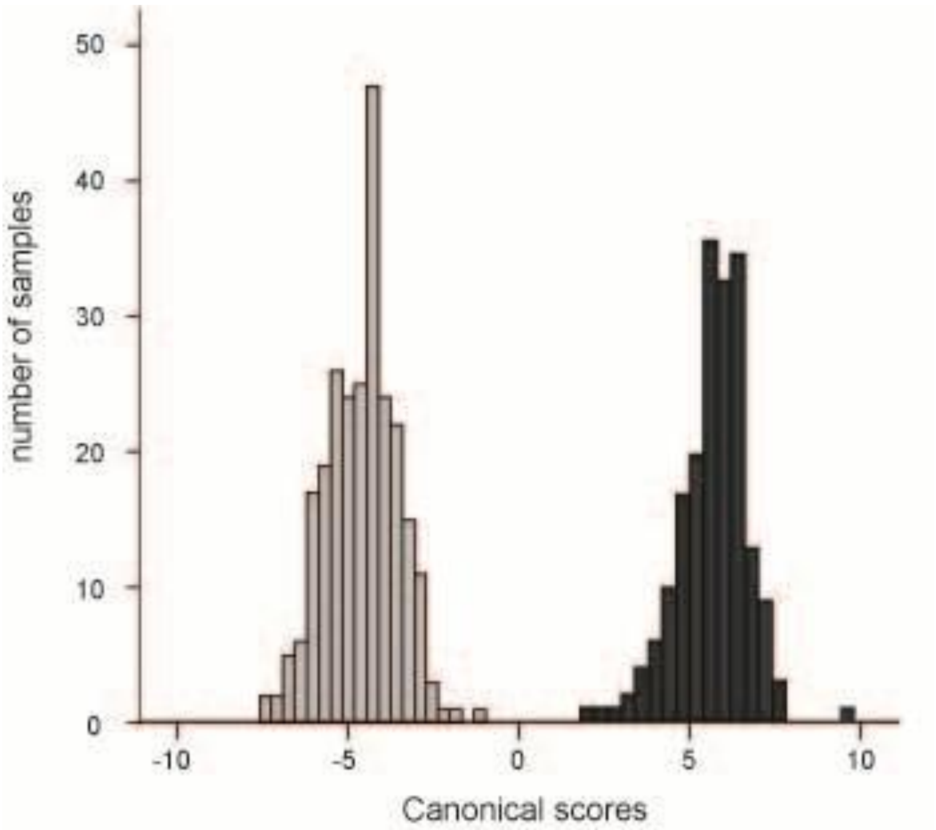
Figure 1



O 1.1.04

Combining old and new stable isotope techniques to evaluate the impact of conservation tillage on soil organic carbon dynamics and stability

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Introduction

Soil organic matter is a major carbon pool and can play a significant role in carbon mitigation measures. It is also a crucial factor for several soil physical properties and a major nutrient source for crops. Soils can act as a carbon sink or source depending on land use and agricultural management practices. Some practices such as conservation tillage or no-tillage could increase the soil organic matter (SOM) stock in the (top) soil, but in the long term it remains to be seen if and how this SOM is stabilized.

In order to evaluate the sustainability and efficiency of soil carbon sequestration measures and the impact of different management and environmental factors, information on SOM stability and mean residence time (MRT) is required. However, this information on SOM stability and MRT is expensive to determine via radiocarbon dating, precluding a wide spread use of stability measurements in soil science. But alternative methods (Balesdent and Balabane, 1992; Conen et al., 2008), based on stable carbon and nitrogen isotopes, can provide this information at a fraction of the cost.

Objectives

In this paper, we look at the impact of long term conservation tillage on SOM distribution, dynamics and stability on four long term conservation tillage experiments in Belgium, using jointly old and new stable isotope and soil fractionation techniques.

Materials & Methods

Four long term agricultural fields were selected in Belgium. These sites have a maritime temperate climate with significant precipitation during all seasons and a warm summer. Two treatments were established since 2002 at each site, i.e. conventional tillage and conservation tillage. The crop rotation consisted of grain maize, winter wheat, potato, winter barley, winter rapeseed and sugar beet.

For each treatment and field, six replicates of 1m soil cores were sampled in the summer of 2014. The cores were divided in 8 different depth layers. Samples from depths of 0-5cm, 10-15cm, 40-60cm were divided into SOM and aggregate classes according to the fractionation schemes described by Conen et al. (2008) and Six et al. (2002). The samples from all depth layers, bulk soil and fractions, were analysed with an elemental analyser coupled to an IRMS for C and N content and their stable isotope ratios.

Results

The soil column sampling showed a significant increase in organic carbon content (%) in the 0-5cm soil layer of the conservation tillage treatment and a slight increase in the total carbon content down to 1m. This increase was mainly concentrated in the particulate organic matter and the protected micro-aggregate fractions. The relative stability of the SOM was calculated in three soil layers using a method, based on isotopic fractionation of ^{15}N developed by Conen et al. (2007). A clear increase in SOM relative stability could be seen with increasing depth and no difference was found between both treatments. The additional SOM in the top soil layer was as stable as the SOM in the conventional tillage treatment. Applying this approach to investigate SOM stability in different soil aggregate fractions, it corroborates the aggregate hierarchy theory. The organic matter in the occluded micro-aggregate and silt & clay fractions is less degraded than the SOM in the free micro-aggregate and silt & clay fractions.

Combining all measured parameters in a multivariate principle components analysis allowed discriminating between sampling depth, crop input and land use (till vs no till) systems. It was found that the $\delta^{13}C$ depth and aggregate profile differed significantly between both treatments.

The Keeling plot approach is used on the bulk soil and aggregate fractions at different depths to estimate the contribution of the different crop residues and SOM turnover rates, as all fields have maize in their crop rotation.

Conclusion

Long term conservation tillage affects the carbon content of the top soil layer, but not the relative stability of the SOM. Changes in SOM aggregate distribution and changes in $\delta^{13}C$ depth profile can be observed between conservation and conventional tillage, suggesting changes in crop residue incorporation.

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O 1.1.06

Development of a continuous density gradient method for soil organic matter fractionation - Decomposition and turnover under different tillage systems in arable soils

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Soil organic matter (SOM) has been considered as an important component for soil quality and agro-ecosystems' fertility, whereas its importance on atmospheric carbon (C) reservoir and C sequestration is a subject of current research. Fractionation of SOM is essential to identify distinctive physical, chemical and biological properties of isolated fractions that helps to analyze the agricultural and environmental importance of SOM. Traditional density fractionation procedures of often divide SOM into so-called light and heavy fractions that seems to separate particulate organic matter from more mineral associated C. But, the complexity of SOM formation and particle distributions might be better understood, if it would be possible to fractionate SOM into more fractions. We propose that a fractionation of SOM into a large number of fractions better explains the continuum of SOM quality distribution. However, this is difficult to do with traditional labor and time-consuming sequential density fractionation. Therefore, this drawback with sequential density fractionation necessitates a new fractionation approach separating SOM into more density fractions, but, taking less time and effort to describe SOM quality distribution.

This study was conducted to develop a continuous density fractionation approach and which can quantify the distribution of bulk soil organic matter by isolating different stabilities of SOM.

Soils were collected in the fall of 2012 from three long-term no till experiment sites in the Corn Belt Region in the state of Ohio, U.S.A. from different parent materials and drainage classes. The soil at the Hoytville site is poorly drained, South Charleston soil is somewhat poorly drained, whereas the Wooster soil is well drained. Experimental sites were cultivated in continuous corn since 1962. Samples were collected from no till (NT, no soil disruption, direct sowing into residues), plow till (PT, 2 times moldboard plowing yr^{-1} to 20-25 cm), and adjacent forest (F) sites (used as reference) from 0-7.5, 7.5-15, and 15-30 cm depth intervals. Soil samples were air-dried and sieved to 2 mm. Site and treatment interaction were studied only for surface soil samples (0-7.5 cm), whereas depth and treatment interaction were studied in all three depth intervals from Hoytville.

The continuous density gradient method involved the development of density gradient that was done by the addition of four different densities (1.5 g cm^{-3}, 2.0 g cm^{-3}, 2.5 g cm^{-3}, and 3.0 g cm^{-3}) of sodium polytungstate (SPT) solutions along with 2.5 g (soil sonified with 10 ml 2.5 g cm^{-3} SPT). This resulted in a continuous density gradient from approximately 1.65 to 2.88 g cm^{-3}. After centrifugation the soil-SPT mixture was separated mixture into five consecutive fractions of 1.65-2.05 g cm^{-3}, 2.05-2.41 g cm^{-3}, 2.41-2.54 g cm^{-3}, 2.54-2.78 g cm^{-3}, and 2.78-2.88 g cm^{-3}, thoroughly washed and dried for further analysis.

For the bulk soil, site, tillage and depth effects on SOM were analyzed by measuring the concentration of total organic C (TOC), total nitrogen (TN), CN ratio, δ^{13}C, C stocks, percent maize and native derived C, and turnover time. Tillage and depth effects in different stabilities of SOM (isolated fractions) were analyzed by measuring relative C percent and all other variables mentioned for the bulk soil except turnover time.

For bulk soil, the TOC (%), TN (%), CN ratio, δ^{13}C (‰), percent maize C contribution and maize C pool was highest at the Hoytville site than the other two sites (*P* P PT) among all sites for TOC, TN, CN ratio, δ^{13}, and C stocks. A significant depth effect (*P*13C, and maize derived and total C stocks.

In isolated fractions from 0-7.5 cm soil depth, a general decreasing trend of TOC, TN, CN ratio, δ^{13}C, maize C (%), and relative C was observed with increasing density across the sites. Significantly highest (*P* 13C, and relative C was observed in the lightest fraction, while the next highest value of measured parameters was observed in the second density fraction. There was no significant consistent trend between the last three fractions among all the soil properties. No till had significantly higher (*P* 13C, and maize derived C (%) across all densities compared to plow till. Depth effect at Hoytville was significant (*P*

The applied continuous density gradient method was able to identify differences and gradients of the concentration of TOC, TN, C stocks in different stabilities of SOM and revealed the SOM quality (new C, old C, $\delta^{13}C$ value, and CN ratio) distribution across the different fractions. The above measurements indicated that NT at these three sites over the last 50 years had a positive effect on SOM stabilization in the surface soil.

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Keywords: soil organic matter, continuous density fractionation, decomposition, stabilization, no tillage, plow tillage

P 1.1.01

Thermal oxidation did not fractionate C pools with different turnover

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Thermal oxidation methods, such as thermogravimetry or ramped-temperature oxidation, have been developed as tools to determine soil organic carbon (SOC) pools of different stability. However, the relation of thermal oxidation patterns and SOC stability is still under debate. Thus, we aimed at investigating the stability of topsoil and subsoil SOC of different sites with vegetation change from cropland to *Miscanthus* (>17 years). The recently developed *Carbon Combustion Fractionation* (CCF) method was used and combined with $\delta^{13}C$ value analyses of evolved carbon dioxide to differentiate between young and old SOC. Temperature levels of 200 °C, 300 °C, 350 °C and 400 °C were adjusted. Three different soils with different texture (sand, sandy loam and clayey loam) originating from three European *Miscanthus* sites as well as one reference site were used. The SOC which was not oxidized at 400 °C was defined as thermal stable. The two loamy soils contained on average 32% of total C as thermal stable SOC. In the sandy soil only 24% of total C were thermal stable. However, the size of the stable SOC fraction strongly depends on its operational definition. Most interesting were the unexpected results of the isotopic signatures of the fractions: $\delta^{13}C$ values increased with increasing oxidation temperatures for all sites with up to 4‰. Thus, there was no larger contribution of young *Miscanthus* C in the so called labile fraction at low oxidation temperatures. The C_3 reference site as well showed increasing $\delta^{13}C$ values with increasing temperatures. This indicates a different contribution of compound classes with different $\delta^{13}C$ values in the various thermal fractions and the need of reference sites for the fractionation of SOC with thermal oxidation. Our results cast doubts on the possibility to separate SOC fractions with different stability using thermal oxidation without further constraining results by using e.g. reference sites for control.

P 1.1.02

Soil carbon changes from the conversion of native C4-dominated (*Themeda triandra)* grassland to C3-dominated agricultural land uses in south-eastern Australia

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Introduction

Knowledge of how land use change and land use practices affect soil carbon processes and stocks is important to better understand global carbon cycles and is a foundation for sustainable agricultural production. In south-eastern Australia the once widespread temperate native grasslands, dominated by the C4 Kangaroo Grass (*Themeda triandra* Forssk.), have been largely converted to agricultural systems dominated by C3 species.

Objectives

Our objectives were: (i) to assess the application of ^{13}C isotope methodology to soils under C4 to C3 vegetation change; (ii) to estimate soil C stocks in the native and agricultural systems; and (iii) estimate soil carbon residence time as may be affected by land use.

Materials & Methods

The study area is located in the Victorian Volcanic Plains bioregion of south-western Victoria, Australia. Mean annual rainfall is 620-740 mm and monthly min. and max. temperatures vary from 4 to 24^{o}C. Three study sites each comprising three 0.9 ha edaphically matched sample plots representing native C4 grassland, exotic C3 pasture, and exotic wheat/canola C3 crop land uses were established.

Soils were sampled to 40 cm depth in 10 cm increments at each plot. *T. triandra*, wheat, canola and pasture shoots and roots were sampled at each site. Samples were analysed for Total C by Dumas combustion, and ^{12}C & ^{13}C by isotope ratio mass spectrometry.

Results

Soil Total C concentrations in the 0-10 cm and 10-20 cm depths were significantly greater in the agricultural land uses than in *Themeda*, but there was no difference between Pasture and Crop land uses (Fig. 1). The calculated differences in Total C stock to 40 cm depth between *Themeda* and agricultural land uses (c. 10 Mg/ha C) are confounded because of differences in soil mass sampled (i.e. varying soil bulk density; data not shown). On an equivalent soil mass basis to a conventional-accounting 30 cm depth (using *Themeda* land use as reference, 2800 Mg/ha), soil Total C stocks averaged (Mg/ha) *Themeda* (50), Pasture (60) and Crop (63).

The isotope data from the soil beneath the C4 *Themeda* suggest a substantial prior contribution of C3 vegetation to total soil C (Fig. 1). While the *Themeda* soils are not pure C4 into which C3 pastures or crops were sown, there was sufficient isotopic differentiation to apply a two-member mixing model. The proportional contribution of C4-C under agriculture land use increases with depth, and is about half that under *Themeda* on an inventory-weighted basis to 40 cm depth. Assuming that the sites were actively converted from native grassland land use 50-70 years ago to C3 pasture, and then more recently to C3 cropping, then >80% of soil C in the surface 10 cm and 17% at 30-40 cm depth has decomposed and been replaced with newer C3-C. Calculated mean residence times increased with depth from 35 years to 313 years.

Conclusions

Conversion of native *Themeda* grassland to 'improved' agricultural pasture and cropping land uses has increased soil (0-40 cm) Total C stocks by c. 10 Mg/ha. Soil C3-C stocks have more than doubled in the surface 20 cm under agriculture. These changes are consistent with agricultural land use effects expected to arise from tillage; nutrient inputs; higher productivity but relatively shallow-rooted exotic 'improved' pasture and crop species; and that generally mean residence time of soil C increases with depth.

The soils of the presently *Themeda* dominated C4 native grasslands have in the past had significant C inputs from C3 vegetation indicating marked vegetation changes prior to European settlement. We hypothesise that *T. triandra* has been an emergent fire-promoted dominant species into otherwise C3 dominated vegetation (which may have been forest, woodland, or grassland).

Figure 1. Soil Total C stock

Figure 2. Soil $d^{13}C$ values by depth (0-10, 10-20, 20-30, 30-40 cm). C3 and C4 plant end-members are given for reference.

Figure 1

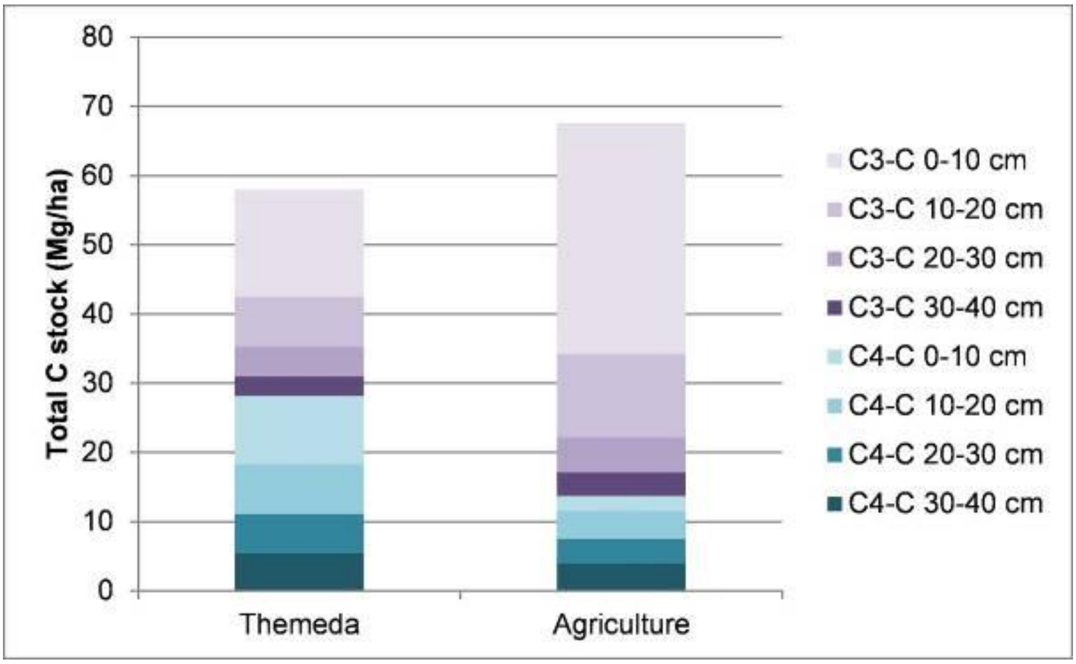
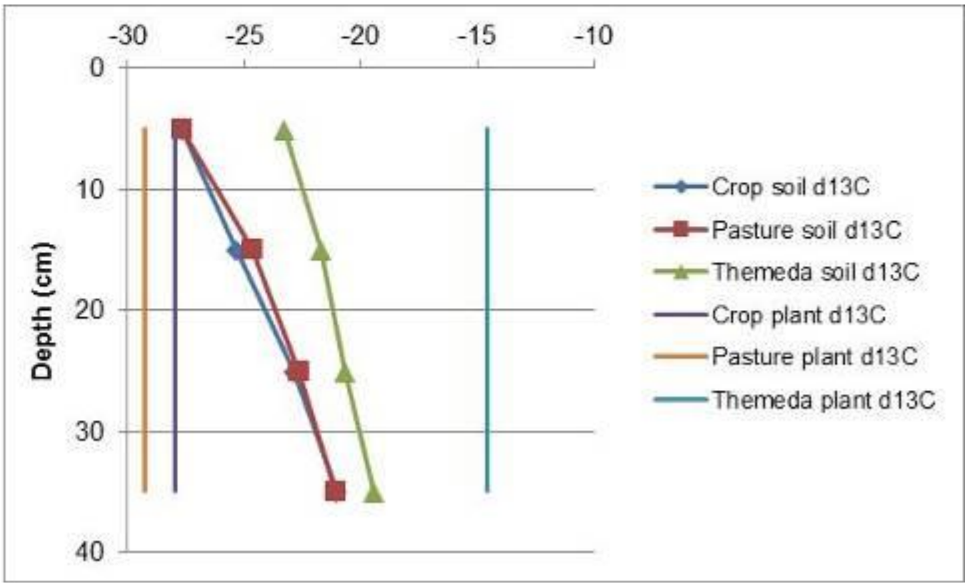


Figure 2



P 1.1.03

A comparison of two methods to determinate SOC in soil samples.

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1. Introduction

Loss-on-ignition method (LOI) is a fast and economic way to measure organic matter. Although the destruction of carbonates with CO2 emission takes place between 900-1.000ºC (Luque, 2003), temperatures about 300-400ºC may promote inorganic carbon losses and weight loss by dehydration of clay minerals. Walkley-Black (W-B) method has a widespread use, but it is laborious, more expensive and has high potential of causing environmental pollution due to the removal of chromium and strong acids used in the analysis. W-B test determines active carbon in soil and does not some other types of organic matter (Pyncho, 2013), while LOI determines a more approximate value of the total organic carbon.

2. Objetives

The aims of this research were to study the statistical relationships between SOM determined with the LOI and W-B methods, and verify whether the presence of calcium carbonate does interfere with the organic matter determination or not.

3. Material and methods

Soil samples were taken from three vineyards in central Spain, two of them calcareous and one non-calcareous. Nine repetitions at 0-10 cm and 10-20 cm depth, were taken per vineyard (a total of 54 samples). For the LOI 8 g of milled soil were taken and heated at 360ºC (optimal temperature according to Salehi et al, 2011) during 2 h.

4. Results

Correlation between LOI and W-B methods was highly significant in all cases, in calcareous as non-calcareous soils, which suggest that the presence of calcium carbonate did not affect the results. A regression equation was obtained as it follows, and Table 1 and Figure 1 show the main parameters of this regression.

Regression equation:

SOCLOI = 1.238 * SOCW-B + 6.89

(g•kg-1) (g•kg-1)

Table 1: Average, standard deviation (SD), correlation coef. (r), significance level (p) and number of cases (n).

Average S.D. r p n

SOCW-B (g•kg-1) 6.05 1.88

SOCLOI (g•kg-1) 14.39 3.12 0.75 0.0000 54

It is noted that the LOI method gives higher SOC values than the W-B method. This is because the charcoal also derives from living tissue, so it is considered organic. It is often called biochar. It can range from 50 to 95 percent carbon by weight. It is more stable and more resistant to bacterial oxidation than most other forms of organic carbon (Pyncho, 2013), and only partially determined by the W-B method. Also we believe That there has been a water losses due to the dehydration of clay minerals. SOC fractions may be active, labile, particulated, occluded, light or heavy. Weil (2003) has recently promoted use of potassium permanganate to measure active carbon in soil, which may give an earlier indication of soil carbon change. But the recalcitrant forms of carbon can be resistant to oxidation by potassium permanganate.Temperature of 360 ° C apparently did not cause loss of inorganic C from carbonates. Another advantage is that LOI method presents results with a lower variation coefficient than the W-B method (21% and 31% respectively).

Figure 1. Regression equation between SOCLOI and SOCW-B.

5. Conclussions

It has been found highly significant correlation ($p<0.0000$) between the contents of SOC determined by the methods of W-B and LOI. Dried oven at 360°C for 2 h has not caused losses of inorganic carbon from calcium carbonates. Therefore, LOI method can be applied in calcareous soils.

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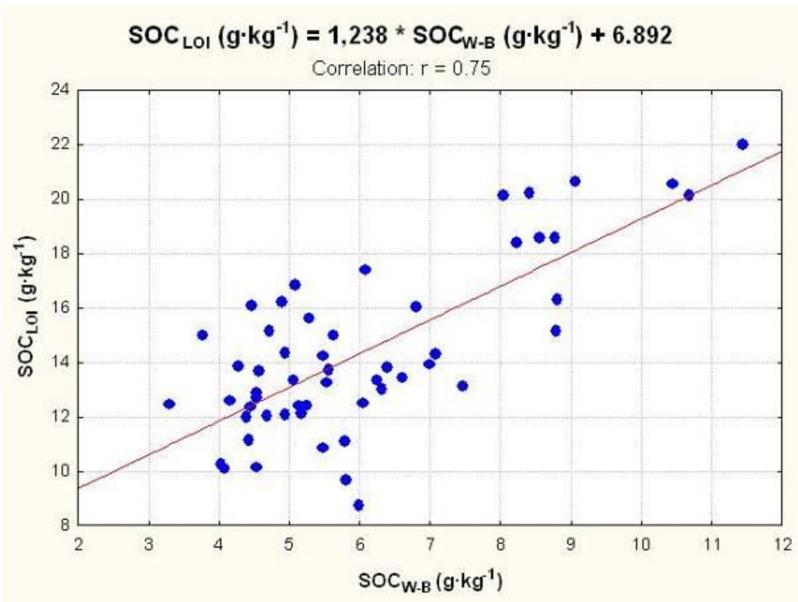
Figure 1



P 1.1.04

Current Advances in Instrumentation of Elemental Soil Analyzers

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Organic elemental analysis (EA) usually requires complete conversion of a solid or liquid sample into the gas phase at approx. 1200 K. Afterwards the mixture of combustion gases is chemically converted to well defined species, separated and most commonly subjected to a thermoconductivity detector (TCD). Traditionally, helium is employed as carrier gas in TCDs. Owing to the decrease in availability directly correlating to an increase in price of helium, novel instrumentation being capable of utilizing either helium or argon was developed. This proof of principle study shows a detailed comparison of EA-data concerning total carbon and total nitrogen content obtained on five different macro-sized soil standard samples based on either helium or argon operation. Results are identical within the experimental error. Furthermore, facilitated total organic carbon (TOC) determination on soils and soil eluates will be presented. Especially particle containing liquid samples and straightforward automatic measurements of solid samples pose problems in the majority of TOC analyzers available on the market. Approaches circumventing such difficulties are discussed.

P 1.1.05

Change in SOC composition after repeated organic waste application assessed by FTIR-PAS and thermal analysis

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1. Introduction

The composition of SOM can be significantly modified following the application of organic waste products (OWP). Characterising these changes and relating them to the initial composition of the applied OWP is important as it may help optimizing SOM turnover and soil fertility in term of C storage, nutrient release and soil improvement, and therefore determines appropriate management of these OWP.

2. Objectives

The objectives of this study were to identify and characterize changes in SOM composition after repeated OWP applications. We hypothesised that the composition of accumulated SOM differs across different types of OWP.

3. Materials & methods

Soil was sampled in the Crucial field experiment near Copenhagen, Denmark in November 2014. The experiment was started in 2003 and has been cropped mainly with spring cereals. The treatments are organized in a randomized block design with three blocks. Selected treatments for this study included: household waste compost (CH), sewage sludge (SA), cattle manure (CMA), NPK fertiliser (NPK) which was taken as a reference treatment. Organic wastes and NPK fertilizer were applied yearly at a rate equivalent to 100 kg N ha^{-1} yr^{-1} for CH and NPK, and at the accelerated rate of approximately 300 kg N ha^{-1} yr^{-1} for SA and CMA. Normal or accelerated rates of the different wastes were selected among the full range of treatments so that they had comparable soil organic carbon (SOC) content after 11 years of OWP application.

Thermal analysis (TG-DSC) coupled with measurement of evolved CO_2 (CO_2-EGA) was used to study changes in thermal stability for the different soils and applied OWP. Fourier transform mid-infrared (FTIR) spectroscopy with a photoacoustic detector (PAS) was used to characterize differences in functional groups and molecules across amended soils and applied OWP. Principal component analysis was used to reveal specific CO2-EGA thermogram and FTIR-PAS spectral regions explaining differences across treatments.

4. Results

After 11 years of yearly OWP soil application, SOC content was significantly greater in amended soil treatments compared to the reference NPK treatment, with 24.8 ± 0.9 g C kg^{-1} for CH, 21.8 ± 1.8 g C kg^{-1} for CMA, 20.4 ± 2.0 g C kg^{-1} for SA and 15.4 ± 0.6 g C kg^{-1} for NPK.

The analysis of CO_2 evolved during thermal analysis revealed a significantly greater thermal stability of the SOM in the soil amended with household waste compost and cattle manure compared to the SOM in the NPK fertilized soil whereas no significant difference was found for the soil amended with sewage sludge. Thermal analysis of the waste applied revealed a high temperature of the second exothermal peak (490°C) for the household waste compost whereas the cattle manure feature a sharp peak at 470°C attributed to oxidation of lignin which could explain the greater thermal stability in soils amended with these OWPs.

FTIR-PAS spectra revealed an increased relative absorbance for the CH and CMA treatments in the region 1580-1500 cm^{-1} attributed to aromatic C=C-C and amide II, 1460 - 1400 cm^{-1} attributed to C-H from methyls possibly overlapping with carbonates, and 1400-1380 cm^{-1} corresponding to C-O from carboxylate and phenolic hydroxyl. In turn, NPK and SA treatments had greater relative absorbance in the region 1680-1600 cm^{-1} corresponding to C=O from amide I and mineral bound water and in the amide III band at 1300-1250 cm^{-1}. The NPK fertilized soil was also significantly enriched in C-H from aliphatics vibrating at 2930 and 2850 cm^{-1} compared to the CH and SA treatments.

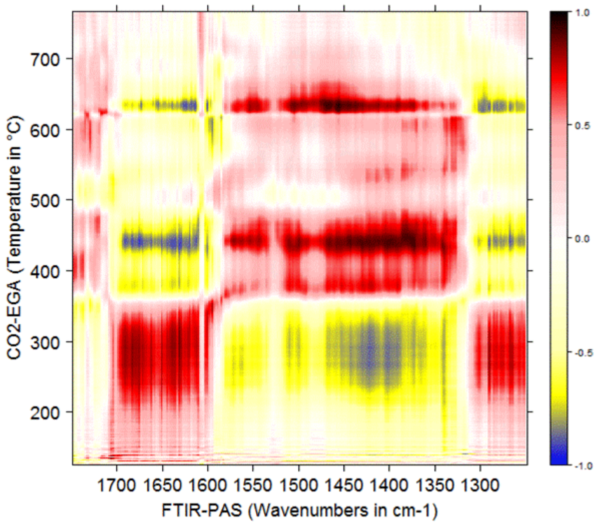
A correlation analysis between CO_2-EGA and FTIR-PAS data revealed a positive correlation between thermos-labile SOC and functional groups vibrating in the region 1700 - 1600 cm^{-1} while thermo-stable SOC was correlated with functional groups vibrating in the region 1600 - 1350 cm-1 (Fig. 1).

5. Conclusion

Results from this study indicated that aromatic and thermally stable compounds may preferentially accumulate in soil amended with household waste compost and cattle manure, probably arising from woody bulking agent in the compost, lignin rich bedding material in the manure as well as humified compounds, whereas sewage sludge and NPK fertilized soil were enriched in amides and aliphatics, indicating the predominance of microbially processed organic matter.

Figure 1. Correlation between FTIR-PAS spectrums and CO2-EGA thermograms.

Figure 1



P 1.1.06

UV and Visible absorption spectroscopic investigations and some information on the nature of soil humic substances

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Natural organic matter is known to be complex in nature with varying structural and functional characteristics. UV-Vis spectrophotometric analysis were used to investigate the nature of organic matter in two fraction of soil humic substances (humic acid, HA; and fulvic acid, FA). In this study humic substances were extracted from five different places of eastern Himalayan region in India. The ratio of optical densities or absorbance in dilute aqueous humic and fulvic acid solution at different pH is used in this study for characterization of these materials.

Humic substances show strong absorbance in UV-Visible range (from 200 to 800nm), particularly in UV region, because of the presence of aromatic chromophores and/or other organic compounds. Accordingly, the UV/ Vis spectra of humic acid and fulvic acid fraction showed a generally decreased absorptivity (or optical density) as the wavelength increase. The spectra appear to be broad and featureless, showing no maxima or minima, the absorption intensities varied greatly among the humic acid and fulvic acid. The Derivative spectrum of fulvic acid contain more maxima and minima compared to humic acid due to presence of more functional groups.

The relative order of ratios of absorptivites at different wavelength recorded at different wavelength and pH. From the study it appears that the ratio of E_{460}/E_{560} (E4/E5), and E_{560}/E_{660} (E5/E6) at neutral pH range related to the degree of condensation of aromatic carbon network, carbon content, and molecular weight of humic substances.

The results of this investigations show that E4/E5 or E5/E6 ratio of humic acid and fulvic acid is: governed by the particle size or molecular weight, affected by pH, apparently related to the relative concentration of condensed aromatic rings, independent of humic acid and fulvic acid concentration at least 100 to 500ppm ranges, related with free radical concentration, contents of O, C, CO_2H and total acidity, identified the relative abundance of functional groups and aromatic chromospheres.

Key words: Humic acids, Fulvic acids, UV-Vis Spectroscopic characterization.

P 1.1.07

Assessment of turnover time of organic matter of Hungarian arable soils by diffuse reflectance FT-IR spectroscopy

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Nowadays, an increased attention falls the more accurate understanding of Earth's global C cycle, including changes in the soil organic carbon stocks and its dynamics. The input data of C dynamics models contains parameters related to the kinetic parameters of soil organic carbon system, such as the turnover times. It is thus crucial to measure kinetic parameters in a more accurate way and to develop such methods which provide that the otherwise circumstantially measurable parameters can be estimated with little time and labour investments.

In our research we want to determine the kinetics parameter of turnover of the carbon pool, which is necessary to describe whether soil can be featured as carbon sink or source in short- and long-term. The aim of our research is to develop a fast and low cost method for the determination of the mineralisation rate of soil organic carbon. For this purpose the soil infrared spectrum seems appropriate: the method requires only a simple sample preparation and the measurement with FT-IR device is very fast. The spectrum of the soil can be considered as a “fingerprint” that is identical for each soil. By the statistical evaluation of the spectrum a regression equation can be determined that calibrates the turnover parameters. By the calibration the significant parameters of organic matter transformations can be estimated for any sampling point of a given site at any time. Thus, the method may supply adequate parameters for climate models.

P 1.1.08

Study of the interaction between of Humic and Fulvic acids extracted from soils of the Amazon region with Copper (II) using Analysis of Quenching

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Soil organic matter (SOM) plays an important role in maintaining soil productivity, accounting for promoting biological diversity. The main components of the SOM are the humic substances (HS), which it can be fractionated according to its solubility in humic acid (HA), fulvic acids (FA) and humin[1,2]. The determination of the chemical properties of organic matter, as well as its interaction with metallic species, is an important tool for understanding the structure of the humic fractions. The complex structure is formed of aromatic rings and reactive functional groups which are responsible for high complexing ability with metal species especially copper metal. Quenching Fluorescence has been used in the study of complexing metal ions capacity with the use of humic substances in the variety of interactions resulting in quenching the excited state reactions and/or molecular rearrangement and/or complex formation in the ground state[3,4]. In this way, Fluorescence Quenching has been studied as a source of information about what is happening at the molecular level these compounds. Therefore, the main objectives of this study was to evaluated of the interaction between Humic and Fulvic Acids extracted from the Amazon region soils with Copper (II) using quenching of fluorescence spectroscopy. The samples were collected from different soil profiles in the Barcelos region (Amazonas) which ranged from 0-400 cm depth. Sampling procedures, preservation, preparation of the samples for the extraction and purification of humic acid followed the recommendations of official methods[5]. Fluorescence Quenching Analysis was performed employing a Hitachi Spectrometer model F4500. To obtain the fluorescence emission spectrum, an excitation wavelength of 350 nm was used, and sample emission scanned from 360-700 nm was performed. The measurements were done in 2D mode and with increment wavelength of 1 nm. Studies of the HA and FA complexing capacity with Cu(II) ions was performed by titrating known concentrations of metal which ranges 0 to 105.9 mg of Cu /L ($CuSO_4$) and determining the decreasing of the molecular fluorescence signal intensity according to the procedure proposed by Ryan and Weber. Results showed there was a stability constant variation ($\log_{10}$ (Kc)) of copper ion (II) for the humic acid from 4.40 to 5.00 in the course of the depth, the largest value of $\log_{10}$ (Kc) obtained at the horizon Bh (240 to 260 cm: $\log_{10}$ (Kc) = 5.00). Whereas the values of stability constant for fulvic acid samples ranged 4.50 to 5.50 in the course of the depth, the largest value of $\log_{10}$ (Kc) obtained at the horizon Bh (260 cm: $\log_{10}$ (Kc) = 5.50). A similar $\log_{10}$ (Kc) result using the Stern-Volmer model was obtained by Esteves da Silva et al.[6] using humic acid and fulvic acid (FA) extracted from soils in the Netherlands with Cu(II) and the value was $\log_{10}$ (Kc) was 4.6. The authors observed that the greater the FA concentration of the samples, the greater the values obtained for the conditional stability constants. The stability of the AH-Cu(II) and AF-Cu(II) complexes are directly related to the number of binding sites present in the structure of the Humic Substance. Therefore the results preliminaries the values of $\log_{10}$ (Kc) shows that Humic Substance present in soil from Amazon contains greater quantities of binding groups in your structure, being verified more intensively for fulvic acid samples which had the highest $\log_{10}$ (Kc) values for this collection point.

Keywords: Humic Acid, Fulvic Acid, Complexation, Fluorescence

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P 1.1.09

Physical, Chemical and Density Fractionations of Soil Organic Carbon Originated from Different Soil Types and Land Uses

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1. Introduction

In recent years, soil organic matter (SOM) occupies great place in soil science due to its significant impact on soil fertility, global carbon cycle, sustainability and stability of biosphere. Despite the fact that SOM concentration is much lower compared to mineral portion of soil, its importance is very important for soil fertility, microbial, water-air and chemical properties of soil and therefore plant yield. It consists of all living organisms and non-living matter which is created biologically and located in soil. Soil organic matter fraction associated to mineral portion is considered as a more stable, while the water soluble and particulate fraction are considered as labile. Labile fraction is easily degradable and makes up to 5% of SOM. This fraction corresponds to the nutritive humus and consists of decomposed plant residues and less stable compounds with a high concentration of carbon. In general, the labile SOM consists of: residues of dead flora and fauna, and their cleavage products, micro-organisms, carbohydrates, polysaccharides, proteins, organic acids, amino acids, waxes, fatty acids and other non-specific humic compounds. Soil organic matter can be estimated from analytically determined soil organic carbon (C_{org}) concentration. The important characteristic of every particular soil type is C_{org} which is formed and stabilized during the process of pedogenesis. Human induced land use changes can greatly influence C_{org} concentration.

2. Objectives

The purpose of this study was to determine qualitative characteristics of C_{org} in different soil types exposed to different land uses. Also, it was relevant to highlight the strengths and weaknesses of applied individual methods.

3. Materials & methods

Field research was conducted in the Province of Vojvodina, Serbia, on five soil types (Arenosols, Chernozems, Fluvisols, Vertisols and Solonetz). Each soil type was examined at three locations and under three different land uses (cropland, meadow and forest) at every location. Soil samples were taken from a depth of 0-30 cm with three replicates approximately 10 m apart.

To test the qualitative characteristics of SOM following C_{org} fractions were determined:

- Physical fractionation :

- organic carbon in the different aggregate size classes ($C_{>2000}$, $C_{2000\text{-}250}$, $C_{250\text{-}53}$, $C_{<53}$);

- Chemical fractionation:

- hot water extractable organic carbon (C_{hwe});
- organic carbon susceptible to oxidation with 333 mM $KMnO_4$ (C_{KMnO4S});
- organic carbon resistant to oxidation with 333 mM $KMnO_4$ (C_{KMnO4R});
- organic carbon susceptible to oxidation obtained by the modified Walkley-Black method using different concentration of 12, 18 and 24N H_2SO_4 (C_{wb1}, C_{wb2}, C_{wb3}, C_{wb4});

- Density fractionation:
- particulate organic carbon (C_{par});
- mineral associated organic carbon (C_{mas});

4. Results

The concentration of C_{hwe} fraction ranged from 243-427 µg g^{-1}, while its relative contribution in C_{org} ranged from 1.5-2.61%. The concentration of C_{KMnO4S} fraction ranged from 1.86-4.07 g kg^{-1}, while its relative contribution in SOC ranged from 7.91-42.55%. Distribution of C_{wb} fractions in C_{org} was following: C_{wb1} (35,6%) > C_{wb2} (27,5%) > C_{wb4} (22,7%) > C_{wb3} (14,2%). The concentrations of C_{par} varied from 3.75-7.89 g kg^{-1} and of C_{mas} from 6.71-20.71 g kg^{-1}, while the relative contribution of C_{par} in C_{org} varied from 23.6-43.4% and C_{mas} in C_{org} varied from 56.6-76.4%. The concentration of C_{org} in the different fractions of stable aggregates was the highest in small macroaggregates (2000-250 µm), which did not coincide completely with aggregate hierarchy.

5. Conclusion

By comparing methods for qualitative analysis of C_{org} it was established which of the applied methods could be used as the discriminator between particular soil types or as an indicator of changes in the ecosystem caused by anthropogenization. It is possible to use a combination of analytical methods applied in this study in order to examine fractions of C_{org}. Research should be focused on the function and interaction between the fractions of C_{org}. A key measure that can be proposed is the monitoring of labile C_{org} fractions as an indicator of sustainability of agricultural ecosystems. Identification and analysis of different functional fractions of C_{org} is important for the overview of the distribution and assessment of the stability of C_{org} in soils.

P 1.1.10

Evaluation of the pre-treatment procedures for mid infrared spectroscopic study of soil organic matter

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Mid infrared (MIR) spectroscopy is a promising technique for both the qualitative and quantitative evaluation of soil organic matter (SOM). This technique measures interaction of electromagnetic radiation in the 4000-400 cm^{-1} range with SOM functional groups. Soil minerals interfere with SOM bands and presents challenge in the application of MIR for the study of organic carbon (OC) in soils. The differences between spectra of ashed and unashed (original) soils have been used to accentuate the SOM bands. This method is based on the assumption that heating efficiently removes OM from soil samples without affecting the mineral spectral properties. The objectives of this study were to evaluate the effectiveness of the ashing method and to investigate alternative methods to the ashing-subtraction for spectroscopic examination of SOM.

We have used bulk soil as well as the density fractions (<1.8 to >2.6 g cm^{-3}) of four soils with contrasting mineralogy. Ferralsol, Luvisol, Vertisol and Solonetz were used to evaluate the effect of ashing (400 ^{o}C, 8 hr) on spectral properties of both organic and inorganic soil components. Density fractionation was done to isolate SOM into free OM and mineral associated OM assemblages. Chemical oxidation (NaOCl) and mineral dissolution (with HF) were performed as alternative approaches to ashing. Diffuse reflectance infrared Fourier transform (DRIFT) spectroscopy was done before and after treatments to observe spectral changes; mass spectroscopy and XRD were used to determine C content and mineralogy.

Ashing of OM altered the spectral bands of goethite and gibbsite in Ferralsol, however, phyllosilicate bands in Luvisol, Vertisol and Solonetz remained largely unaffected. Some OC bands, such as aromatic (1680-1580 cm^{-1}) and aliphatic (2960-2840 cm^{-1}) were still present in the ashed samples. This was prominent mainly in the bulk soils and mineral dominated density fractions. The incomplete removal of OM as well as dehydroxylation of mineral alteration might induce artefacts in the spectra subtraction procedure that could lead to misinterpretation of SOM spectra. These effects vary across the diversity of soil textures, mineralogies and composition of SOM. Thus, the ashing-subtraction method should be used with caution and perhaps only for soils that are devoid of Fe/Al oxides.

The NaOCl treatment oxidised relatively labile OC (e.g. aliphatics) without any mineral alteration; and stable OC (aromatic, O-alkyl and amides) fractions also remained largely unaffected. The HF treatment removed minerals efficiently from both bulk soils and density fractions, which minimised mineral bands in the spectra of HF treated samples. This treatment also removed OC that was associated with minerals (mostly phenolic lignin, aromatic and amides) and left non-mineral bound OC in the residues. The amount and type of OC oxidation as well as the effect of HF treatment varied with the mineralogy, and the composition and content of SOM. We conclude that chemical oxidation and mineral dissolution can be used as a pre-treatment for spectroscopic characterisation of SOM, particularly for distinct OM pool study.

P 1.1.11

Elucidating aggregate microstructure with NanoSIMS and digital image processing

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Soil aggregation is a key factor for a number of biogeochemical processes (e.g. soil organic matter stabilization and nutrient and pollutant sorption) in soils. Although there is a large number of studies on the factors controlling such soil processes, it is still challenging to study these processes in-situ. However it can be assumed that the spatial arrangement of organic and mineral soil constituents in soil aggregates and thus the aggregate structure determine the processes happening at the aggregate scale.

We used the nano-scale secondary ion mass spectrometry (NanoSIMS) technology to study a cross section of a single large aggregate from the top-soil of an agricultural cropland with a regular grid of 45 measurements (each with a size of 30x30 µm). Using Cs+ as primary ion, the negatively charged ions 12C-, 12C14N-, 12C15N-, 27Al16O-, 56Fe16O- and 28Si- were collected with a lateral resolution of up to 100 nm. We applied pre-processing algorithms and unsupervised classifications to separate and identify organic and inorganic compartments in the NanoSIMS measurements.

Our approach enabled us to explore the elemental and isotopic composition of organic and mineral particles at a hitherto unresolved lateral resolution for a complete soil aggregate and spatially explicitly map and quantify the different compartments.

P 1.1.12

The key role of Geographic Information Systems and Remote Sensing in Soil Monitoring

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The existing soil maps in many countries are different, in assumptions, scales and methods. Therefore, generating new maps considering the needed harmonization and/or simplification is not possible in a short term. However, updating; re-sampling; generalization the new soil data and maps could be performed based on remotely sensed data and GIS. But how? Where and When?

The soil quality, erosion, water holding capacity and crop yield are highly effected by soil organic carbon. Soil organic matter content could be used as a guide herbicide and fertilizer Recommendations. In fact, a review of recent achievements in the field of remote sensing soil parameter studies is needed. Therefore, we review several research had been done in soil remote sensing including soil organic matter. This study aimed to literature evaluation in the mentioned field and intensify the efficiency of remote sensing in soil studies.

Researchers have investigated estimates of soil surface properties from remotely sensed information as a means of rapidly quantifying and monitoring some surface soil properties, such as SOC. In general, soils with higher organic matter contents appear darker. As a result, most of the remote sensing studies of soil organic matter are based on this criteria. Several laboratory researches have been conducted to identify SOC using soil reflectance. The result of the researches had led to the development of high spectral resolution sensors. These sensors produced remotely sensed data that can provide ancillary information about the soil (Ladoni et al., 2010 a). Baumgardner et al. (1970) and Al-Abbas et al. (1972) had carried out the first studies of the relationship between organic matter and reflectance using airborne sensors. Chen et al. (2000) found a good agreement between the measured (from 31 locations) and the predicted values of SOC with an R2 around 0.98. Recent research has suggested that correlation between reflectance in certain spectral bands and soil properties could provide a low cost method to predict the soil organic carbon (Ladoni et al.,2010 b). This review showed that remote sensing could be effectively used as a complementary tool for monitoring soil organic matter.

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P 1.1.13

Droplet-based Microfluidics for Evaluation of Response of Soil Microbial Communities on Heavy Metal Stress

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1. Introduction

Droplet-based microfluidics has been proved to be a powerful tool for miniaturized toxicological studies. The easy generation of large ordered sequences of nanoliter droplets with step-wise varied concentrations of poisonous substances makes this technique very useful for the determination of highly resolved dose/response functions. Up to now, the potential of microfluidics is nearly not used for investigating the development of microbial communities. But, the investigation of plasticity of soil communities is particular important for understanding how soils can react on changing environmental conditions including pollution, natural chemical impacts and mobilization of heavy metal ions.

2. Objectives

Therefore, it should be evaluated how microfluidic investigations can support an empirical evaluation of the response behavior, of tolerance and robustness of soil microbial communities against toxic components in dependence on their concentration. Heavy metals have been chosen as test examples.

3. Materials & Methods

Material from soil samples from areas of ancient copper mines (Mansfeld/Harz and Saalfeld region, Germany) is mixed with cultivation medium (AM) and effectors in a fluid manifold, which is also used for simultaneous generation of nanoliter fluid segments of regular size by use of an inert water-immiscible liquid. The concentration of effectors (salts of Cu, Ni, Co) in each segment is defined by PC-controlled actuation of low-pulsation syringe pumps (Cetoni, Germany). The random distribution of small portions of soil material onto the nanoliter droplets corresponds to the principle of stochastic confinement, which is applied here in form of a subdivision of organisms from complex composed soils into "stochastic reduced microbial communities". The fluid segments are stored for incubation times between 2 and 90 days (mostly 3 weeks). The concentration-dependent microbial growth was characterized after the incubation by a combination of micro flow-through photometry (optical density measurement) and fluorometry (autofluorescence measurement).

4. Results

A very large spectrum of different response patterns has been obtained from incubation experiments with different soil samples and heavy metals. In the obtained dose/response pattern, critical concentration thresholds can be identified in many cases. Steep transitions between intensive and strongly reduced microorganismic growth can be regarded in analogy to lethal doses in toxicological studies with single target species. Particular important is a frequently observed sharp change in the character of response pattern in small concentration intervals (Fig. 1). It reflects a switch-like change in the response of microbial communities in dependence on the effector concentrations. It is assumed that these critical concentrations are related to sharp transitions between the dominance of different species or partial communities. Soil samples respond frequently by a sequence of such transitions in case of increasing heavy metal concentration.

The complementary picture of such sharp transitions and a comparatively homogeneous response behavior in the concentration ranges between allows the identification of typical response groups (Fig. 2). It is assumed that these response groups correspond to different compositions of communities of growing organisms in certain concentration intervals. The number and variability of such response groups is obviously a feature for the characterization of the ability of a soil to respond to stress by toxic substances beside the maximum concentration of tolerance.

5. Conclusion

The investigations show that the microfluidic approach is very well suited for an empirical evaluation of the response of soil microbial communities on toxic substances. It supports the identification of characteristic response patterns and allows to distinguish the response of a soil against different toxic substances and to differentiate the response of different soils. The technique of micro segmented flow can be used for long-time studies and is suited, therefore, for the evaluation of the development of slowly growing microbial populations, too. This will be in future particular interesting for studying effects of shifts of environmental conditions and for evaluation of the potential of soils to respond to environmental changes on different time scales.

Figure 1

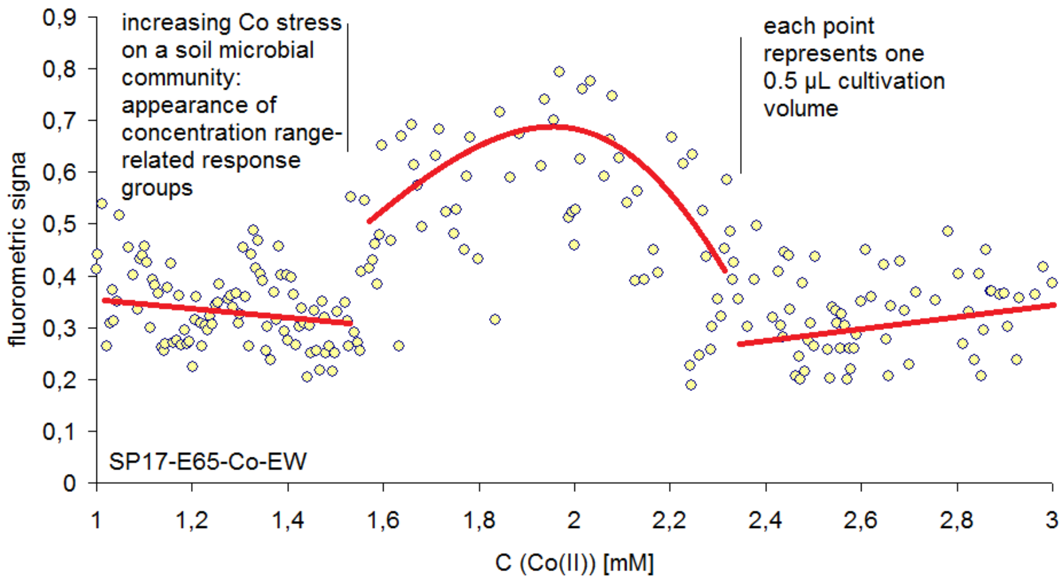
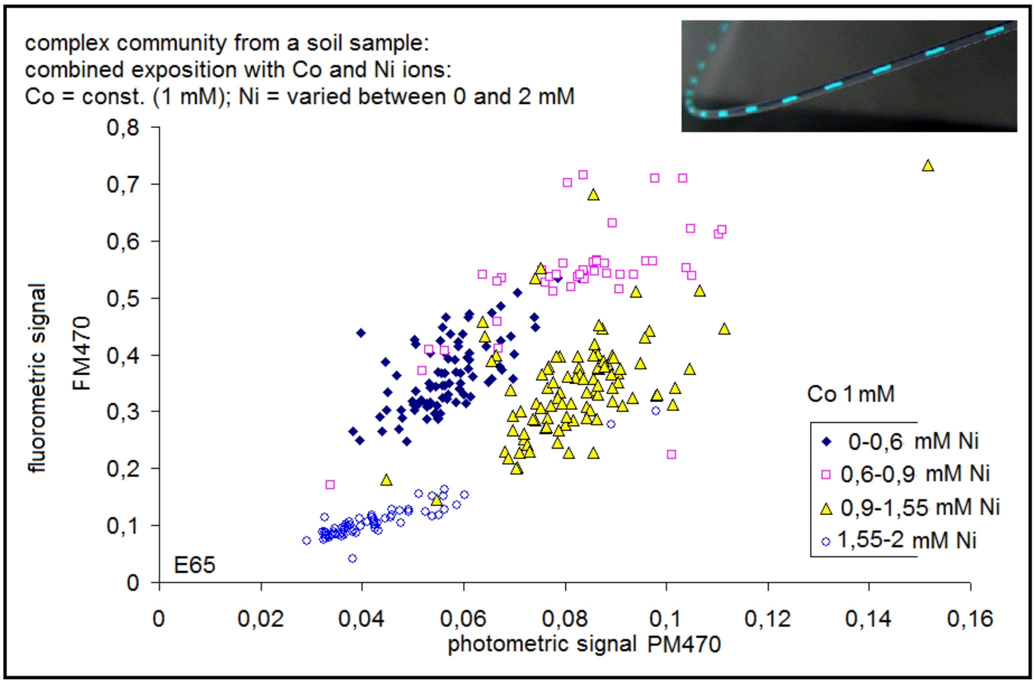


Figure 2



P 1.1.14

Experimental C-Enrichment of Tropical Farm Soil with Biomass

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1. Introduction

Soil organic matter plays a central role in keeping soil functionality and ecosystem services. It improves soil nutrient and water retention capacity, as well as its structure and biological quality (Swift & Woomer 1993). Croplands have shown a reduction of organic matter (OM), due to some traditional agricultural practices, such as soil plowing and tillage. These practices break down soil aggregates and expose OM to microbial decomposition, causing carbon loss to the atmosphere (Zech et al. 1997; Tivet et al. 2013). It is especially critical in the tropics, as the high temperature accelerate microbial activity (Price & Sowers 2004). Biomass additions to tropical farmland can help to restore soil OM and therefore soil carbon (Sundermeier et al. 2005).

2. Objectives

In this study we aim to assess soil organic carbon (SOC) in a Red Latosol, after two and three years of a single event of different biomass addition, which are considered either cost-efficient or waste materials. We studied the effect of three biomass types and amounts and two disposition methods (direct on the soil or with harrow incorporation) on soil from arable fields.

3. Materials & methods

Study area

The experimental site is located at the Rio Engano Farm, located into the Brazilian Cerrado (savanna) biome. The experiment was established in February 2012, in an area of 1.15 ha (15° 24.260' S, 54° 50.967'W; 685 m a.s.l.) on Red Latosol. The area is cultivated with a soybean and corn rotation.

Experimental Design and Sampling

At the beginning of the experiment we applied three different types of biomass amendments. They include (a) Filter cake of sugarcane residues (*Saccharum officinarum* from alcohol/sugar-production, (b) sawdust of Peroba and Cedrinho (*Peroba jaune* and *Erisma uncinatum*, respectively) and (c) coarse chips of *Eucalyptus sp*.

We added 0 (control), 6, 12 and 18 tons of each biomass per hectare; using two disposition methods: direct on the soil and with harrow incorporation. Each treatment was done in triplicate. Subsequent to the first biomass application; there have not been further experimental additions. The area was not fenced to allow the farmer to continue with their arable field routines on all treatment plots.

After two and three years of the biomass application, we took soil samples (three sub samples/plot) from 0 to 5 cm depth (February 2014 and 2015). The samples were in a ventilated oven at °60 C and passed through a 2mm stainless steel sieve. The sieved soil portion was used to calculate total organic C- and N-contents in a CN-Analyzer (LECO-CHN 628, Leco-Corporation, Michigan, U.S.)

Statistical Analyses

As the treatments were applied to different plot sizes, one contained in other, we used Split-plot ANOVA (Crawley 2007) to test the significance of the treatment effects on SOC % and their possible interactions. The response variable data, SOC%, were arc-sine transformed, due to carbon results are presented as a proportion of soil. Additionally, we used t-test to determine the significance of the difference between SOC mean before (year 0) and after two and three years of the biomass addition. Data analysis was conducted using the 'R' program (R Core Team 2013).

4. Results

After two and three years of the biomass addition, the SOC% was not significantly affected by the biomass amount and type, neither by the application method. In the same way, there are not significant treatment interactions (Table 1).

Table 1. Effect significance after two and three years of the addition of different biomasses on soil organic carbon in a Red Latosol, from the Brazilian Cerrado.

On the other hand, SOC% after two years, was significantly higher than before and after three years of the biomass addition (*p*-value=0.028 and *p*-value<0.001, respectively). Regarding before and after three years of the biomass addition, SOC% was not significantly deferent (*p*-value=0.139) (fig. 1).

Figure 1. Soil organic carbon (SOC) percentage in the first five centimeters of Red Latosol from the Brazilian Cerrado, before and after two and three years of a single event of biomass addition. The median, quartiles, 1.5 interquartile range and outliers are indicated.

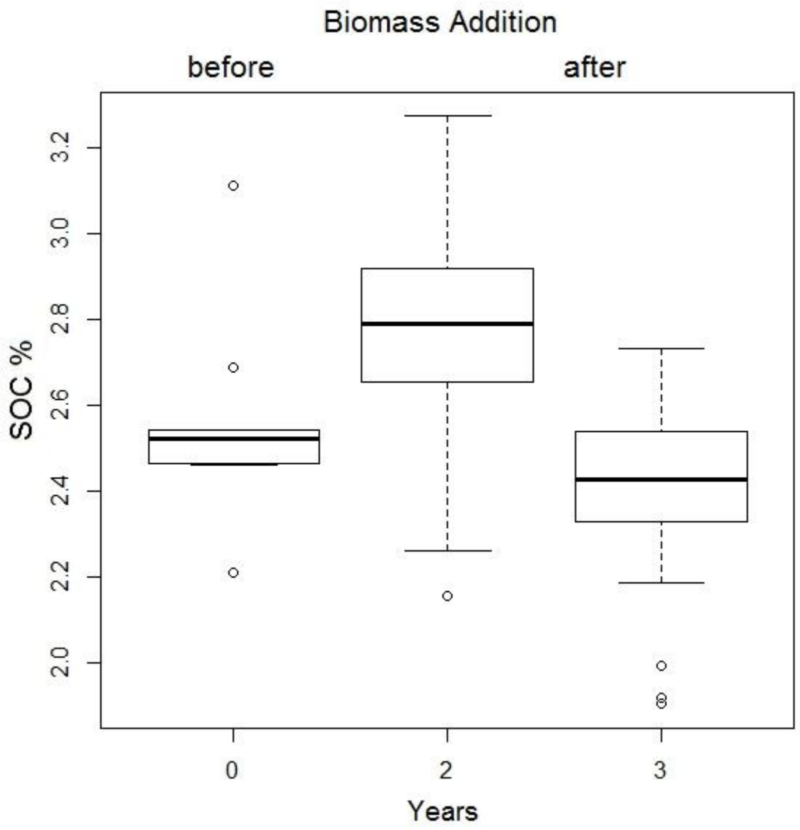
5. Conclusion

The no significant effects of biomass types and amounts and incorporation methods can be a result of the similarity between the chosen treatments. However, there was a significant augment of SOC% after 2 years, followed by a decrease after 3 years of the biomass addition; suggesting that biomass reapplication should be done every 2-3 years. We consider the SOC increase in the second year a remarkable outcome; taking into account that this soil has been for more than 20 under conservational farming practices such as no-till.

Figure 1

Treatments and Interactions	*p* -value	
	Year 2	Year 3
Biomass amount (Amt)	0.208	0.257
Biomass type (Typ)	0.178	0.280
Biomass disposition method (Dis)	0.948	0.101
Amt * Typ	0.217	0.876
Amt * Dis	0.968	0.527
Typ * Dis	0.596	0.526
Dis * Typ *Amt	0.576	0.501

Figure 2



Biomass Addition
before
after
SOC %
3.2
3.0
2.8
2.6
2.4
2.2
2.0
0
2
3
Years

O 1.2.01

Linking molecular composition of extractable soil microbial biomass to its carbon turnover time

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We aimed at linking the soil microbial molecular characteristics (structure and size) to its carbon (C) turnover time. A $^{13}CO_2$ plant pulse labelling experiment was used to trace plant C into rhizosphere soil microbial biomass obtained using chloroform fumigation extraction. Molecular characterization of the microbial biomass was performed using complementary approaches namely size exclusion chromatography (SEC) liquid chromatography coupled with Fourier transform infrared spectroscopy (SEC-LC-FTIR) and electrospray ionization Fourier transform ion cyclotron resonance mass spectrometry (ESI-FT-ICR-MS). ^{13}C content in molecular size classes of microbial biomass was analysed using SEC coupled online to liquid chromatography–isotope ratio mass spectrometry (SEC-LC-IRMS). SEC-LC-FTIR suggests that mid to high molecular weight (MW) microbial biomass was richer in aliphatic CH bonds, carbohydrate-like compounds and possibly P=O derivatives in phospholipids. On the contrary, C-O bonds from esters, ethers and alcohols were more abundant with decreasing MW, suggesting dominance of oxidized compounds in the low MW microbial biomass. ESI-FT-ICR-MS suggests that microbial biomass is richer in N containing compounds and is more abundant in aliphatic compounds. Both molecular characterization tools suggest that CFE derived microbial biomass is largely lipid and carbohydrate and to a smaller extent protein derived. CFE is a widely used technique in soil biology and this study sheds light on the hitherto unknown molecular characteristics of the extracted microbial biomass from soil. SEC-LC-IRMS analysis revealed that ^{13}C enrichment decreased with increasing MW of microbial biomass size classes and the turnover time was deduced as 30, 48 and 67 hours for low, mid and high MW size classes, respectively. In conclusion, we suggest that the low MW class of extractable soil microbial biomass represents the rapidly turned-over metabolite fraction consisting of microbial compounds like organic acids, alcohols and sugars; whereas, larger structural compounds are part of the cell envelope (likely membrane lipids or polysaccharides) with a much lower renewal rate. This dependence of microbial C turnover on its macromolecular structure and composition thus highlights influence of the latter on microbial contribution to the maintenance of soil organic matter.

O 1.2.02

Bacterial biomass as a source of SOM: Imaging spectroscopy allows for better characterisation

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In recent years the paradigm of the nature of soil organic matter (SOM) has been shifting towards a microbial biomolecule derived composition. Studies indicated that SOM consists of amino sugars, proteins and lipids rather than of humic compounds (e.g. Kelleher & Simpson 2006).

Miltner et al. (2012) suggested that most organic material entering the soil will be transformed by microorganisms. This implies that the chemical nature of this organic material shifts from being plant- to microbial derived. Upon death of these microorganisms, parts of the cells will be mineralised while other parts will remain in the soil. The authors hypothesised that the cell envelope fragments into pieces of 200 - 500 nm in size, which show a patchy distribution in soil. By means of scanning electron microscopy (SEM), they found these fragments in soils from laboratory incubations and in groundwater microcosms.

Later, Schurig et al. (2013) found an increasing number of morphologically similar fragments during pedogenesis along a chronosequence in the forefield of a receding glacier. While the authors of the studies could provide lines of evidence of the fragments being of microbial origin, their quantification was solely based on optical inspection. An exact chemical characterisation of individual fragments remained impossible (Schurig et al. 2013).

The aim of this study was a chemical characterisation of the fragments together with an observation of the viability of the microorganisms they derive from. A multi-labelling approach was chosen for investigating these issues (Schurig et al. 2015). Briefly, initially sterile microcosms were loaded with a ^{13}C labelled substrate and incubated in a constructed wetland. The activity of microorganisms was measured via ^{13}C stable isotope probing. Their identity and localisation compared to the ^{13}C label was determined via a catalysed reporter deposition-fluorescence in situ hybridisation approach, which labelled bacterial cells with fluorine.

For visualisation, nano-scale secondary ion spectroscopy (NanoSIMS) was used. NanoSIMS offers several advantages for this kind of study: only the top few nanometres of the sample are analysed; discrimination of isotopes even in complex samples is feasible. In our study, ^{12}C, ^{13}C, ^{15}N, ^{16}O, ^{19}F, ^{31}P and ^{32}S were detected simultaneously.

Although the microcosms were initially sterile, abundant microbes were detectable after incubation for 4 weeks. Active ^{13}C labelled cells were accompanied by unlabelled and inactive biomass. Irrespective of the degree of ^{13}C-labelling, most of this biomass was derived from bacteria, as indicated by the fluorine labelling. The identified biomass often had the shape of microbial cells, but we also detected features which were morphologically similar to the cell envelope fragments observed by Miltner et al. (2012) and Schurig et al. (2013). The cell-shaped material had in common that it was enriched with ^{31}P compared to the background. The remainder of the material showed little or no ^{31}P enrichment.

^{31}P as a macronutrient is likely to be recycled rapidly upon cell death, because terrestrial ecosystems are commonly ^{31}P-limited. Hence, the depletion of the cell envelope fragments indicates that the material is already dead but must be of microbial origin, because it remains labelled with fluorine.

The combination of an in situ microcosm approach and NanoSIMS analyses allowed for determination of the origin of the microbial cell envelope fragments found in earlier studies. Applying this methodology to fractions isolated from soils of a chronosequence should provide more insight into the formation of SOM in a natural system.

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O 1.2.03

Exploring the biological relevance of carbon fractions: integrating spectral chemistry and metagenomic sequencing

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1. Introduction

Our ability to collect detailed information about the nature of soil organic matter and about the microbial community has increased significantly. However, our ability to integrate this complex information into models aimed at predicting soil functions remains limited. Knowledge gained from modelling and empirical measurements have shown the importance of dividing soil organic matter into pools/fractions that differ in their rates of turnover. The 'conceptual' pool constructs of carbon turnover models have been validated with 'measurable' soil organic matter fractions. The measurable fractions can be predicted through rapid, cost effective spectroscopic methods negating the need for lengthy isolation procedures and analysis and opening the door to widespread use. However relatively little known about the biological relevance of these fractions, and how they relate to taxonomic and functional information gained from metagenomic sequencing. Improving our understanding of the correlations between organic matter composition and the microbial community may help to: a) fine-tune fractionation methods to ensure biological relevance; b) provide valuable insight into how to better aggregate metagenomics data into a format useful for model integration.

2. Objectives

We aimed to determine the extent to which soil organic matter composition correlated with taxonomic and functional community data in soils from a low rainfall dry-land cropping system of Western Australia.

3. Materials & methods

To provide diversity in soil organic matter composition, the study included soils from management treatments where stubble was retained or where stubble was burnt, with depth sampling (0-10cm, 10-20cm, 20-30 cm). Soil organic matter composition was characterised by a) solid state nuclear magnetic resonance (NMR) spectroscopy; b) mid-infra-red (MIR) spectroscopy and estimation of carbon fractions (as per Baldock et al 2013). The soil microbial community structure and function was characterised by metagenomic sequencing using the Illumina MiSeq platform. Data analysis included a range of non-parametric multivariate correlation analysis (PRIMER-E) and predictive approaches through partial least squares (PLS; UnScrambler, CAMO).

4. Results

Sample depth had a far stronger impact on soil carbon composition, and microbial community structure and function compared to stubble management. Differences in the carbon composition with depth were driven by a relative decrease in carbohydrate-like moieties and an increase in lipid-like moieties, while differences in lignin- and char- like moieties contributed to more subtle differences between management. Taxonomic differences, evident with increasing depth ($R=0.49$, $P<0.001$) and correlated ($P<0.001$) with carbohydrate and lipid chemistry, included *Gemmatimonadetes*, *Bacteroidetes*, *Actinobacteria*, and *Acidobacteria*. In the top 10 cm, management differences were only evident in the microbial functional data, and were correlated ($P<0.001$) with differences in carbohydrate. A range of further analyses aim to explore the correlations between spectral chemistries and the metagenomics data, discussing approaches to better integrate data types to advance our understanding of the biological relevance of carbon fraction data.

O 1.2.04

Autotrophic fixation of geogenic CO_2 by microorganisms contributes to soil organic matter formation and alters carbon isotopic signatures in a wetland mofette

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To quantify the contribution of autotrophic microorganisms to organic matter formation (OM) in soils, we investigated natural CO_2 vents (mofettes) situated in a wetland in NW Bohemia (Czech Republic). Mofette soils had higher SOM concentrations than reference soils due to restricted decomposition under high CO_2 levels. We used radiocarbon ($\Delta^{14}C$) and stable carbon isotope ratios ($\delta^{13}C$) to characterize SOM and its sources in two moffetes and compared it with respective reference soils, which were not influenced by geogenic CO_2. The geogenic CO_2 emitted at these sites is free of radiocarbon and enriched in ^{13}C compared to atmospheric CO_2. Together, these isotopic signals allow us to distinguish C fixed by plants from C fixed by autotrophic microorganisms using their differences in ^{13}C discrimination. We can then estimate that up to 27 % of soil organic matter in the 0-10 cm layer of these soils was derived from microbially-assimilated CO_2 .

Isotope values of bulk SOM where shifted towards more positive $\delta^{13}C$ and more negative $\Delta^{14}C$ values in mofettes compared to reference soils, proving that geogenic CO_2 emitted from the soil atmosphere is incorporated into SOM. To distinguish whether geogenic CO_2 was fixed by plants or by CO_2 assimilating microorganisms, we first used the proportional differences in radiocarbon and $\delta^{13}C$ values of plants to indicate the magnitude of discrimination of the stable isotopes in living plants. Deviation from this relationship was taken to indicate the presence microbial CO_2 fixation, as microbial discrimination should differ from that of plants.

Dark $^{13}CO_2$-labelling experiments confirmed high activity of CO_2 assimilating microbes in the top 10 cm of the soil profile, where $\delta^{13}C$ values of SOM where shifted up to 2 ‰ towards more negative values and low C/N ratios indicated high contribution of microbial derived C. We inferred that the negative $\delta^{13}C$ shift was caused by the activity of chemo-lithoautotrophic microorganisms, as indicated from quantification of cbbL/cbbM marker genes encoding for RubisCO by quantitative polymerase chain reaction (qPCR) and by acetogenic and methanogenic microorganisms, shown present in the moffettes by previous studies. Combined $\Delta^{14}C$ and $\delta^{13}C$ isotope mass balances indicated that microbially derived carbon accounted for 8 to 27 % of bulk SOM in this soil layer. The findings imply that autotrophic organisms can recycle significant amounts of carbon in wetland soils and might contribute to observed reservoir effects influencing radiocarbon signatures in peat deposits.

O 1.2.05

Incorporation of ^{13}C labelled shoot residues in *Lumbricus terrestris* casts: A combination of Transmission Electron Microscopy and Nanoscale Secondary Ion Mass Spectrometry

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Earthworms play a central role in litter decomposition, soil structuration and carbon cycling. They ingest both organic and mineral compounds which are mixed, complexed with mucus and dejected in form of casts at the soil surface and along burrows (Blouin et al., 2013). Bulk isotopic or biochemical technics have often been used to study the incorporation of litter in soil and casts, but they could not reflect its complexity at the microscale. Nano-scale secondary ion mass (NanoSIMS), which is a high spatial resolution method providing elemental and isotopic maps of organic and mineral materials, has recently been applied in soil science (Herrmann et al., 2007; Vogel et al., 2014). It appeared a promising tool combined with other microscopic techniques (Poch and Virto, 2014). Transmission Electron Microscopy (TEM) has proven its efficiency to investigate organo-mineral associations in soil and earthworm casts (Pey et al., 2014). For the first time in this field, we combined NanoSIMS and TEM to investigate the dynamics of incorporation and decomposition of labelled litter in earthworm casts.

This study aimed to (**1**) determine the nature of the organic matter incorporated by earthworms in casts and its association with mineral particles and (**2**) identify the organic constituents coming from labelled residues. A one year mesocosm experiment was set up to study the incorporation of ^{13}C labelled Ryegrass (*Lolium multiflorum)* litter in a soil in presence of anecic earthworms (*Lumbricus terrestris*). After six months of incubation, surface casts were sampled, embedded in epoxy resin and cut into ultra-thin sections. Samples were analyzed with a JEOL EMXII TEM and a Cameca NanoSIMS 50, obtaining secondary ion images of ^{12}C, ^{16}O, $^{12}C^{14}N$, $^{13}C^{14}N$ and ^{28}Si. The $\delta^{13}C$ maps were obtained using the $^{13}C^{14}N^-/^{12}C^{14}N^-$ ratio.

NanoSIMS images highlighted the labelled organic matter incorporated in casts (**Fig.1**). Using TEM images, the organic material was recognized and characterized with high degree of confidence (**Fig.2**). Thus, the combination of these two methods participated to clarify the complex microscale organization in earthworm casts. The various stages of decomposition of plant residues suggest that earthworms incorporated fresh plant residues both by ingesting and ploughing them inside casts. Casts are populated with abundant and diverse microorganisms which participate actively to litter decomposition. The $\delta^{13}C$ values of plant residues and microorganisms are highly variable (from 14 to 943 ‰), underlying the complexity of organic matter dynamics and the importance of microscale analyses to identify and explain this variability. Ongoing investigations are performed to address the effect of earthworms on litter incorporation in soil.

Fig. 1. NanoSIMS images of casts of Lumbricus terrestris, indicating the location of ^{16}O, ^{28}Si and $^{12}C^{14}N$. A map of the $\delta^{13}C$ is also represented; a mask was applied to remove the epoxy resin contribution, using a defined threshold for the $^{12}C^{14}N^-$ element. Then, black regions represent either a hole on the section or resin. b, bacteria; db, damaged bacteria; cw, cell wall; f, fungi.

Fig. 2. Micrographs of TEM of casts of *Lumbricus terrestris*. b, bacteria; ba, bacterial aggregate; cf, cellulosic fiber; cw, cell wall; h, hole; m, mineral; p, organo-mineral association with exopolymers

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Figure 1

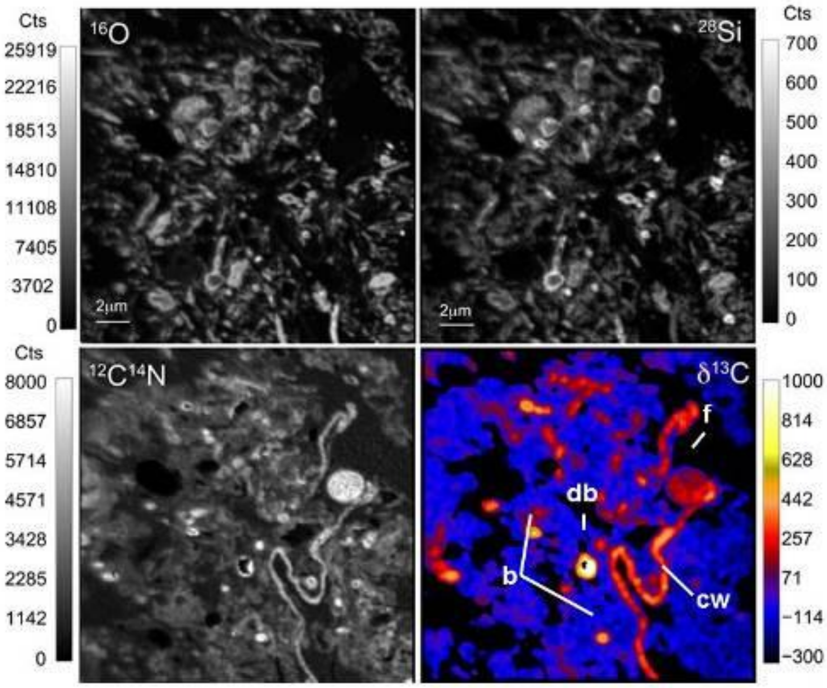
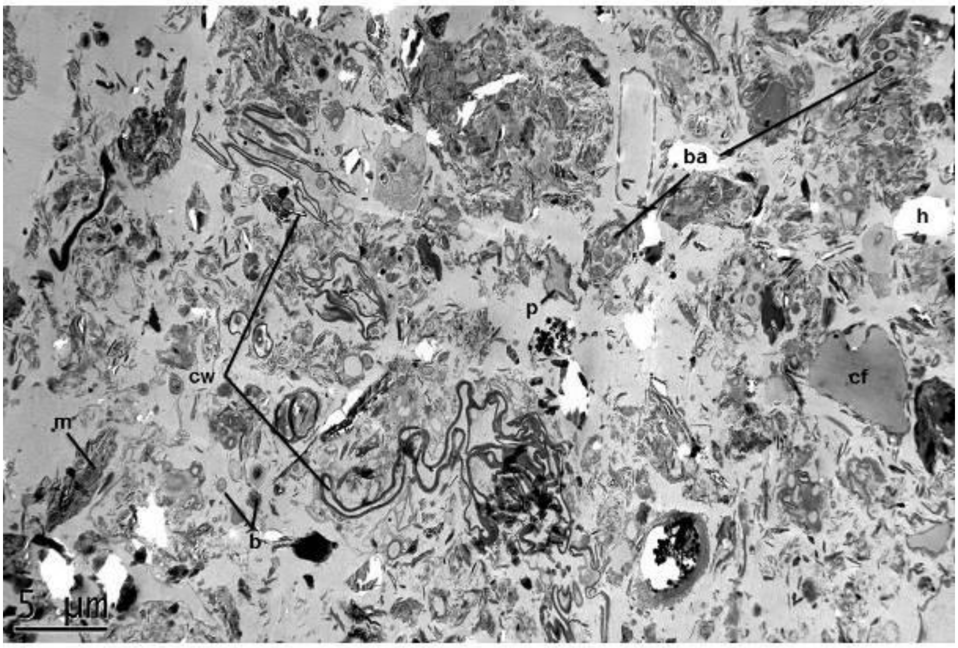


Figure 2



O 1.2.06

The long and windy road: Investigation of the early stages of nitrogen accumulation in humic substances

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Introduction

The pathways leading to accumulation of covalently bonded nitrogen in humic substances are still a controversial issue in soil science and geochemistry. Similarly, structural elucidation of the variety of the types of nitrogenous moieties present in SOM is still in its infancy even though recent NMR studies suggest amide-type nitrogen to form the majority of organically bonded nitrogen which is, however, frequently not in accordance with the results of wet-chemical analyses. The polyphenol theory which is based on fundamental work of Flaig and Kononova is hitherto the most accepted concept of the formation of humic substances as it emphasizes highly reactive polyphenols and quinones as key intermediates formed by microbial degradation of both polysaccharides and lignin which can re-condensate in the presence of ammonia, amines or amino acids to higher molecular *N*-rich compounds.

Objective

Following the polyphenol theory but fully aware of the imperfection of a semi-abiotic simulation approach, this work communicates the results of a study that investigated some potential nitrogen accumulation pathways occurring in the re-condensation branch of the theory following the reactions between well-known low-molecular lignin and carbohydrate degradation products with nitrogenous nucleophiles occurring in soils under aerobic conditions.

Hypothesizing that polyphenols, such as catechol, hydroquinone, methoxy hydroquinone, respective *o*- and *p*-benzoquinones and their hydroxylated counterparts are crucially involved in the formation of humic substances under aerobic conditions, selected low molecular model compounds have been chosen to investigate their fate under aerobic conditions in the presence of protein degradation products, such as ammonia, amines, or amino acids. The reaction of polysaccharide degradation products with ammonia under aerobic conditions has been investigated as well to assess the width of the spectrum of *N*-nucleophiles that has to be considered for nitrogen accumulation in humic substances.

Materials and Methods

Different low-molecular degradation products of lignin, cellulose, and hemicellulose, such as hydroquinone, methoxyhydroquinone, *p*-benzoquinone, 2,5-dihydroxy-[1,4]benzoquinone, glucose, xylose, and the polymers itself, i.e. cellulose, xylan and various types of lignin were ammoxidized under varying conditions, partly using ^{15}N labeled aqueous ammonia hydroxide for further ^{15}N CPMAS NMR studies. Methyl amine, dimethyl amine and lysine have been also used as *N*-nucleophiles under otherwise identical conditions. Product mixtures derived from mono- and polysaccharides have been comprehensively fractionated and analyzed by GC/MS after derivatization. Some of ammoxidized polyphenols and quinones have been analyzed by X-ray photoelectron spectroscopy. The product obtained from ammoxidation of methoxy hydroquinone using ^{15}N labeled ammonia was fractionated following the established IHSS protocol. Individual humin (H), humic acid (HA), and fulvic acid (FA) fractions of this reaction have been subjected to elemental analyses, non-quantitative liquid and solid phase ^{13}C and ^{15}N NMR spectroscopy, respectively. The reactions of hydroquinone, methyl hydroquinone and *p*-benzoquinone with ammonia and dimethyl-ammonium dimethylcarbamate - a source of dimethyl amine - affording the respective (substituted) 2,5-diamino-[1,4]benzoquinones under aerobic conditions have been studied by EPR spectroscopy for both oxygen-free and oxygen-rich conditions.

Results

^{15}N CPMAS NMR and XPS spectra of ammoxidized technical lignins and of ammoxidized low-molecular polyphenolic and quinoid products of the aerobic, microbial lignin degradation using ^{15}N labeled aqueous ammonium hydroxide share many similarities, highly indicative for reaction sequences proceeding via common key intermediates. It has been demonstrated that 2,5-dihydroxy-[1,4]benzoquinone which can be surprisingly formed from both lignin and cellulose reacts with *N* nucleophiles to the respective 2,5-amino derivatives. The latter are semi-stable and react further to nitrogenous compounds of higher molecular weight. Hydroquinone and methoxy hydroquinone react even faster affording the respective 2,5-diamino-[1,4]benzoquinones. EPR experiments revealed that the reaction of hydroquinone with dimethyl amine proceed via radical intermediates. The results of this study strongly support the polyphenol theory and is hoped to contribute to a better understanding of nitrogen accumulation in soil organic matter.

O 1.2.07

Biomass residues from different classes of soil microorganisms are a significant source of soil organic matter

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Introduction and objectives. Cell envelope fragments originating from soil microorganisms were demonstrated to contribute significantly to the formation of soil organic matter (SOM) [1]. This hypothesis was supported by chemical and microscopic analyses [1] as well as by NMR spectroscopy [2]. Different genera of soil microorganisms have different chemical compositions of their cell envelopes and thus may contribute to SOM formation to a different extent. We compared the fate of *Escherichia coli* (Gram-negative bacterium), *Bacillus subtilis* (Gram-positive bacterium) and *Laccaria bicolor* (ectomycorrhizal fungus) in soil to estimate their relative contributions to SOM formation.

Material and Methods. ^{13}C-labeled organisms produced by growing them on labeled substrate were mixed with soil and incubated for 250 days. Isotopic analyses of soil and CO_2 produced allowed setting up mass balances. Additional information about the fate of the biomass C was derived from the quantitative and isotopic analysis of fatty acids and amino acids. Selected samples were also analysed by scanning electron microscopy (SEM).

Results and Discussion. For all classes of microorganisms, substantial amounts of the label remained in the soil and fragments of bacterial cell envelopes and fungal hyphae were found in all stages of decay. Fungal biomass was mineralised slower than bacterial biomass, with Gram-negative bacteria being mineralised slightly slower than Gram-positive ones. The amount and isotopic composition of the biomolecules showed that the label from the bacterial biomass was dominantly incorporated into non-living SOM. Proteins seemed to be particularly stabilised in soil: Highly labeled *B. subtilis* proteins were detected until the end of the experiment.

Conclusions. Our results thus demonstrate that biomass residues from all types of microorganisms contribute to SOM formation and that proteins are particularly prone to stabilization of carbon and nitrogen in soil. This mechanism thus will substantially contribute to stabilization of SOM and thus to soil fertility and to the ability of soils to mitigate greenhouse gas emissions.

[1] Miltner et al. (2012) Biogeochemistry 111, 41-55. [2] Simpson et al. (2007) Environ Sci Technol 41, 8070-8076.

P 1.2.01

Novel tool for simultaneous carbon and nitrogen stable isotope analyses in aqueous samples

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The quantitative and isotopic analysis of dissolved matter (e.g. dissolved organic carbon, total dissolved nitrogen, etc.) is of particular importance since this pool is a prime conduit in the cycling of N and C. Studying the two elemental pools simultaneously is of importance, as the transformation and transport processes of N and C are inextricably linked in all biologically mediated systems. Dissolved Carbon concentration and isotopic composition can now be determined routinely through coupling of high temperature combustion (HTC) systems to isotope ratio mass spectrometry (IRMS). However the analysis of δ15N of Total Dissolved Nitrogen is fraught with limitations: low concentration makes lyophilisation followed by EA/IRMS laborious and subject to contamination; wet chemical oxidation-IRMS runs the risk of incomplete conversion and cannot distinguish dissolved N2 from Total Dissolved Nitrogen. Further development of our HTC system lead to the implementation of the δ15N determination which is now coupled into a novel total organic carbon (TOC) analyzing system. An integrated, innovative purge and trap technique (peak focusing) for nitrogen with aluminosilicate adsorber and thermoelectric cooling element based system, in combination with high injection volume (up to 3 mL) significantly improves sensitivity. Down to 1ppm and less total nitrogen can be measured with precision of ≤ 0.5‰. To decrease the background caused by physically dissolved nitrogen a new, membrane-based, degasser was designed for online separation of physically dissolved nitrogen. This novel HTC system, “iso TOC cube”, provides an innovative tool with large potential in investigation of biogeochemical carbon and nitrogen cycles.

P 1.2.02

Molecular characterization of soil organic matter along a soil chronosequence in Midtre Lovénbreen foreland in Svalbard

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Glacier forelands give an opportunity to study the successional processes in the terrestrial ecosystem along the chronosequence at a time, since the ice covers of glacier have receded over the past century. The newly exposed soil gives chances for plants and microorganisms to be established, and these organisms would contribute to build up the soil organic matter (SOM) pool in this region. To investigate a shift of molecular compositions in newly input SOM along a soil chronosequence, we took the surface soil samples (0-5 cm depth) from nine sites in Midtre Lovénbreen foreland in Svalbard in 2014, representing soil ages of 3, 36, 53, 54, 57, 65, 70, 76, and 88 years (sites 1 - 9, respectively). Two sites outside the moraine (sites 10, 11) were selected as a reference site. In each site, three samples were taken randomly, and vegetation coverage was surveyed. To obtain a clear picture of newly added SOM's composition, free light fraction (FLF) organic matter (OM) was separated by density fractionation with sodium polytungstate (1.55 g cm^{-3}). The molecular composition of FLF OM has been analyzing by using pyrolysis-Gas Chromatography/Mass Spectrometry (py-GC/MS) and TMAH(tetramethylammonium hydroxide)-py-GC/MS from several pyrolysis temperature (300 ~ 800 °C). The closest site to the glacier terminus (site 1) showed low soil organic carbon content (0.110 ± 0.017%), and there was no vegetation. The other sites inside moraine except site 9 had a similar carbon concentration (0.41 - 0.96%), and were covered by black crust and vascular plants, especially for *Saxifraga oppositifolia*. Two sites outside the moraine showed a relatively high carbon concentration (> 2%). We are currently analyzing molecular characteristics of SOM from these sites. The results of this study look forward to provide better understanding of SOM formation and successional processes in a newly exposed soil and to investigate the relationships between SOM composition shift and vegetation.

P 1.2.03

Belowground carbon allocation patterns as determined by the in-growth soil core ^{13}C technique across different ecosystem types

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1. Introduction

Terrestrial plant carbon partitioning to above- and below-ground compartments can be better understood by integrating studies on biomass allocation and estimates of rhizodeposition based on the use of stable isotopes. Belowground carbon inputs are, in fact, a key component of the global carbon cycle, yet their accurate quantification remains a major challenge. Such detailed information is essential to model ecosystem metabolism and predict the effects of global change on carbon cycling.

2. Objectives

The main purpose of this study was the analysis of the carbon partitioning strategies within different ecosystems with a particular focus on belowground compartments. Using in-growth soil cores in conjunction with the ^{13}C natural abundance method we quantified net plant-derived root carbon input to the soil, which is often the main NPP (net primary productivity) component remaining unaccounted for.

3. Materials & Methods

Four different ecosystem types (forest, alpine grassland, apple orchard and vineyard) in northern Italy, characterized by C_3 vegetation with a broad range of aboveground net primary production (ANPP; 155 - 770 gC m^{-2} y^{-1}) were investigated. Cores, filled with soil of a known C_4 isotopic signature were inserted at 18 sampling points for each site and left in place for twelve months. After extraction, cores were analyzed for %C and $d^{13}C$, which were used to calculate the proportion of new plant-derived root C input ($Rhizo_{CNEW}$) by applying a mass balance equation. Moreover, the GPP (gross primary productivity) of each ecosystem was determined by the eddy covariance technique while ANPP was quantified using a repeated inventory approach.

4. Results

NPP partitioning among sites differed, with fruit production dominating at agricultural sites. At these sites, belowground C inputs were dominated by rhizodeposits, likely due to relatively high root turnover. In natural ecosystems (forest and grassland) fine root production dominated belowground net primary production (BNPP) likely due to higher root growth determined by low phosphorus availability. $Rhizo_{CNEW}$ represented a significant contribution to BNPP with values between 40 and 60%.

NPP was allocated differently above- and below-ground according to ecosystem type: 71% of the NPP was allocated belowground in the grassland, whereas NPP was equally allocated above- and below-ground in the forest. A considerable investment in belowground compartments was also evident in the vineyard (63% of NPP) whereas in the orchard higher quantities of C were invested in aboveground organs.

5. Conclusions

The applied method, combined with in-growth cores, enabled the estimation of net rhizodeposition in a range of ecosystem types under natural and managed "non-stressed" conditions. One major potential drawback of this technique is achieving the same soil properties inside the core as outside (*i.e.* in the bulk soil), which could affect root growth patterns inside the in-growth core. Overall, the C transferred belowground as rhizodeposition was a relevant fraction of BNPP ranging from 38 to 63%, leading to a substantial change in the estimated value of NPP in all ecosystems. Therefore the failure to account for rhizodeposits may lead to a significant underestimation of BNPP.

P 1.2.04

The Microbial Ecology of Soil Carbon

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Linking population biology with ecosystem science has a strong foundation in macro-ecological systems, but the connections are not yet convincing for microorganisms. Thus, the hackneyed “black box” of microbial ecology persists: ecosystem scientists ignore and collapse microbial diversity and biochemistry into a box and a few arrows. We do this because this has been and still is a useful approach on scales relevant for biogeochemistry. The population ecology of the microbial world does not yet connect strongly to quantitative biogeochemistry. Yet, there is good reason to try to make these connections, and there are promising new approaches for doing so. Here, I explore this frontier in the context of the quantitative microbial ecology of soil carbon.

P 1.2.05

Microbial communities in buried humic horizons can possess smaller size and mineralization activity than expected in volcanic soils of Hokkaido, Japan

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Introduction & objectives: Over ten thousand years, Hokkaido soils have been formed through deposition events of volcanic ash. The past surface layer has been buried in the deeper soil profile. The buried humic horizons contain the high amounts of organic matter (OM) and they serve as a large C reservoir. The microbial degradation activity can generally decrease with soil depth and OM in the deeper soil horizons is preserved, due to limitation of organic matter input. In contrast, the high amounts of OM can fuel soil microbial activity in the buried humic horizons and therefore, microbial activity is hypothesized to be high in deeper horizons of volcanic soils. To test this, we examined the microbial mineralization kinetics in the buried humic horizon using ^{14}C-tracer incubation.

Materials & methods: Soil samples were collected from the soil profiles in three forest sites and one pasture site in Hokkaido, Japan. These ''fresh'' field moist, un-sieved soils were used for mineralization kinetic studies. A ^{14}C-glucose solution (100 µL; 100 - 300000 µM) was added to 1 g of field-moist soil and incubated for 24 h at 20ºC. The $^{14}CO_2$ production was trapped in the scintillation vial containing NaOH and determined by liquid scintillation counting. The experiments were performed in triplicate. The data of mineralization kinetics were fitted to a single Michaelis-Menten equation: $V = V_{MAX}C/(K_M+C)$, where V is the mineralization rate (nmol g^{-1} h^{-1}), C is the substrate concentration (µM) in soil solution, V_{MAX} is the maximum mineralization rate (nmol g^{-1} h^{-1}), and K_M is the Michaelis constant (µM) representing the concentration at which 1/2 V_{MAX} is achieved. We also measured soil microbial biomass by chloroform fumigation extraction method, fungal/bacterial (F/B) ratio by EL-FAME method and GC-MS, fine root biomass, inorganic N concentrations (ammonium and nitrate) and the other physicochemical properties of the soil profiles.

Results & discussion: Soil organic C (SOC) concentrations ranged from 0.6% to 13.1% throughout the soil profiles, while the buried humic horizons contained 2.8 to 8.4% of SOC. Microbial biomass C amounted to 0.6 to 1.3% and 0.1 to 0.5% of SOC in surface horizons and buried humic horizons, respectively. MBC/SOC percentages in the buried humic horizons were lower than in surface horizons. Their Michaelis-Menten kinetic parameters (V_{MAX} and K_M) varied widely from 303 to 18598 nmol g^{-1} h^{-1} and 198 to 1294 µM. The kinetic parameters in the buried horizons were lower than expected from their high SOC concentrations. The both of V_{MAX} and K_M parameters were correlated positively with microbial biomass-C and -N, respectively. This indicated that microbial biomass could be a primary factor regulating the potential degradation activity in the buried humic horizons. The small microbial biomass in buried humic horizons could be supported by the low input of fresh organic substrates in the deeper soil horizons. The differences of V_{MAX} and K_M parameters between surface and buried humic horizons may be accounted for by those in microbial community structure. The F/B ratios were higher in the buried humic horizon, compared to the surface horizon. This may change the mineralization kinetic parameters in buried humic horizons due to differences of substrate use efficiency and growth speeds between fungi and bacteria.

Conclusions: Despite high SOC concentrations, microbial biomass and its mineralization activity could be reduced in buried humic horizons. Mineralization kinetics of OM in the buried humic horizon can be regulated by soil microbial biomass, which is limited by input of fresh organic matter. The reduced size and activity of soil microorganisms in the buried humic horizons suggested that OM decomposition can be stimulated by addition of easily-biodegradable OM or exposure to the surface by cultivation.

P 1.2.06

Effect of post-fermentation sludge on carbon sequestration in soil

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1. Introduction

Mitigation of global warming is a major priority in European energy and environmental politics today. The current global energy supply is mostly dependent on fossil sources, which release carbon dioxide (CO_2) into the atmosphere. The Directive of the European Parliament and Council Directive 2009/28/EC stipulates levels of renewable energy use within the European Union. Poland's 2020 target for renewable sources is 15% of gross final energy consumption. The expansion of renewable energy sources is therefore a necessity. Biogas plants offer one such climate-friendly solution, while simultaneously assisting with the important environmental problem of organic waste management.

Anaerobic digestion of organic wastes converts the substrate into biogas, which can be used as a renewable fuel, and post-fermentation sludge. The post-fermentation sludge can be used as an organic fertilizer in agriculture. It is usually rich in micro- and macro-nutrients. The exact nutrient content depends on the substrates used in bio-fermentation and the process parameters. Post-fermentation sludge contains more inorganic N, which is easily accessible to plants, than comparable composts. Soil application is therefore a common method of utilizing post-fermentation sludge, thereby generating economic and environmental benefits from the final product of anaerobic digestion.

2. Objective

The main aim of this study was to determine the effects of post-fermentation sludge on soil when applied as an organic fertiliser. Specifically, it examined the efficiency and sequence of sludge utilisation by microorganisms and its influence on the utilisation of native soil organic matter (SOM).

3. Materials and methods

To determine changes in SOM turnover after the addition of sludge, the isotopic signatures of both C sources were used. Using differences in the natural abundance of the ^{13}C isotope in the soil and in the post-fermentation sludge, we could trace the CO_2 fluxes arising from both C sources. Different ^{13}C isotopic signatures were achieved by using materials from plants with contrasting types of photosynthesis (C_3 and C_4 plants). The experiments were carried out on soil that originated solely under plants with C_3 photosynthesis, while the post-fermentation sludge was produced from plants with C_4 photosynthesis (maize).

4. Results

The addition of post-fermentation sludge increased the CO_2 emissions from the soil threefold. The amounts of total CO_2 showed the decomposition of both SOM and sludge, but did not enable evaluation of the contribution of individual C sources. The $\delta^{13}C$ signatures allowed the total CO_2 efflux to be partitioned into contributions from SOM and sludge. This revealed that post-fermentation sludge increased SOM decomposition by 13%, since more SOM-derived CO_2 was evolved than in the control. After two months of incubation in the soil, 96% of the post-fermentation sludge had been mineralized.

5. Conclusion

This study investigated the degradation of post-fermentation sludge in soil and its effect on SOM dynamics. Based on the $\delta^{13}C$ signatures of C sources (C_3 soil and C_4 post-fermentation sludge), the pathways and contribution of each source to C sequestration and turnover were estimated. Application of post-fermentation sludge accelerated SOM decomposition.

P 1.2.07

Poor Soil in Qatar and Contamination by Uranium

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The soil of Qatar is very poor on organic matter. The occurrence, source, distribution, concentration, mobility, and speciation of uranium in the soil environment depend on both natural and anthropogenic factors. Uranium is classified as “very toxic”, causing skin, lung, intestinal and bone marrow disorders, particularly where individuals have been chronically exposed by skin contact, direct ingestion or inhalation of dust (such as in mines and processing). Iraq, a near neighbor to Qatar, has received extensive (400 tonnes) depleted uranium (DU) contamination from the two wars in 1991 and 2003, and the predicted cost for remediating the 300 sites is about US$ 30 Million.

Naturally, U is released into solution by weathering of primary minerals; therefore uranium occurrence varies with climate and underlying bedrock conditions. This could explain the low contents of uranium in the topsoil of Qatar as a result of very low concentration of organic matter in the sandy and dry soil. The occurrence of uranium and other elements in several Mediterranean soils and they confirmed that soils characterized by absence or scarcity of 2:1 clay minerals are poor in uranium. This shows that the rich soil carbonate of Qatar associated with natural ranges of NU which may go up to 5 mg/Kg. The average uranium concentration in carbonate rocks is 2.2 mg/Kg due to the fact that uranium can replace calcium in the lattice of calcite or be adsorbed by the principal phosphate minerals. Four major factors may play roles on the occurrence (mobility/immobility) of uranium in soil; the soil pH, the organic matter (OM), the microbial community, the Fe and Mn oxides and the carbonate complexes. It is believed that the major role is the pH.

This presentation will review and highlight: uranium in the environment and methods of analysis, sampling of soil from >400 locations in Qatar, results of total uranium in soil and calculation of uranium ratios which may indicate the presence of depleted uranium in soil or not.

P 1.2.08

Utilisation of young and old soil carbon sources by microbial groups differ during the growing season and between experimental treatments in a long-term field experiment

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Question

In agricultural soils, management of plant residues and the use of organic fertilisers play important roles for maintaining soil organic matter. Switching from C3 plants to C4 plants such as maize, enables a natural labelling in situ; when coupled with compound specific ^{13}C isotope analysis of phospholipid fatty acids (PLFAs) it allows the proportion of new C and the proportion of old C utilised by the soil microbial community to be determined.

The hypotheses tested were i) that differences in the microbial community structure, as determined by PLFA analysis, were caused by seasonal changes rather than affected by fertiliser management, ii) that the assimilation of younger C4 material compared to older C3 material was more influenced by fertiliser management rather than by seasonal changes, including effects caused by a growing crop, and iii) that such changes could be traced to specific groups of microorganisms.

Methods

A field experiment in Sweden, amended with different mineral and organic fertilisers since 1956, was grown with C3 plants, mainly cereals until 1999. From the year 2000 silage maize was grown every year. In 2012, soil from four replicate plots of five experimental treatments, N fertilised, N fertilised amended with straw and sewage sludge, and two controls (bare fallow and cropped unfertilised) were sampled three times: before, in the middle of and after the growing season. Phospholipid fatty acids (PLFAs) were extracted from all soil samples and analysed for concentrations and ^{13}C content. A more detailed view of the fungal community composition was obtained based on high throughput sequencing of amplified ITS2 markers from extracted DNA templates.

Results

Weighted mean values of $\delta^{13}C$ in PLFAs show that the plots fertilised with only calcium nitrate had the highest $\delta^{13}C$-values in PLFAs before (-20.24 ‰) and after the vegetation period (-20.37 ‰), due to a large input of 13C-enriched plant material. However, during the vegetation period the values were much lower (-21.85 ‰). This coincided with a strong increase of the PLFA 18:2 (from 0.99 up to 2.37 nmol g dry wt soil-1), indicating utilisation of old organic matter by fungi, while mono-unsaturated PLFAs, indicating Gram-negative bacteria, were more frequent before and after the growing season. Preliminary results from high throughput sequencing show diverging fungal communities in treatments with organic matter input (amended with sewage sludge or straw), whereas sampling time had little influence. Microbial dynamics in the unfertilised control followed the same seasonal pattern but PLFAs were less enriched in ^{13}C due to lower yields compared with the N-fertilised treatment. The addition of organic amendments (straw or sewage sludge) lowered $\delta^{3}C$-values in PLFAs below values of the control due to input of labile material with C3-origin. PLFAs in the bare fallow treatment, that had not received plant carbon inputs during twelve years, were most ^{13}C depleted among the treatments but still enriched by about 2‰ compared with SOM, indicating a degree of microbial fractionation.

Conclusions

In this study, the microbial community composition was more influenced by the fertiliser regime than by seasonal changes. Important exceptions were found, as the PLFAs 16:1ω7c and 18:2ω6,9 were more affected by sampling date than by treatment. Even considering the high variation among $\delta^{13}C$ values in PLFAs, some trends could be discerned, such as young C4 material being mainly assimilated by microbes before and after the growing season in the treatments without addition of C3 organic matter. This suggests an effect of plant growth, both in the unfertilised control and calcium nitrate treatments.

The utilisation of old SOC during the growing season could be attributed to fungi, as indicated by increase in the biomarker 18:2ω6,9 during the vegetation growth period, while at the same time becoming more deplete in ^{13}C. A shift in metabolism occurred after harvest, when C3-derived material was replaced by fresh C4 carbon from decaying roots, although the microbial community composition did not change greatly at this time. This was most evident for mono-unsaturated PLFAs in the calcium nitrate treatment, indicating assimilation of C4 carbon by Gram-negative bacteria.

The effect caused by 13 years of maize cultivation on the microbial pool, measured as total PLFAs, was estimated to have resulted in C4 derived C supplying 10% to 33% of total C. However, the observed 'rebound' effect of $\delta^{13}C$ during the vegetation growth period indicates that the turn-over of both microbial biomass C and SOM can be a lot more dynamic than suggested from pool values alone.

P 1.2.09

The effect of organic and mineral fertilizers "Supergumus" on the content of the soil in irrigated mobile forms of nitrogen

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The natural nitrogen cycle involves the formation, transport and accumulation of nitrates in the various components of the biosphere. The value of prevention of accumulation of nitrate nitrogen in the prevention of possible nitrate leaching from the vadose zone is particularly increasing in the application of nitrogen fertilizer. The accumulation of nitrates in the aeration zone reaches its maximum value when using high doses of nitrogen fertilizers, which takes place in our country in the cultivation of cotton and other major crops.

The aim of our study was to investigate the influence we have created organo-mineral fertilizer "Supergumus" (1) on the dynamics of the content of mobile forms of nitrogen in the soil.

Subjects and Methods. The studies were conducted in Zangiota district of Tashkent region. The study area belongs Tashkent-Pskent area irrigated typical gray soils Angren-Chirchik District.

Driving field experience included the following options: Control - lysimeter norm making N200P140K100 - background, lysimeter with the norm of making 5 t / ha "Supergumusa" in the background, with the norm lysimeter making 10 tons / ha "Supergumusa" in the background, making lysimeter norm 15 t / ha "Supergumusa" in the background. Lysimeter experiments were conducted in four replications.

Results: The results showed that the introduction of "Supergumusa" on the background N200P140K100 has a significant impact on the transformation of nitrogen compounds in the gray-oasis soils. In making "Supergumusa" in rates of 10 and 15 t / ha of ammoniacal nitrogen content in the soil is significantly increased compared to controls in all stages of definition. For example, in the arable layer of options with the introduction of "Supergumusa" in the rules 10 and 15 t / ha of ammonia nitrogen content in the 3rd quarter 2008 was, respectively, 15.7 and 20.0 mg kg in Q4 and 11.7 13.2 mg kg in Q1 2009 to 10.2 and 12.0 mg kg against 6,3-7,1 mg kg on the control. This situation appears to be due to the strengthening of the biological processes of fixing nitrogen in the soil by microorganisms and its subsequent ammonification and ammonia and latching soil minerals in making "Supergumusa" that eventually led Washed reduce nitrification of nitrogen in the soil conservation in fixed form.

The natural nitrogen cycle, which has a global nature, including education, transport and accumulation of nitrates in the various components of the biosphere. The value of prevention of accumulation of nitrate nitrogen in predot¬vraschenii potential nitrate leaching from the vadose zone is particularly increasing in the application of nitrogen fertilizer. The accumulation of nitrates in the aeration zone reaches its maximum value when using high doses of nitrogen fertilizers, which takes place in our country in the cultivation of cotton and other major crops.

So, when making "Supergumusa" in the rules 10 and 15 t / ha the nitrate content in the topsoil in Q3 2008 were, respectively, 25.7 and 24.3 mg kg against 28.9 mg kg Control . The same pattern was observed in the remaining terms of the determination of nitrate in the soil. This tendency reduce the nitrate content in the soil in the 4th quarter 2008 1st quarter 2009, which is obviously the result of assimilation by plants during the growing season, nitrate leaching and denitrification processes.

The content of nitrates in the soil with the depth gradually decreases and they are found in all layers of the studied strata of soil at all the options. Nitrate content at a depth of 280-300 cmbeginning of the experiment varied between 4,7-9,0 mg kg. After application of mineral fertilizers and "Supergumusa" in Q3 2008 at a depth of 280-300 cmin versions with standard 10 and 15 t ha nitrate content were, respectively, 7.9 and 5.5 mg kg against 14.0 mg kg on the control, indicating that the decrease in nitrate leaching in making "Supergumusa." At the same time the lowest nitrate content (2,4-3,7 mg kg) were observed in the 1st quarter of 2009 variants, where he was introduced "Environmental Shield." During the same periods determining the nitrate content in control, at the same depth it was, respectively, 13.6 and 14.0 mg kg, which is considerably more than the variants with the introduction of "Supergumusa." Thus, the use of "Supergumusa" an effective concentration me¬hanizmom remove excess nitrates in the aeration zone and the accumulation of nitrogen in ammonium and organic form.

P 1.2.10

Characterization of ^{13}C and ^{15}N Enriched and Biochemically Fractioned Eucalyptus Plants by Termochemolysis Using Tetramethylammonium Hidroxyde (TMAH)

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Introduction

Soil organic matter (SOM) collectively refers to a complex mixture of organic compounds derived from plant residues and microbial biomass organic. (SOM) is directly related to soil quality and sustainability of long term production systems (Mendham et al., 2004). This is not different in brazilian planted forests where the characteristic that best relates to eucalyptus productivity is its SOM content (Menezes, 2005). Litter chemical composition differs among tissue types which in turn affects the SOM decomposition pattern and quality.

Objective

The aim of the present study was to evaluate the enrichment and uniformity of ^{13}C and ^{15}N labeling in eucalyptus plant parts (bark, leaves, twigs, wood and roots) and characterize biochemical fractions (extractives soluble in water, extractives soluble in organic solvent, lignin and holocellulose) by thermochemolysis -GC/MS using TMAH.

Materials and Methods

The experiment was a completely randomized blocks design with 3 replicates, with each block having nine containers with two plants each. The labeling with ^{13}C and ^{15}N was executed on 2 month old *Eucalyptus grandis X Eucalyptus urophylla* clones, which were grown to 60 days. At the end of labeling period, the plants were cut and divided into bark, leaves, twigs, wood and roots. Each plant component was grounded and analyzed by IRMS (*Isotope-ratio mass spectrometry)*. The water and organic solvent soluble extraction were done in sequence in flat-bottomed flask under reflux for 4 hours in Soxhlet, using acetone as organic solvent. The holocellulose extraction was done according to Kurschner & Hoffer (1979) and the lignin extraction according to Tappi (1969). Subsequently the fractions were analyzed by IRMS. An off-line thermochemolysis using TMAH and analyzed by GC-MS was conducted in all the samples. Gas chromatographic analyses on a GC-MS equipped with a 15-m fused silica capillary column (DB-5MS: 30 m; 0,25 mm DI; 0,25 µm); furnace temperature: 60°C with na increase rate of15ºC/min until 300 ºC stabilizing for 5 min; injector temperature 300 ºC; detector temperature 290 ºC; splitless injection mode and injected volume of 1 µL. Totalizing a run time of 48,5 minutes. The peaks were identified using the NIST 11 library and standards.

Results

No statistical difference was found on the ^{13}C enrichment of the plant parts, which attained values from 319 to 397% for ^{13}C and the ^{15}N was above the detection limit of the IRMS. The biochemical fractioning accomplished a mean recovery rate of 37.89%. The root biochemical fractions showed no statistical significant difference regarding ^{13}C enrichment. The leaves and bark presented statistically higher ^{13}C enrichment in the organic solvent extractable and in the hollocelulose fractions. The twig and wood presented higher enrichment values in the lignin and hollocelulose fractions. The GC-MS analysis of the termochemolysis of the lignin fraction of all the part plants, showed consistent results with different proportions of monomethoxyphenyl, dimethoxyphenyl, and trimethoxyphenyl analogs in samples. The water extractable and hollocelulose fraction showed the least peaks of all, this may be due the thermosensibility of its components (essentially sugars). The organic extractable fraction presented several FAME derivatives, lignin, protein and cutin monomers, presenting itself as a more heterogeneous fraction.

Conclusions

The ^{13}C enrichment between the plant parts proved to be homogeneous, although differences between biochemical fractions were observed. Thermochemolysis appears an interesting tool to characterize the biochemical fractions. Moreover, the comparison of the lignin fraction shows different ratios of its components in the different plant parts. The organic solvent extractable fraction proved to be a more heterogeneous fraction. The water extractable and holocelullose fractions may have been affected by the instability of its components in higher temperatures.

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P 1.2.11

Towards linking fungal genes to chemical spectra from soil organic matter using machine learning

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1. Introduction

Characterization of biological and chemical processes in soil organic matter (SOM) are increasingly being done by complementary high-throughput experimental techniques. Interpreting these diverse high-dimensional data types together poses challenges about data integration and analysis. A bioinformatics merge of machine learning and chemometrics may be a promising avenue to fully explore links between biological and chemical processes. We make here a proposal and demonstrate proof of concept for integrating genome-wide transcriptomic data (RNA-Seq) with chemical spectra (FT-IR, Pyrolysis-GC/MS).

2. Objectives

We aimed to propose computational methods for linking genes to decomposition mechanisms by integrating genome-wide transcription profiling data (RNA-Seq) with chemical changes in the organic compounds occuring during SOM decomposition as measured by chemical spectra (FT-IR, pyrolysis-GC/MS). The methods are intended to enable extraction of patterns that can be recognized and interpreted by domain experts. We also wanted to show proof of concept of integration of genome-wide gene expression data with chemical spectra from a study of two fungal species in a SOM decomposition time series under gradual glucose depletion.

3. Materials & methods

A controlled experiment was set up to measure effects of decreasing glucose levels over time on the decomposition of SOM. Two ectomycorrhizal fungi with distinct growth rates (Paxillus involutus and Laccaria bicolor) were grown on SOM water extracts under axenic conditions in a time series experiment. To trigger the fungal decomposition activity, the extracts were initially supplemented with glucose. Four time points were selected such that the glucose was almost depleted between the 2nd and 3rd time point. Sampling points were chosen for each species based on matching glucose levels to define a common time reference scale of the two fungal growth experiments during the time course. The mycelia was collected for transcriptome profiling using RNA-Seq, while the SOM extracts were analysed by means of FT-IR spectroscopy and Pyrolysis-GC/MS at these four species-specific time points. Species-specific co-expression networks were constructed from pairwise correlations between gene transcriptions across the time points. Genes of similar functions between fungi were identified from orthology detection using the ProteinOrtho software program. Spectral associations akin to chemometric 2D synchronous correlation analysis were computed and correlated with gene transcriptions to create gene-spectral association networks. The OrthoClust software for discovery of conserved as well as species-specific modules of co-expressed genes was modified to include correlated spectral patterns thus enabling characterization of the glucose starvation responses in terms of modules of genes and associated spectral ranges.

4. Results

We propose some computational approaches for integrating biological and chemical data types of genome-wide transcriptional RNA-Seq data and chemical spectra. As proof of concept we demonstrate the use of a clustering method on a time series experiment. [Anticipated:] Modules of genes with similar expression profiles across time points were found and linked to certain spectral ranges of the FT-IR chemical spectra as well as certain compounds found with pyrolysis. Our current work involves more complex statistical modelling of several high-dimensional data types using tailored variants of sparse factor analysis to discover interpretative correlation patterns of SOM decomposition mechanisms. The dataset consist of RNA-Seq and chemical spectra from 10 fungal species in controlled experiments comparing growth medium and SOM extracts. Some of the challenges involve cross-species normalisation of RNA-Seq, orthology mapping for functional comparison and identification in the statistical model.

However, these statistical methods require large data sets for detailed inference about molecular mechanisms from modern high-throughput data and collaborative efforts are encouraged to reach critical data mass.

5. Conclusion

We have demonstrated a[n anticipated] powerful application of machine learning clustering tools for integration of transcriptomics and chemical spectra to leverage interpretation of data from controlled fungal SOM experiments.

P 1.2.12

Vertical δ^{13}C and δ^{15}N changes during pedogenesis and succession across a temperate rainforest dune chronosequence

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The natural abundance of stable carbon and nitrogen isotope signatures in soil organic matter are subject to vertical changes from litter to mineral soil, which provides important information on element dynamics. Trends in δ^{13}C and δ^{15}N and their interrelations have rarely been related to temporal changes during pedogenesis and ecosystem development.

We sampled 55 soil cores across the fordune progradation Haast-chronosequence in New Zealand, covering a time span of soil and ecosystem development from 120 to 2870 years. Vertical changes of δ^{13}C and δ^{15}N values were investigated in the litter, the organic layers and in one-cm depth intervals of the upper 10 cm in mineral soil.

Isotopic data of C and N pools revealed relationships between nutrient dynamics, N_2 fixation, mycorrhizal fractionation and plant physiological responses. Increasing organic layer thickness coincided with low decomposition as shown by δ^{13}C depth profiles. The interrelation and concurrence of microbial transformation and C and N transfer through mycorrhizal fungi, together with C and N accumulation in the organic layer and leaching impeded the approximation of isotopic fractionation and decomposition but accounted for exaggerated gradients between litter and mineral soil δ^{13}C and δ^{15}N values. We could illustrate the separation of aboveground input from pools in soil at old stages.

With our investigations we provide insights into responds of plant-root-soil-systems under environmental stress within a temperate rainforest dune chronosequence, challenge the existence of a decomposition continuum and exclude the use of a fractionation factor at the proceeding absence of major ecosystem disturbances.

P 1.2.13

Stable isotope techniques: Recent developments in tracing changes in C and N cycling and biodiversity

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Stable isotopes like 13C and 15N have been used in ecology for decades in tracer studies of plant materials in organic environments like natural soils. They are used to study distribution of recently added organic matter over POM and SOM fractions, fluxes of C and N between soil organic matter pools, or to unravel biodiversity and food web issues in complex soil ecosystems.

IsoLife produces uniformly labelled plant materials (single-labelled with 13C or double-labelled with 13C+15N) since 2005. Labelling services using 13CO2 in an atmosphere with an extreme high 13C abundance (>97 atom %) during months have been concurrently provided. Both opened up new ways in studying decomposition of plant materials, trophic interactions, and functional relationships in complex soil ecosystems. Moreover, their application also improved the sensitivity of analytical techniques.

Recent developments in soil ecology

i) Decomposition studies have been carried out with uniformly 13C-labelled plant parts (whole leaves or roots; intact or ground) or extracted plant materials like lignin or (hemi-)cellulose yielding detailed information about fractions respired, distribution among soil organic matter fractions, and organic matter transformation. Moreover, knowledge was acquired about which organisms played a role in decomposition processes by using SIP.

ii) Stable Isotope Probing (SIP) enables the detection of functional organisms in complex ecosystems at species level using U-13C substrates and density gradient centrifugation to separate 12C- from 13C-DNA or -RNA. Subsequent sequencing of the 13C-bands reveals the active, functional species. This technique yields valuable information especially in complex soil ecosystems with high background 12C. Trophic interactions in food webs, biodiversity issues, and carbon flows in symbiotic associations can be studied with a renewed focus.

iii) Methods for studying *in situ* ecological relations, enable tracing C and nutrient transfer between hosts and symbiotic organisms. These can be measured using continuous 13C-labelling at extreme enrichment levels (>97 atom %) or visualised by direct imaging using microscopy techniques such as high resolution imaging mass spectrometry (NanoSIMS).

iv) Atmospheric labelling with 15N2 enabling measurement of N2 fixation in m3 volumes.

The poster shows an overview of the achievements during the last 5 years of using uniformly 13C-labelling and uniformly 13C-labelled substrates.

IT 1.3

Critical unknowns for unraveling molecular and bulk soil organic carbon turnover times

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Large uncertainties remain in estimating bulk and molecular soil organic carbon (SOC) turnover. This is due to inadequate parameterization of temperature sensitivity, microbial carbon use efficiency and mineral surface interactions for SOC protection. This presentation we will focus on isotopic tools to assess turnover of SOC at the molecular level as well as on the relative role of climatic versus geochemical factors controlling SOC storage.

First, we will present data following experimental approaches to determine mean residence time of i) amino sugars upon *in situ* ^{13}C labeling and ^{13}C analyses with liquid chromatography - isotope ratio mass spectrometry (LC-IRMS), and ii) biochar via ^{13}C labeled feedstock and ^{13}C analyses in respired CO_2 via infrared laser spectroscopy. Second, we will also present data on a ^{13}C amino sugar method to quantify microbial carbon use efficiency. Third, we will present data on the role of geochemistry for SOC storage using an extensive North to South transect across Chile and the Antarctic Peninsula. Herein we also illustrate the use of Nanoscale secondary ion mass spectrometry (NanoSIMS) to visualize the spatial differences in the binding mechanisms of newly added and old C to soil minerals in two geochemically distinct soils.

O 1.3.01

Fungal and bacterial residues and their relationships to the C/N/P/S ratio of soil organic matter and microbial biomass

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The interrelations between total N, organic P, and organic S for the accumulation of soil organic C (SOC) and the contribution of fungal and bacterial residues to SOC were investigated in the current study. The soils had been developed under humid temperate, arid sub-tropical, and tropical climatic conditions and were used as arable, grass, and forest land. They covered a wide range in soil pH, in salinity as well as in the contents of clay and SOC. The basic data of the soils, i.e. pH, texture, contents of SOC, total N, total P, total S, microbial biomass C, microbial biomass N, and ergosterol were taken from recently published papers in most cases. The soils were re-analysed for organic P, organic S, and amino sugars in the current study. The mean SOC/total N ratio and the mean SOC/organic P ratio varied around weighted means of 11.3 and 90, respectively, in the arable, saline arable, and grassland soils. The mean of these two ratios was roughly twice that in the forest soils. The SOC/organic S ratio was generally more variable, especially in saline soils. The ratio of fungal ergosterol to microbial biomass C varied between 0.05 and 1.97% and that of fungal C to bacterial C, based on fungal glucosamine and bacterial muramic acid, ranged from 0.3 to 11.3. Both ratios increased in the order saline arable soils < arable < grassland < forest soils and were significantly correlated. Microbial residue C contributed nearly 50% to SOC in arable and grassland soils and roughly 25% in saline arable and forest soils.

O 1.3.02

Linkage of bacteria-fungi succession with the stabilization of microbial residues in soil

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There is increasing concern about the sustainability of agroecosystems, especially for the degraded arable soil. The only way for sustain soil quality is balancing the loss of soil organic matter (SOM) by returning crop residues, which is transformed and become SOM eventually. In addition, the immobilization of residue fertilizer nitrogen (N) is very important for reducing the environmental risk of fertilizer N loss. However, how different soil microorganisms contribute the transformation of both plant residue and fertilizer N and how the substrate-derived SOM is stabilized is not clear. The linkage of long term microbial function with extraneous carbon (C) and/or N transformation and stabilization might merely be explicit by probing into the time-integrated response and acclimation of soil microorganisms to substrate supply. Differentiating between the newly synthesized and the inherent portions of microbial residue biomarker such as amino sugars, by C and N isotope tracing techniques, can provide an integrated view of long-term microbial dynamics, as opposed to live biomass. Hence, the response of different microbial populations to C and N supply was investigated based on the dynamics of glucosamine (GluN) and muramic acid (MurN). Here, we firstly undertook laboratory incubation with a silt loam soil amended with C and N isotope labeled substrates. A multi-year field experiment was then conducted in a temperate agroecosystem using ^{15}N-labeled fertilizer and maize stalk with separately. The ^{13}C and ^{15}N enrichment in the target amino sugar was identified by gas chromatography/mass spectrometry and those in soil was measured by elemental analyzer-isotope ratio mass spectrometer. In the incubation microcosms, the dynamic transformations of extraneous C and N into amino sugars were compound-specific, indicating different contributions of heterogeneous microbial residues over time. The extraneous C and N were preferentially utilized by bacteria firstly but then dominantly converted by fungus population and stabilized in fungal products in succession. In the field experiment, the microbial transformation of maize stalk depends on carbon availability, especially for the initially formation of bacterial residue, while the immobilization of maize stalk N was dominantly attributed to fungus-functioned decomposition of recalcitrant components with less extent passing through mineralization. The carbon-controlled substrate utilization induced a shift from a bacterial to fungal dominant community and the similar succession dynamics of fertilizer and maize stalk N related microbial populations.

There was no preferential utilization of inorganic N over stalk N into amino sugars during both the incubation course and the field tracing experiment. On the contrary, the microbial utilization efficiency of maize stalk N was remarkably higher than fertilizer in the field except for the first-year decomposition. The effective maintenance of maize stalk N in soil may be an important mechanism for soil N accumulation and replenishment in conservation tillage systems.

O 1.3.03

Assimilation and accumulation of C by fungi and bacteria attached to soil density fractions

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Introduction. While soil microorganisms play a key role in soil organic matter (SOM) dynamics -promoting SOM degradation and accumulation-, little is known about the controls affecting the distribution of microbial biomass and their residues in soil.

Objectives. This study aims at capturing the distribution of newly-produced fungal and bacterial biomasses derived from the added substrates and firmly attached to soil density fractions. Specifically, we used glycine to inform where the microbial activity is preferentially located; and beech leaves to inform on naturally occurring microbial processes of plant litter degradation.

Materials & methods. A forested Cambisol topsoil was incubated in the lab with ^{13}C-labeled glycine or finely ground beech leaves for 92 days prior to sequential density fractionation. The incorporation of the ^{13}C label in amino sugars (AS) was used to gain insight into bacterial and fungal assimilation of the added substrates, and determined by liquid chromatography coupled with isotope ratio mass spectrometry.

Results. Bacteria slightly dominated leaf C assimilation, while a pronounced fungal dominance was observed for glycine.

Original and glycine-derived AS were similarly distributed among soil density fractions (Fig. 1), both peaking in the microbial aggregate fraction (1.8-2.4 g cm^{-3}). This suggests that the microbial activity is preferentially located in the microbial aggregate fraction. Leaf-derived AS was mostly found in association with the free plant debris (-3), where most of the leaf-derived C is found (Fig. 1). The comparison of the distributions of the glycine and leaf-derived AS suggests that the microbial C is mostly produced where the resource is located.

The ratios of substrate-derived AS-C to substrate-derived C increased with soil fraction density for both glycine and leaves (Fig. 2). The same pattern was observed with original AS-C to soil fraction C ratios (Fig. 2). This suggests a greater contribution of microbial C residues to the mineral-attached C of the microbial aggregate fraction (1.85-2.4 g cm^{-3}) and, mostly, of the mineral grain fraction (2.4-2.65 g cm^{-3}).

Conclusion. We concluded that bacteria and fungi were most active where the resource was even though their residues accumulate mostly in microbial aggregates (1.8-2.4 g cm^{-3}). We suggest that such accumulation might be attributed to (1) an increasing stabilization efficiency of microbial residues and (2) the progressive SOM transfer, from plant debris to microbial aggregates (1.8-2.4 g cm^{-3}).

Figure 1. Mass distribution of original amino sugars (AS) and AS derived from glycine or beech leaf fragments among soil density fractions (n=2). Dark bars represent the recovered leaf $AS_{S,92d}$. Grey bars represent the recovered glycine $AS_{S,7d}$ (left) and glycine $AS_{S,92d}$ (right). White bars show the recovered AS-C. Symbols show the distribution among soil density fractions of the total C (dark triangles), the residual leaf-derived C recovered after 92 days (white dots) and the residual glycine-derived C recovered after 7 days (white squares) and 92 days (dark squares).

Figure 2. Estimated contributions of bacterial and fungal C residues to residual substrate C ($C_{S,t}$) among soil density fractions (n=2). The bacterial and fungal C contributions are expressed as percent of fraction $C_{S,t}$ (lower panel) and relatively as fungal C to bacterial C ratios (upper panel). Errors bars represent the 95% confidence limits for the conversion of the substrate-derived muramic acid into bacterial (without pattern) biomass or fungal glucosamine into fungal (with pattern) biomasses.

Figure 1

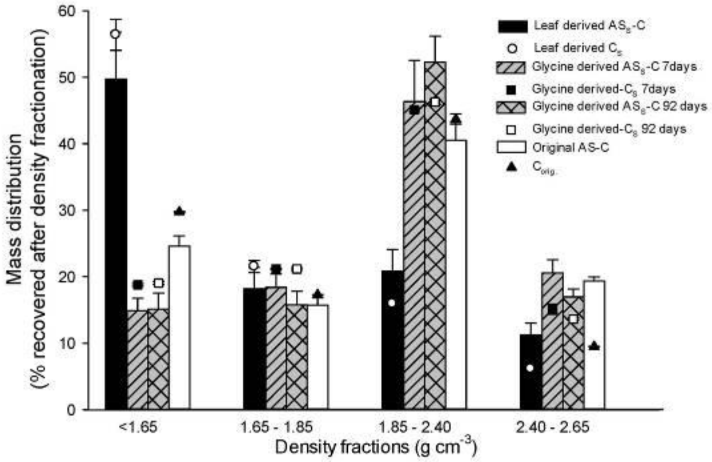
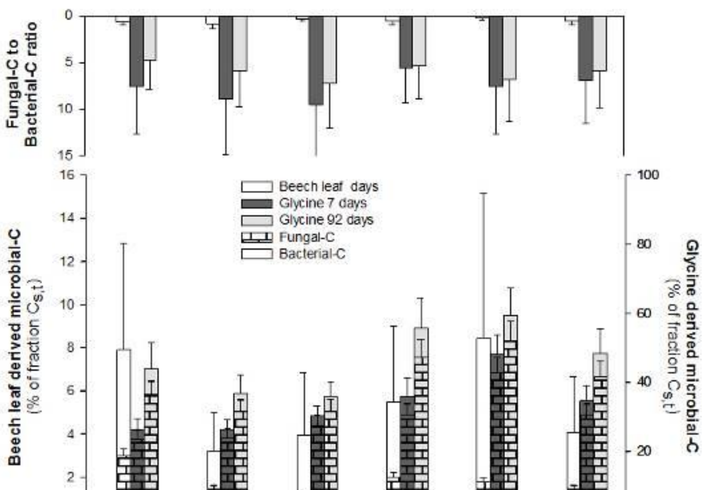


Figure 2



O 1.3.04

Use of lipid biomarkers to trace the source of soil organic carbon in afforested soils across Europe

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Afforestation projects have been developed to mitigate climate change by increasing carbon (C) stored as biomass and as soil organic carbon (SOC). Whereas C stored as biomass visibly increased after afforestation, changes in SOC stocks were rather variable among different studies. Therefore, we need more information about the amount SOC that is derived from planted forests in comparison to SOC originating from previous land use in order to answer to the question: Can we separate potential sources of SOC to determine the effect of afforestation on SOC sequestration?

Method: Biomarkers are considered as a useful approach to trace the source of SOC. They are organic compound with a defined structure indicative of its producer, e.g. different plant species and tissues. In our study we used n-alkanes and base hydrolysis products derived from cutin and suberin monomers to trace the source of SOC in afforested soils. Suberin-derived compounds are supposed to be indicative for roots whereas cutin-derived compounds are indicative for leaves. Biomarker distributions were studied in soil samples of coniferous and deciduous forests, which were compared with control samples of cropland and grassland soils across six different sites in Europe.

Results: Using a principal component analysis it was possible to distinguish between the two forest types and between litter and root samples, based on specific types of alcanoic acids, alcohols and n-alkanes. With ratios of cutin- and suberin-derived compounds it was possible to separate possible sources of SOC (e.g. leaf litter, roots, O-horizon, mineral soil). These ratios indicated a higher contribution of roots to SOC compared to leaves. Using cutin-derived parameters we were able to distinguish leaves and roots and the two forest types. Soil samples were more difficult to differentiate.

Conclusions: We can conclude that our biomarker approach was partly successful to separate potential sources of SOC. We only found minor traces of forest-derived SOC after afforestation. That might indicate weak afforestation effects on SOC sequestration or transformations of biomarkers after entering the mineral soil.

O 1.3.05

Sediment source attribution from the soil to the river with CSIA of long-chain fatty acids

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Sediments are listed among the top ten causes of biological impairment in freshwater ecosystems. Several sediment fingerprinting approaches and sediment source attribution were established using techniques based (1) on the natural carbon isotopic difference between C3 and C4 plants and the resulting significant difference in the bulk $\delta^{13}C$ signal of the soils and/or (2) on the involvement of multi-element tracer approaches reflecting the lithological differences within the studied catchment. However, the successful application of these techniques requests a special setting in the investigated catchment, either different plant species (i.e. C3 compared to C4), and/or a significant shifts in the lithology within the catchment. Another tracing technique is to use the stable carbon isotope composition of specific fatty acids (FA). Plant wax biomarkers like long-chain fatty acids (FA) and their carbon isotopic composition can serve as a tool to answer the question of sediment origin and distribution. We present results of sediment source contribution to a lowland river located in Central Switzerland using compound specific stable isotopes (CSSI) of saturated long-chain FAs within land use systems of C3 vegetation only. The use of significantly different CSSI FA signatures from different source areas (i.e. forest and agricultural land), allowed us to find unique solutions for our distribution equations without the use of mixing models. Compared to previous existing studies, we were able to reduce uncertainty by adapting data evaluation and interpretation. Results showed unambiguously that during base flow agricultural land contributed up to 65% of the suspended sediments, while forest was the dominant sediment source during high flow, which indicates that during base and high flow conditions connectivity of sediment source areas with the river change. Our findings are the first results highlighting significant differences in CSSI signature and quantification of sediment sources from land uses dominated by C3 plant cultivation.

O 1.3.06

Microbial energetics in terrestrial ecosystems: A new approach for evaluating microbial metabolism in soils

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Introduction

Soil microorganisms and their activity play a central role in nutrient cycling and soil fertility, but the importance of microbial diversity in ecosystem functioning is still debated. Based on basal and substrate-induced respiration approaches, there is a general consensus that the diversity of microbial metabolic processes is poorly related to overall soil function such as e.g. soil fertility. This is due to the inherent functional redundancy that exists within many microbial communities. We recently devised a novel thermodynamically based approach for gaining improved comprehension of microbial community function using microbial energetics in terrestrial ecosystems [1; 2]. Pertinent to this, the nominal oxidation state of carbon (NOSC) has been proposed as a universal metric of the availability of energy in organic substrate for microbial metabolism [3; 4]. By taking an energetic view of soil microbial metabolism, we may improve our understanding of the significance of microbial biodiversity on ecosystem functioning such as e.g. impacts of land use managements on soil fertility.

Objectives

We will present our recent findings illustrating the capacity of a microbial energetics approach, using the latest technology available in isothermal calorimetry, to improve our fundamental understanding of soil microbial metabolism. The emphasis will be on (i) data interpretation of energetically based indicators and (ii) practical considerations for using isothermal calorimetry in combination with other methods.

Materials & Methods

Functional diversity profiling, i.e. multiple-substrate induced respiration (MicroResp™) and microbial energetics (TAM Air isothermal calorimetry, TA Instruments Sollentuna, Sweden) and phenotypic profiling of the microbial communities (phospholipid fatty acid approach) in combination with stable isotope chemistry were applied in a wide range of terrestrial ecosystems (boreal, temperate and tropic ecosystems including cultivated, grassland to forest management systems). Thermodynamic efficiency indices, calorespirometric ratios and NOSC were devised as energetically based indicators to evaluate microbial metabolism/community composition in relation to soil function.

Results

Using isothermal calorimetry, we show that direct measures of microbial energetics provide a functional link between energy flows and the composition of below-ground microbial communities. In contrast this link was not apparent when CO_2 was used as an aggregate measure of microbial metabolism [1]. These findings provide an indication that microbial communities may not be functionally redundant with respect to carbon cycling as hitherto thought. Under aerobic conditions, thermodynamic efficiency indices and calorespirometric ratios can be used to evaluate microbial carbon use efficiencies. Furthermore, the calorespirometric ratio can also be used as a coarse indicator of switches in microbial metabolism during the transition from aerobic to anaerobic conditions [2]. Microbial communities with low diversity, e.g. from long-term bare fallow soils, tend to have reduced catabolic diversity and were more adapted to use substrates with positive NOSC, i.e. highly oxidized substrates, relative to substrates used by microorganisms from their cultivated counterparts with higher microbial diversity [3]. Also, along a successional forest gradient, communities residing in mineral horizons preferentially used substrate with positive NOSC relative to carbon utilization by microorganisms from the organic horizons. These results support the use of NOSC as an indicator for microbial resource availability.

Conclusions

Our work suggests that a microbial energetics approach provides complementary information to soil respiration for investigating the involvement of microbial communities in below-ground processes: In a broader perspective, the microbial energetics approach has the potential to provide further information when employing ecological theory in microbial ecology to better understand soil systems. In particular, it provides new insights into the relation between biodiversity and changes in land use management systems and key ecosystem functioning such as carbon sequestration and soil fertility.

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P 1.3.01

Effect of Organic and Inorganic Fertilizers on the Growth and Yield of Physic Nut (Jatropha curcas).

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The research was conducted in 2011 cropping season at the Teaching and Research farm of the Faculty of Agriculture and Natural Resources Management, Enugu State University of Science and Technology, Enugu, Nigeria to study the effect of organic and inorganic fertilizers on the growth and yield of physic Nut (*Jatropha curcas*). There were five treatments namely, control, (no application of treatment), NPK 20:10:10, NPK 15:15;15, poultry droppings and goat dung. The treatments were laid out in a Randomized complete Block Design (RCBD) with five replications. The total land area used was 228m^2 (19x12m) while the plot size was 3mx2 (6m^2). The growth parameters measured were plant height, number of leaves, and leaf area, index (LAI).

The results obtained showed that there were significant differences at P=0.05 among the different treatments in 30, to and 90 DAP.

Based on the results T4 (poultry droppings) had higher effect at P=0.05 at 30, 60, 90 DAP than the other treatments when compared and is hereby recommended as the best type of fertilizer for the optimum growth and production of physic Nut (Jatropha Curcas) in South Eastern Nigeria.

Keywords: organic, Inorganic fertilizers, growth, yield, *Jatropha curcas*.

P 1.3.02

The Effect of sewage sledge and their bio-char as mulch and top-soil incorporated on some soil attributes, lead adsorption and desorption Isotherms potassium uptake and plant growth in a loss soil with high specific surface area in a temperate climate

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Bio char (BC) application as a soil amendment has aroused much interest and was found to considerably improve soil nutrient status and crop yields on poor soils. However, information on the effect of BC on temperate soils is still insufficient. The primary objective in this study was to investigate the effect of pyrolysis temperature on the structure (e.g., surface functional groups and surface areas) of biochar and to assess the influence of biochar on the soil quality and plant production. The result may also provide a reference for the use of biochars as a solution in agricultural waste management and as a soil amendment to reduce the environmental risk of agrochemicals We investigated the effects of BC on soil nutrient, crop yield, and quality in a greenhouse pot experiment. We compared BCs of two different temperature (400°C and 650°C The BCs were applied at two rates (1% and 3%, which would correspond to 30 and 90 t ha-1 in the field). Soybean was grown successively within one year. The investigated soil properties included pH, electrical conductivity (EC), cation-exchange capacity (CEC), calcium- acetate-lactate (CAL)-extractable P (PCAL) and K (KCAL), C, N, and nitrogen-supplying potential (NSP). The results show pH and CEC increase in all soils. The C : N ratio increased at 3% application rate. Improving the soil nutrient status partly, yield of the crop was significantly increase through BC application (by up to 68% in 400°C) Despite improving the soil nutrient status partly, yields of the crop was not affected(in 650°C). Only the BC (in 400°C) in the range of the control and even increased soybean yield by 6%. The initial yield reduction was accompanied by notable decreases (Cu, Fe, Mn, Zn) and increases (Mo) in micronutrient concentrations of plant tissues while nitrogen concentrations were hardly affected. The results of the pot experiment show that despite additional mineral fertilization, short-term growth inhibition may occur when applying BC without further treatment to temperate soils.

P 1.3.03

Bioremoval of an azo textile dye, Reactive Red 198, by *Rhizopus oryzae*

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Among all environmental contaminations, industrial dye is one of the major pollutants of soil, water and air. There are different chemical, physical and biological methods to remove all types of synthetic medium. One of the common biological methods is to utilize the microorganisms like yeast, fungi or bacteria. In this study, we tried to identify a soil-derived microorganism and evaluate its efficacy on self-removal of industrial dye. Firstly, the strain of isolated fungus from various bulks of used oil was defined via colonial identification and DNA sequencing. Secondly, bioremoval activity of defined fungus (*R. oryzae*) was evaluated using High-performance liquid chromatography (HPLC). The optimum conditions in biological elimination of oil including the incubation time, pH level of culture and amount of reagents were determined. In the best condition, a removal rate of 96.0% was obtained.

P 1.3.04

Effect of Water Extractable Organic Matter from Composted Manure and Diluted Humic Substances on Phosphorus Availability of Some Tropical Soils

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INTRODUCTION

The use of composted organic matter to increase the availability of P for plant growth and other chemical and physical properties of soil has been studied by many researchers, for example Zhen-Li *et al*. (1992), Sato and Comerford (2006), Agbenin and Igbokwe (2006), Negassa *et al*. (2008). Unfortunately, the compost application level is relatively high, ranging from only 2-5 ton/ha to 10-15 ton/ha that it causes scarcity of compost as ameliorating agent in some areas due to its limited availability. Therefore, it is necessary to find a more effective method in applying organic matter to soil.

OBJECTIVES

This study aims to find out the effects of application of organic matter extracted from composted poultry manure, composted cow manure, and diluted humic substances on the availability of P in several soil types in Indonesia.

MATERIALS AND METHODS

Composite soil samples used in this study were taken at a depth of 0-20 cm from top soil Andisols, Ultisols and Inceptisols; all three of them located in Bogor District, West Java. Soil samples were air dried and sieved with a 2 mm-sieve.

WEOM used was extracted from composted poultry manure (PM) and composted cow manure (CM), whereas humic substances was extracted from coal (HS).

In order to figure out the effects of WEOM on the availability of P in soil, each soil sample was soaked in WEOM at the ratio of 1:10 and in diluted humic substances at the ratio of 1:4. Soaking process was done with daily stirring in the morning and afternoon for one week. After soaking process was done, soil was then air dried**,** and pH was measured with pH-meter and P level with Bray I method.

RESULTS

Table 1 shows some properties of selected compost.

Table 1. Some properties of composted poultry manure and composted cow manure

Compost Type	pH	Organic-C (%)	Total P (%)
Poultry manure	7.5	28.46	1.1
Cowmanure	6.9	21.42	0.2

Analysis results on extracted composted poultry manure, composted cow manure, and diluted humic substances are presented in Table 2.

Table 2. Some properties of WEOM from composted poultry manure and composted cow manure and diluted humic substances

OM Type	pH	EC (mS/cm)	Total P (mg/l)
WPM	7.90	11.5	143.4
WCM	7.20	3.1	102.5
HSA	7.70	3.2	0.2
HSB	7.60	2.0	0.3

The application of WEOM from composted poultry manure and cow manure had increased the value of soil pH from approximately 4.4-4.7 to 6.5-6.9, while the application of diluted humic substances had only increased the pH level of Ultisol and Inseptisol soil sample, where the pH level of Inceptisols was higher than that of Ultisols. Figure 1 shows the effects of WEOM and diluted humic substances application on soil pH value.

Figure 1. The effects of WEOM and diluted humic substances application on soil pH value

Figure 2 shows the effects of WEOM and diluted humic substances application on the availability of P. The application of WEOM from composted poultry manure and cow manure had increased the availability of P from approximately 5.3-6.5 ppm to 74-250 ppm, while the application of diluted humic substances had increased the availability of P to approximately 15-49 ppm. Despite its relatively low level of P, the application of diluted humic substances could increase the availability of P significantly.

Figure 2. The effects of WEOM and diluted humic substances application of the availability of P

CONCLUSION

The findings of this study suggested that the application of WEOM extracted from composted poultry manure and cow manure as well as diluted humic substances increased the availability of P on Andisol, Ultisol, and Inceptisols from Bogor District, West Java. The highest increase in P resulted from the application of WEOM from composted cow manure, followed by WEOM from composted poultry manure and diluted humic substances. The application of WEOM from composted manure and diluted humic substances also increased soil pH value, except on the application of diluted humic substances on Andisols.

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Figure 1

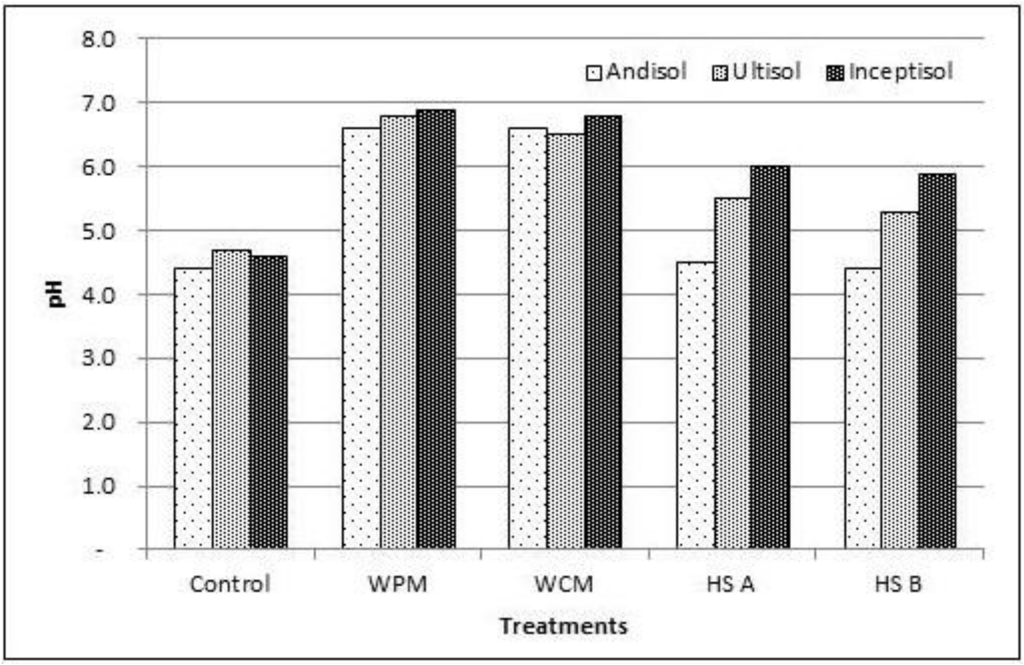
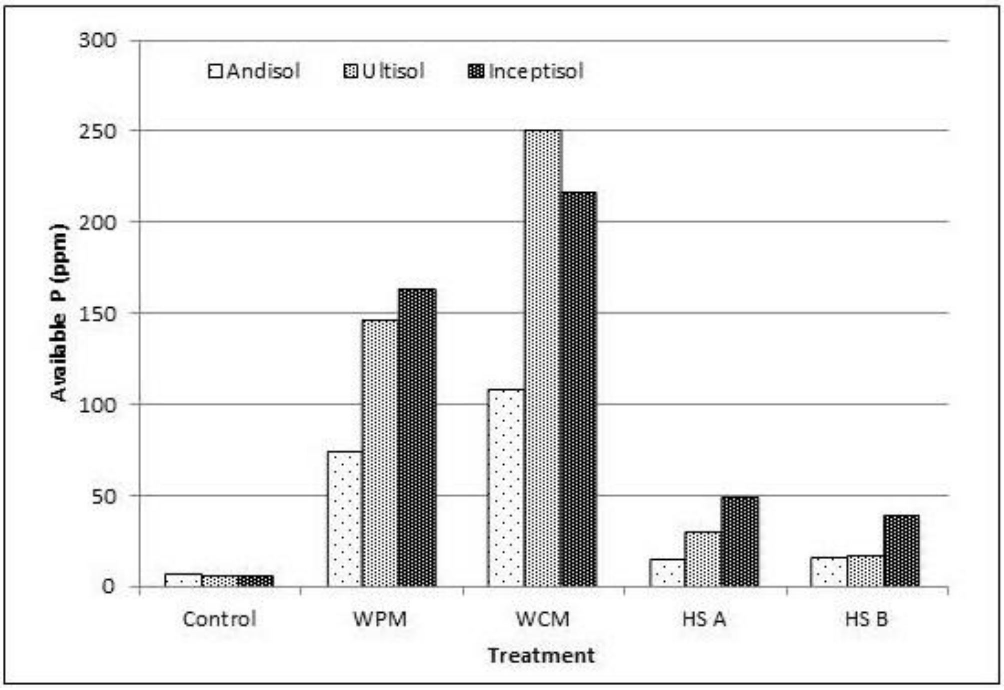


Figure 2



P 1.3.05

Soil assays to predict nitrogen mineralization potential of sedimentary and allophanic soils in New Zealand

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A realistic estimate of N mineralized from soil organic matter is essential to optimize fertilizer N use and minimize impacts of excessive N on the environment. A large-scale study was conducted to identify laboratory assays that may enable soil N mineralization potential of New Zealand soils to be estimated reliably and rapidly. To ensure that the study delivered robust conclusions, samples were collected from a wide range of soils in both the North and South Islands. The 130 paddocks sampled (0-15 cm sampling depth) represented different soil Orders (sedimentary and allophanic soils), management histories (dairy, sheep/beef, intensive and mixed cropping), and textural classes. Based on a literature search and previous experience, candidate assays were selected. These included biological assays: N mineralized in a 7-day anaerobic incubation at either 40 or 25^{o}C; CO_2-C evolved in 24-h following re-wetting of air-dry soil ("CO_2 burst test"); and N mineralized in a two-week aerobic incubation. Dissolved organic matter was determined using "mild" extractants: cold and hot water and 0.01 *M* sodium bicarbonate. Particulate organic matter was included as it is known to be labile and can be rapidly quantified (e.g., using mid-infrared spectroscopy). These assays were evaluated against mineralization measured in 14-week aerobic incubation at 25^{o}C, with soil moisture maintained at -10 kPa. The assays that correlated closely with mineralization potential included anaerobically mineralisable N and CO_2 burst test values. Particularly strong correlations were obtained for hot water extractable N, suggesting that this easily-measured organic N fraction can be used to predict N supply potential across the range of soil types and land uses found in New Zealand.

P 1.3.06

Effects of different cropping patterns on soil enzyme activities and soil microbial community diversity in oasis farmland

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Effects of long-term cropping patterns on the activities of peroxidase, invertase, arylsulfatase, dehydrogenase, and protease were investigated in this paper. Four long-term cropping patterns included (1) 10 years continuous cropping of corn, (2) 8 years continuous cropping of wheat followed by 10 years continuous cropping of cotton, (3) 15 years continuous cropping of cotton, and (4) 6 years continuous cropping of cotton followed by 6 years of wheat/sunflower rotation. The responses of soil bacteria, fungi, ammonia oxidizing bac-teria (AOB), and the ammonia-oxidizing archaea (AOA) to different copping patterns were analyzed. The results showed that cropping patterns significantly affected the activities of soil peroxidase, arylsulfatase, dehydrogenase, and protease, while had no significant effect on soil invertase activity. The cropping patterns significantly influ-enced the diversity index of AOA, but had no significant influence on that of soil bacteria, fungi, and AOB. The community structures of soil fungi and AOB were more sensitive to cropping patterns than soil bacteria and AOA. In conclusion, long-term continuous cropping of cotton decreased the activities of soil enzymes activities and soil microbial diversity in oasis farmland, while crop rotation could alleviate the negative influence.

Key words: continuous cropping; soil enzyme activity; microbial diversity; crop rotation; PCR-DGGE.

Figure 1

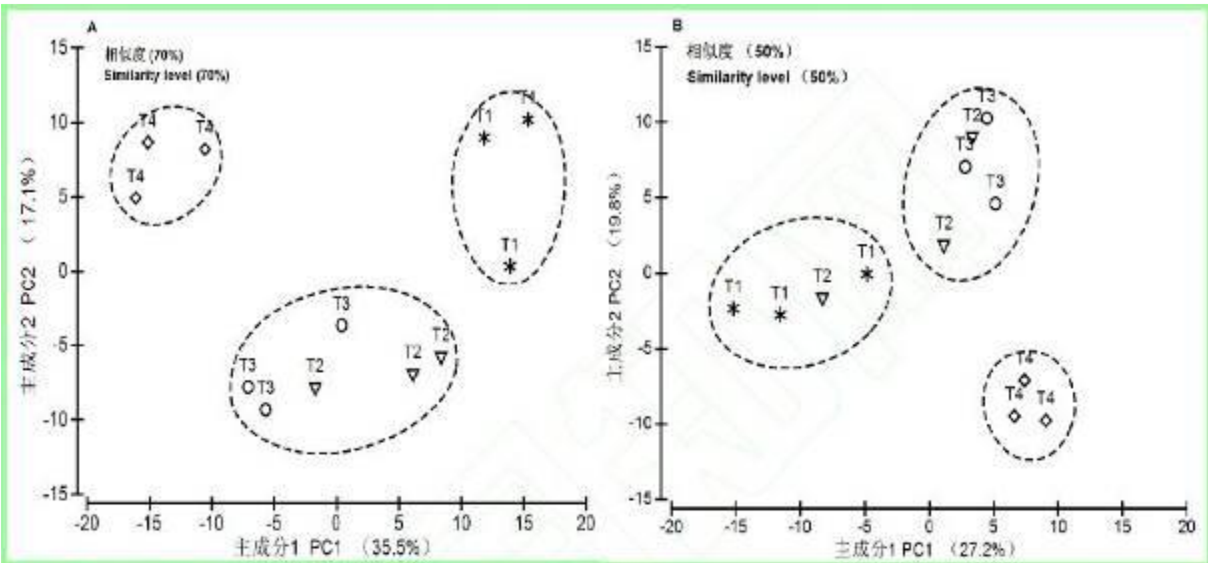

图 2 不同种植方式土壤氨氧化古菌(A)、氨氧化细菌(B)主成分分析
Fig. 2 PCA analysis of AOA (A) and AOB (B) as affected by cropping patterns.

Figure 2

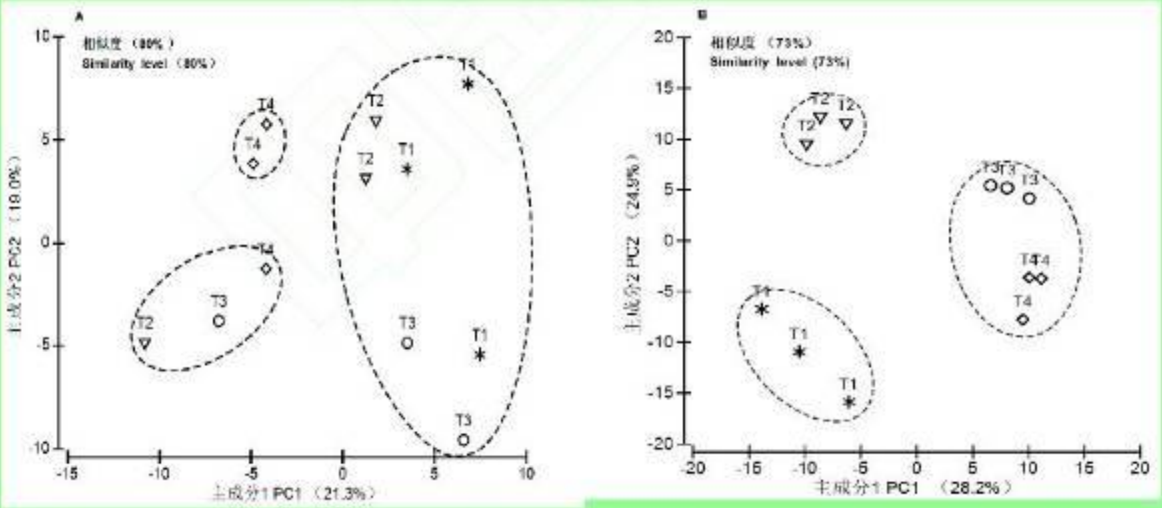

图 1 不同种植方式土壤细菌(A)、真菌(B)主成分分析

Fig. 1 PCA analysis of bacterial (A) and fungal (B) diversity as affected by cropping patterns.

T_1: 玉米连作 10 年 10 years continuous cropping of corn; T_2: 小麦连作 8 年-棉花连作 10 年 8 years continuous cropping of wheat followed by 10 years continuous cropping of cotton; T_3: 棉花连作 15 年 15 years continuous cropping of cotton; T_4: 棉花 6 年- 6 年小麦/油葵轮作 6 years continuous cropping of cotton followed by 6 years of wheat/sunflower rotation. 下同 The same below.

P 1.3.07

Investigation of the degradation of ^{13}C-labeled fungal biomass in soil - fate of carbon in a soil bioreactor system

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Introduction and Objectives. Nutrient balances and degradation processes in boreal forests are mainly influenced by interactions of plant roots and ectomycorrhizal fungi. Plants benefit from nitrogen compounds provided by their symbiotic interaction partner. In return ectomycorrhiza are provided with large amounts of carbon by the plants, which is used for the synthesis of hyphal networks in soil and for metabolic activity including nutrient uptake. Therefore, ectomycorrhizal fungi play a major role in ecosystems of boreal forests and are consequently an important sink for carbon by building large amount of mycelia.

Recently, it has been shown that microbial biomass residues contribute significantly to soil organic matter formation. This suggests that also residues of ectomycorrhizal fungi may be an important source for soil organic matter formation in forest soils where these fungi are abundant. However, the fate of ectomycorrhizal biomass residues in soils is unknown. We therefore investigated the fate of ectomycorrhizal biomass in soil.

Material and Methods. We used a soil bioreactor system to quantify the contribution of this material to soil organic matter formation. As a model organism, we selected *Laccaria bicolor*, which was labeled by growing the fungus on ^{13}C glucose. The stable isotope-labeled biomass was then homogenized and incubated in a podzol from a typical forest site in Central Germany. The fate of the labeled biomass was traced by analyzing the amount of ^{13}C mineralized and the amount remaining in the soil.

Results and Discussion. The fungal biomass carbon was mineralized rather rapidly during the first 50 days. Then the mineralization rate slowed down, but mineralization continued until the end of the experiment, when approximately 40% of the ^{13}C was mineralized and 60% remained in soil. In addition, we analyzed biomolecules such as fatty acids to trace the incorporation of the *L. bicolor*-derived biomass carbon into other microorganisms and to identify potential primary consumers of fungal biomass. By these analyses, we found a significant incorporation of *L. bicolor*-derived carbon into a wide variety of different bacterial taxa, indicating the relevance of fungal biomass residues as a carbon source for soil bacteria.

***Conclusion*.** The presented results show that the turnover of ectomycorrhizal biomass is a major source of SOM and we can provide a comprehensive view of the role of ectomycorrhizal fungi and their residues on soil carbon cycling.

P 1.3.08

Tracing phosphorus into soil organic matter and out again

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- **Introduction**

Organic phosphorus (P) in soils typically comprises 20-80% of total P and is present in various non-living forms as well as in the living microbial biomass. The quantification of net soil organic P mineralization rates is hampered by the potentially rapid sorption of released phosphate. An isotopic dilution approach based on an incubation experiment with ^{32}P- or ^{33}P-labeled soils allows assessing rates of gross and net organic P mineralization as well as microbial immobilization. The conventional data evaluation requires an additional short-term batch experiment to establish the decrease of ^{32}P or ^{33}P in the soil solution due to physicochemical processes only. Isotopic dilution due to biological processes is then derived by difference. A numerical modelling approach to calculate P transformation rates based on the incubation experiment only would potentially yield more precise rates of net P mineralization and allow a more mechanistic understanding.

- **Objectives**

We reviewed published isotopic dilution studies to assess gross and net organic P mineralization rates and developed a numerical ^{33}P tracing model. Our objective was to compare the rates calculated using the conventional approach with the rates rendered by the modelling approach, and to conclude on the relative importance of microbial immobilization and re-mineralization vs. mineralization of non-living soil organic P.

- **Material & methods**

Gross and net organic P mineralization rates found in six published studies were first summarized using the conventional approach (Bünemann, 2015) and subsequently re-evaluated by the modelling approach. The tracing model (Müller & Bünemann, 2014) combines a process-based numerical model with a parameter optimization routine to estimate nine distinct gross P transformation rates (Figure 1). Each rate can follow either zero-order, first-order or Michaelis-Menten kinetics. In the underlying conceptual model, the pool of phosphate ions in the soil solution is connected with two inorganic P pools (fast or slow) via physicochemical processes. Direct transfer from the fast to the slow inorganic P pool is also possible. The fast organic P pool equals microbial P and the slow organic P pool can be equated with non-living organic P. Both are connected with P in the soil solution via immobilization/mineralization processes.

- **Results**

Published isotopic dilution studies show that isotopically exchangeable P during incubation can partly or even predominantly (20-90%) result from biological and biochemical rather than physicochemical processes, with the contribution tending to be lower in arable soils than under grassland and forests (Figure 2). Typical basal gross organic P mineralization rates range between 0.1-2.5 mg P kg^{-1} d^{-1}, but rates up to 12.6 mg P kg^{-1} d^{-1} have been observed in grassland and forest soils.

The model was able to simulate the observed dynamics of ^{31}P and its radioactive tracer in various soil P pools. However, net organic P mineralization rates were lower than previously published. For most P transformations, the choice of kinetic setting did not make a great difference. For microbial P immobilization, however, selecting Michaelis-Menten kinetics typically improved the model fit significantly.

- **Conclusions**

For most datasets, the modelling approach yielded lower gross and net organic P mineralization rates than the conventional data evaluation. The modelling approach in particular showed the overriding dominance of microbial immobilization and re-mineralization processes over the mineralization of non-living organic P.

The numerical modelling approach will enable assessment of soil P transformation rates under non-steady-state conditions, where P fluxes are likely to be greater than under steady-state conditions.

References

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Müller C & Bünemann EK 2014: A ^{33}P tracing model for quantifying gross P transformation rates in soil. Soil Biol Biochem 76: 218-226.

Figure 1: Conceptual P tracing model to analyze soil P transformations, including 5 P pools (P_w: water-extractable phosphate. P_{if} and P_{is}: fast and slow inorganic P. P_{of} and P_{os}: fast and slow organic P) and 9 P transformations. Modified from Müller and Bünemann (2014).

Figure 2: Effect of land use on absolute and relative contribution of physicochemical vs. biological/biochemical processes to isotopically exchangeable P determined during 5-10 days of incubation.

Figure 1

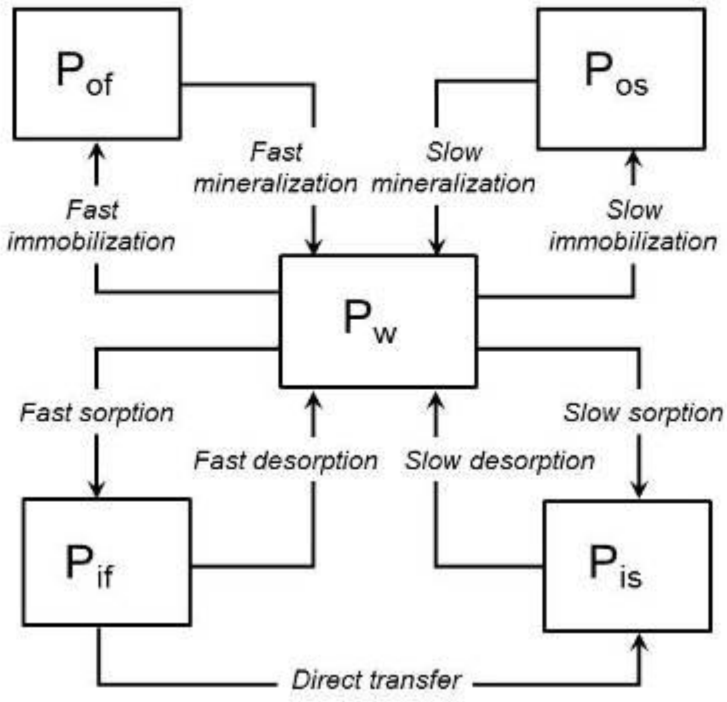
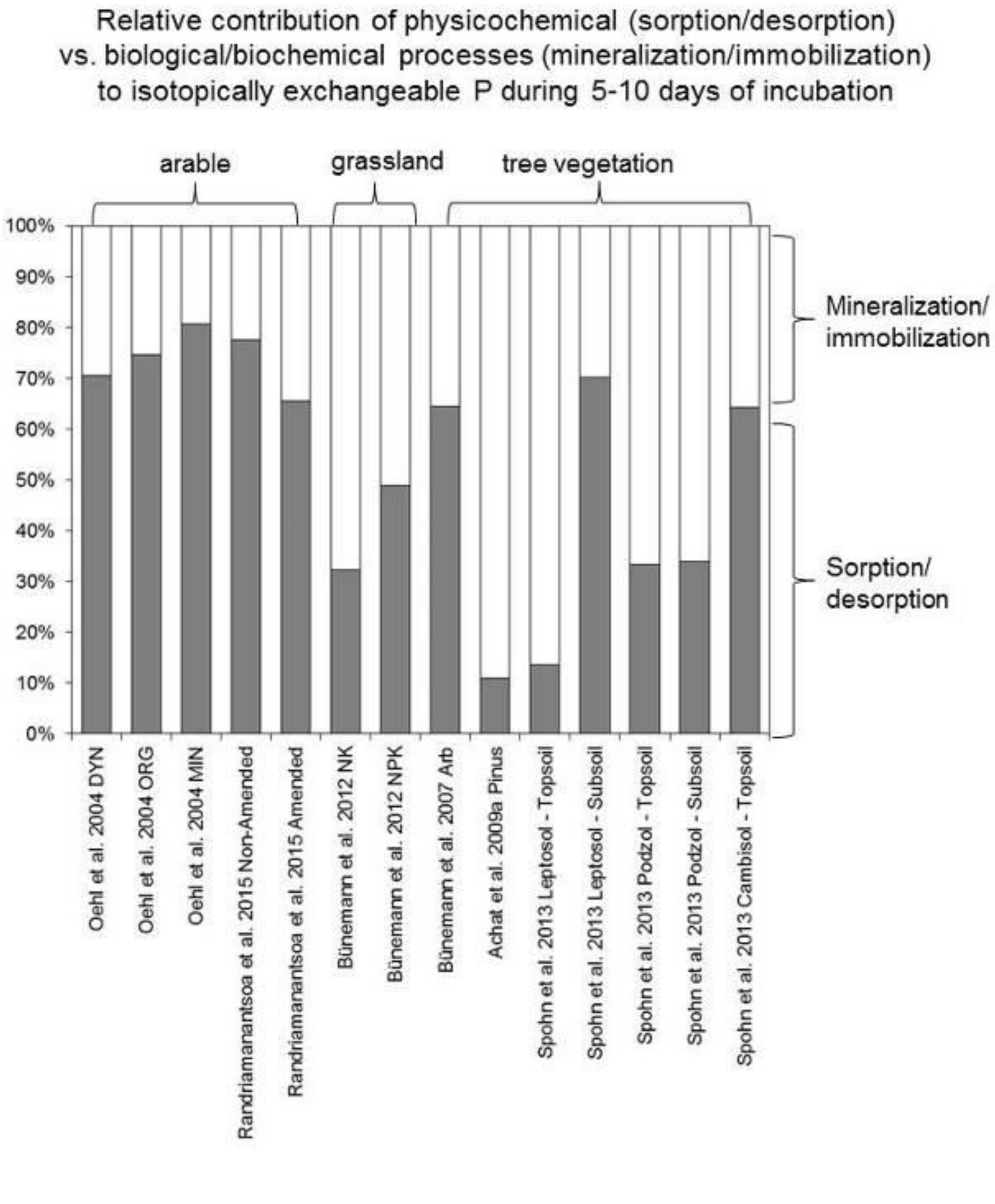


Figure 2


Relative contribution of physicochemical (sorption/desorption) vs. biological/biochemical processes (mineralization/immobilization) to isotopically exchangeable P during 5-10 days of incubation
arable
grassland
tree vegetation
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Mineralization/ immobilization
Sorption/ desorption
Oehl et al. 2004 DYN
Oehl et al. 2004 ORG
Oehl et al. 2004 MIN
Randriamanantsoa et al. 2015 Non-Amended
Randriamanantsoa et al. 2015 Amended
Bünemann et al. 2012 NK
Bünemann et al. 2012 NPK
Bünemann et al. 2007 Arb
Achat et al. 2009a Pinus
Spohn et al. 2013 Leptosol - Topsoil
Spohn et al. 2013 Leptosol - Subsoil
Spohn et al. 2013 Podzol - Topsoil
Spohn et al. 2013 Podzol - Subsoil
Spohn et al. 2013 Cambisol - Topsoil

P 1.3.09

Impact on soil parameter after two sewage sludge annual successive amendment

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The aim of this study was to evaluate the fertility parameter into uncultivated sandy soil, amended with different quantity of sewage sludge (0 t/ha, 40t/ha, 80t/ha and 120t/ha), after two consecutive years. We studied the relationship between sewage sludge amount (treatment) and microbial soil properties (enzymatic activities and microbial biomass), in order to illustrate the function of microbial properties as bio-indicators of soil-health. The addition of the sewage sludge increased microbial biomass and enzymatic activity illustrated by dehydrogenase, protease, phosphatase and cellulose activities, with a significant correlation ($p<0.05$) even when the organic matter and the quantity of sewage sludge increased. We observed a good linear relation between microbial biomass and the microbial activity higher than 0.68. Heavy metals studied (Cu, Cr, Cd and Zn) have also increased while sewage sludge amendment increased. The 40T/ha dose and 80T/ha dose have a statistical likeness and that samples didn't shown a great toxicity with heavy metal after two annual successive sewage sludge amendment. Despite at 80T/ha dose the total organic carbon and other fertility elements such as phosphorus available and total nitrogen are more important than at 40T/ha dose. In addition to the lettuce root elongation inhibition which show a no significant difference between 80T/ha and 120 T/ha sewage sludge dose. 80T/ha Sewage sludge amount seems to be the optimized dose to avoid the organic matter restoration with less soil toxic contamination.

P 1.3.10

Drivers for the diversity of cellulose-degrading microbes and their genes in agricultural soils

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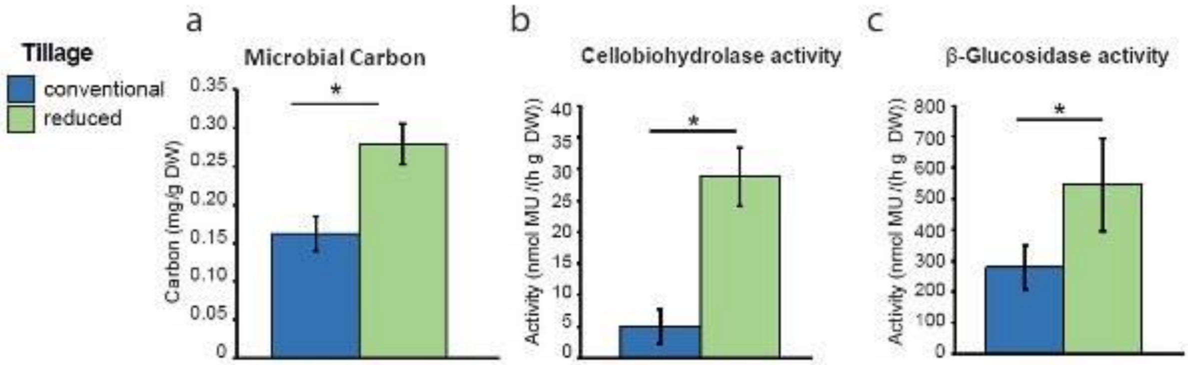
Cellulose degradation takes place in agricultural soils mainly after plant residue incorporation, and it plays an important role in carbon mineralization and sequestration. Several studies have shown, that the turnover rates of cellulose are influenced by a large number of abiotic and biotic soil properties, for example water availability, soil texture or nutrient content, as well as the presence of cellulase-producing microorganisms. As the degradation of cellulose is a complex process that requires several transformation steps including glycoside hydrolases, carbohydrate binding modules and auxiliary activity families, a network of interacting microbes which express different cellulase gene-families is needed to transform cellulose into monomers. Low sequence conservation of these genes has made it difficult to quantify the activity and abundance of cellulolytic microorganisms in soil. Therefore, the drivers for cellulose-degrading microbial communities in soil are still not clearly identified. It was the aim of this work to relate cellulase gene abundance and diversity in a soil to its cellulose degradation potential.

To this end, we took a metagenomic sequencing approach to identify genes coding for cellulases in agricultural soil. Focus was set on the comparison of conventional and reduced tillage, as tillage is known to affect the amount of soil organic matter in soils to a large extent. Soil samples were taken from the top soil (0 - 10 cm) in autumn, one month after harvest and maize litter incorporation, from a long term field trial located in Scheyern, southern Germany. The soil has been characterized as Luvisol with a loamy texture. Total DNA was extracted from these samples and an equimolar amount was sequenced with the 454-pyrosequencing technology. Sequencing yielded a total of 1.1 million clean reads with an average length of 410 base pairs. In addition, from fresh soil, the microbial biomass was measured and enzyme assays were performed to measure potential activities of cellulases.

As expected, our results show that the top layer of soils under reduced tillage contains a higher amount of carbon, microbial biomass and potential cellulase activity per gram dry weight, than the top layer of soils under conventional tillage (Figure 1). In soils under both management types a large diversity of cellulase gene families could be predicted, including glycoside hydrolase families 1, 3, 5, 74 and 94, auxiliary activity families 3.1 and 8, and carbohydrate binding modules 2 and 6 (Figure 2). These genes were harboured by microbial genera belonging to the phyla *Proteobacteria, Actinobacteria* and *Bacteroidetes.* Unexpectedly, our analysis of the metagenomic data related to cellulose degradation did not reveal prominent differences between tillage treatments (Figure 2). However, glycoside hydrolase family 48- cellulase genes could be found only in the soil under reduced tillage, whereas soil under conventional tillage harboured a higher amount of carbohydrate binding family 11-genes.

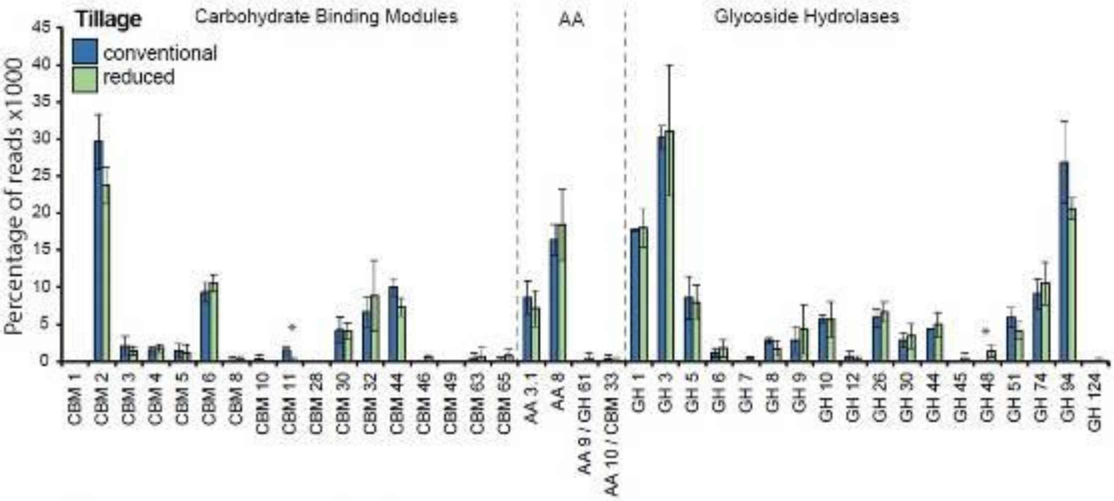
Our data confirms on the molecular level that a large diversity of microorganisms with a broad array of cellulase genes is involved in soil cellulose degradation. In addition, it shows that tillage management strongly influences soil microbial biomass and enzyme activity. However, the effect of tillage management on the abundance and diversity of microbes which have the potential to express genes involved in the breakdown of cellulose was not prominent. This might be related to (i) the long term nature of the experiment studied, where microbes were able to form their new niches according to their demands and (ii) the sampling time point as the high amount of added litter material might have stimulated microbes involved in cellulose degradation more, than the type of management. However, it cannot be excluded that the regulation of cellulose degradation is more on the transcriptional level than on the level of community structure. Therefore additional experiments using extracted mRNA are needed to identify the level on which management influences the degradation potential of the soil microbiome.

Figure 1



Reduced tillage increases microbial carbon and potential cellobiohydrolase and β-glucosidase activities in the topsoil: a) Depicted is the amount of microbial carbon detected in soils with conventional and reduced tillage treatments, in mg per gram dry weight soil. b,c) Shown is the amount of produced methylumbelliferone (MU) in nmol per hour and gram dry weight soil, that has been released by the enzymatic degradation of MU-β-cellobioside (b) or MU-β-D-glucoside (c). Significant differences between conventional and reduced tillage were determined by unpaired t-test statistics (* = $P<0.05$, n=3)

Figure 2



Prediction of cellulases and carbohydrate binding modules from metagenomes of conventional and reduced tillage-treated soil: Depicted is the percentage of reads multiplied by 1000 annotated to catalytic and carbohydrate binding modules found in the metagenomes of conventional and reduced tillage treated soil using HMM modules and after an additional quality control using a curated database. Significant differences between conventional and reduced tillage were determined by unpaired t-test statistics (* <0.05, n=3).

P 1.3.11

Plant- and microbial-derived lipids: mean residence time of C_3-C_4 vegetation type changes

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Lipids of terrestrial soils can be separated to three groups by their functional characteristics: 1) intact (polar) lipids of microbial and plant cells, 2) plant- and microbial-derived (free lipids), and 3) hydrolysable lipids. The methods for extraction of free lipids do not require any hydrolyzation step, but are just based on a soft extraction without any modification of the primary molecule structure. Free lipids are of special interest for studies, focusing on biogeochemical cycles and soil organic matter (SOM) transformation. Lipids are quantitatively important, rather stable, compound of the SOM and responsible for hydrophobic properties of soils. Thus, quantification and characterization of this compound class provides significant information on the quality of SOM. Soil free lipids characterized by two different sources: they could have plant-derived organic matter input or they can have the origin of the microbial residues degradation. Thus, specific lipids for plants and microorganisms could be used to assess the sources of SOM.

A step forward in SOM studies was done by combining biomarkers studies with isotope approaches - a methodological combination which has a high potential to unravel various ecological processes. This study focused on estimation of free lipids mean residence time in a C_3-C_4-vegetation change experiment ("Ewiger Roggen" of the Halle University, Germany) determined bycompound-specific isotope ratio mass spectrometry.

Comparison of lipid composition under rye (*Secale cereale*) and maize (*Zea mays*) was performed by an optimized method of lipid extraction, purification, quantification and $\delta^{13}C$ determination. We established liquid-liquid extraction and silica gel column chromatography to separate and purify 5 different lipids classes: 1) alkanes, 2) aromatics, 3) alcohols (including sterols and ketones) within the neutral lipid fraction and 4) fatty acids, 5) hydroxy fatty acids and dicarboxylic acids within the acid lipid fraction.

Fifty-three years after vegetation change from rye to maize, plant-derived fatty acids showed an increase in their $\delta^{13}C$-value of 5‰. In contrast, the increase of the $\delta^{13}C$-value of microbial fatty acids was only up to 2‰. This demonstrates that microbial growth occurs on both, old C_3-derived (rye) and newly incorporated C_4-derrived (maize) soil organic matter. A lower $\delta^{13}C$ increase of alkanes (2‰) compared to fatty acids of similar chain length indicates a faster mean residence time of lipid classes with polar functional groups. Including the $\delta^{13}C$ changes of alcohols and hydroxy fatty acids will further deepen the knowledge on mean residence time dependence on chain length and amount/polarity of functional groups in the various classes of n-alkyl lipids.

This demonstrates that differentiation of C_3- and C_4-derived C is possible even for slow-cycling compound classes (e.g. n-alkyl lipids) based on biomarker methods optimized particularly for compound specific isotope analysis. Using this approach, we were able to differentiate the dynamics of mean residence time of lipids with various molecular features as well as plant- and microbial derived lipids.

P 1.3.12

A novel technique to study soil organic matter quality in arable soils - Coupling pyrolysis with mid-infrared spectroscopy (Pyro-MIRS)

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Introduction

Most analytical techniques to characterize soil organic matter (SOM) quality and its dynamics are unsatisfactory because they commonly require extractions changing the nature of SOM as well as suffer from mineralogical interferences hindering qualitative and quantitative analysis of SOM.

Objectives

Here we present a novel approach to overcome these known limitations. We coupled pyrolysis with mid-infrared spectroscopy (Pyro-MIRS) to characterize SOM quality in arable soils with different mineralogical characteristics. After method development that included primarily the optimization of heating rate, final pyrolysis temperature and holding time, evolved volatiles from thermal decomposition of SOM were then related to different SOM qualities. Accordingly, we hypothesized that different mid-infrared peaks of evolved pyrolysis gases correspond to vibrations of certain organic functional groups of SOM suitable to study changes in SOM quality.

Materials and methods

Soil samples were taken from two sites: (i) the Static Fertilization Experiment, Bad Lauchstädt, Germany (Chernozem) from the treatments of a combination of farmyard manure and mineral fertilizer (FYM + NPK), farmyard manure (FYM), mineral fertilizer (NPK) and control without fertilizer inputs, and (ii) the Ultuna Long-term Experiment, Sweden (Cambisol) from treatments of farmyard manure (FYM), continuous bare fallow and control without mineral fertilizer inputs. In the final setting, the infrared spectrometer recorded the absorbance intensities of the evolved volatiles from 100 to 700°C with a heating rate of 20°C ms^{-1} and a holding time of 30 s at 700°C.

Results

Results indicated that the intensities of the different mid-infrared peaks were affected by fertilizer treatment. In more detail, the long-term application of FYM led to an increase in the aliphatic and carbonyl components of SOM and a decrease in the aromatic component of SOM compared to the non-FYM manure treatments. The ratio of the aromatic to aliphatic peaks taken as an indicator of the SOM stability decreased following the long-term application of FYM.

Conclusion

This study has shown that the peak analysis of pyrolysis spectra was suited to assess different qualities of SOM in two contrasting soils without acid pretreatment to remove interfering minerals within the soil matrix. The applicability of this technique needs to be further tested on soils with different clay mineralogies and land uses.

P 1.3.13

Changes in soil carbon, nitrogen and phosphorus composition with ecosystem development at Glacier Bay, south-east Alaska

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We report on the changes in soil carbon and nutrient (nitrogen and phosphorus) along a glacier foreland chronosequence at Glacier Bay, south-east Alaska. The contributions of inorganic and organic forms to soil N were also investigated. Samples from the organic surface and upper mineral horizons were collected at eight sites along the chronosequence of increase time since being ice free and with different vegetation types. The results showed that soil N content rapidly increased over the first 70 years as the vegetation changed from open pioneer vegetation (with *Dryas drummondii*) to dense, tall scrubland dominated by alder (*Alnus sinuata*). Thereafter, soil N concentrations slowly declined. Soil carbon C increased for the first 250 years (*Picea sitchensis* and *Tsuga heterophylla* forest) thus was partly decoupled from the soil N development. Soil P content was mostly comparable, but inorganic P declined rapidly in the organic horizon from nearly 90% (10 years) to less 10% of total P (14,000 year ice free, old *Tsuga heterophylla* forest and developing bogs). Gross patterns in changes of amounts and distribution of soil N compounds were related to the progressive (10-2000 years; relatively more amino acid-N) and retrograde phase (14,000 years ice free; more unknown-N) on the primary succession. The latter chemically unidentified organic N compounds comprised up to 55% of total soil N along the chronosequence. Furthermore, despite significant changes in soil N, P content and composition along the 14,000 year chronosequence the mineral part remained N limited, whereas the organic horizon was P (mostly) limited.

P 1.3.14

Microbial DNA Extraction Method from Humus-Rich Tropical Peat Soil for Use as Template DNA for PCR-DGGE-Based Analysis of Microbial Community Structures

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INTRODUCTION

Tropical peat soil is a histosol with an intermediate-to-strong acidic nature, consisting of >65-75% organic matter, and an extraordinarily high amount of humus and polyphenols. Contaminants from plant debris, such as humic substances, plant polyphenols, and polysaccharides, not only cause chemical damage to DNA but also inhibit subsequent molecular manipulations (Kim *et al.*, 1997; Koonjul *et al.*, 1999).

OBJECTIVE

To describe a method suitable for the preparation of PCR-DGGE-grade DNA template from tropical peat soil containing high levels of humic and plant material.

MATERIALS AND METHODS

Soil Sampling and Preparation Peat soils from 2-year old (2Y), 12-year old (12Y) oil palm plantations and a secondary peat swamp forest in Sibu, Sarawak, Malaysia (02°12′N, 111°50′E), were sampled from depths of 0-50 cm and 350-400 cm in December 2012.**Conventional DNA Extraction Method and its Modification** The conventional DNA extraction method was based on the protocol by Zhou *et al.*, (1996) with further modifications as shown in Figure 1. **Agarose Gel Electrophoresis for Effective Removal of Humic Substances from DNA Extracted from Decomposed Peat Soils** Twenty microliters of the DNA solution (approximately 14 µg) were run at 100 V on 1.5% agarose gel in 1× TBE buffer for 0.5-2 h to separate the brown-colored humic substances from the DNA. **Modification of PCR Components and Conditions** To prevent inhibition by contaminants, 1 µg/µL bovine serum albumin (BSA) and standardized 2-6% PVP were added to the PCR reaction mixture. Primary PCR for bacterial 16S rRNA-targeted denaturing gradient gel electrophoresis (DGGE) was performed using GC-clamped primer 341_{gc}F (5′-CGC CCG CCG CGC CCC GCG GGG GTC CCG CCG CCC CCG CCC GCC T AC GGG AGG CAG CAG-3′) and primer 907R (5′-CCG TCA ATT CCT TTR AGT TT-3′). **Denaturing Gradient Gel Electrophoresis (DGGE)** Denaturing gradient gel electrophoresis (DGGE) was carried out using a DCode™ Universal Mutation Detection System (Bio-Rad, Hercules, CA, USA) instrument and Gradient Former Model 475.

RESULTS AND DISCUSSIONS

Effective Cell Lysis, DNA Recovery, and Removal of Humic Substances Using a Conventional Extraction Method Modifications of the conventional DNA extraction method involving the use of 1.5 M NaCl buffer led to improved DNA extraction from rainforest topsoil (Pang *et al.*, 2008), as well as the removal of contaminating polysaccharides (Fang *et al.*, 1992). The physical freeze-crushing process facilitated in dislodging the cells tightly bound in the soil micropores and breaking cells of lysis-resistant groups such as gram-positive actinomycetes; this enhanced DNA recovery (Kauffmann *et al.*, 2004). **Removal of Humic Substances from Soil DNA using the Modified Conventional Method** We applied agarose gel electrophoresis for the removal of humic substances. The resulting gel exhibited an extended and bright DNA smear after staining with EtBr; however, the DNA recovered from the gel at both short and long migration distances could be used as PCR templates for 16S rRNA amplification. **Effective PCR Amplification** Ex*Taq* polymerase with increased enzyme units (a maximum of 5 units per reaction). The addition of 2-6% PVP to the PCR reaction mixture to prevent reaction inhibition by plant-originating contaminants also resulted in improved amplification. **Eubacterial Community Structure in the Tropical Peat Soil Ecosystem** PCR-DGGE for DNA extracts from peat soil samples from the oil palm plantations and the secondary forests. The DGGE profiles demonstrated the soil bacterial community fingerprint for each of these samples (Figure 2). Of the GC-clamped 341_{gc}F-907R amplicons, >30 of the DNA bands representing the fingerprint of the bacterial community (from both shallow and deep soil samples) corresponded with those of unculturable bacteria.

CONCLUSION

This newly developed efficient method for DNA extraction from tropical peat soils rich in humic substances allows us to effectively monitor microfloral succession in the soils under different conditions and/or different land management (Lau *et al.*, 2014).

Figure 1. Procedures for the improved conventional method with steps for successful extraction and purification of DGGE-grade DNA from humus-rich tropical peat soils

Figure 2. Eubacterial 16S rRNA gene-targeted PCR-DGGE profiles for DNA extracted from shallow and deep peat layers.

Figure 1

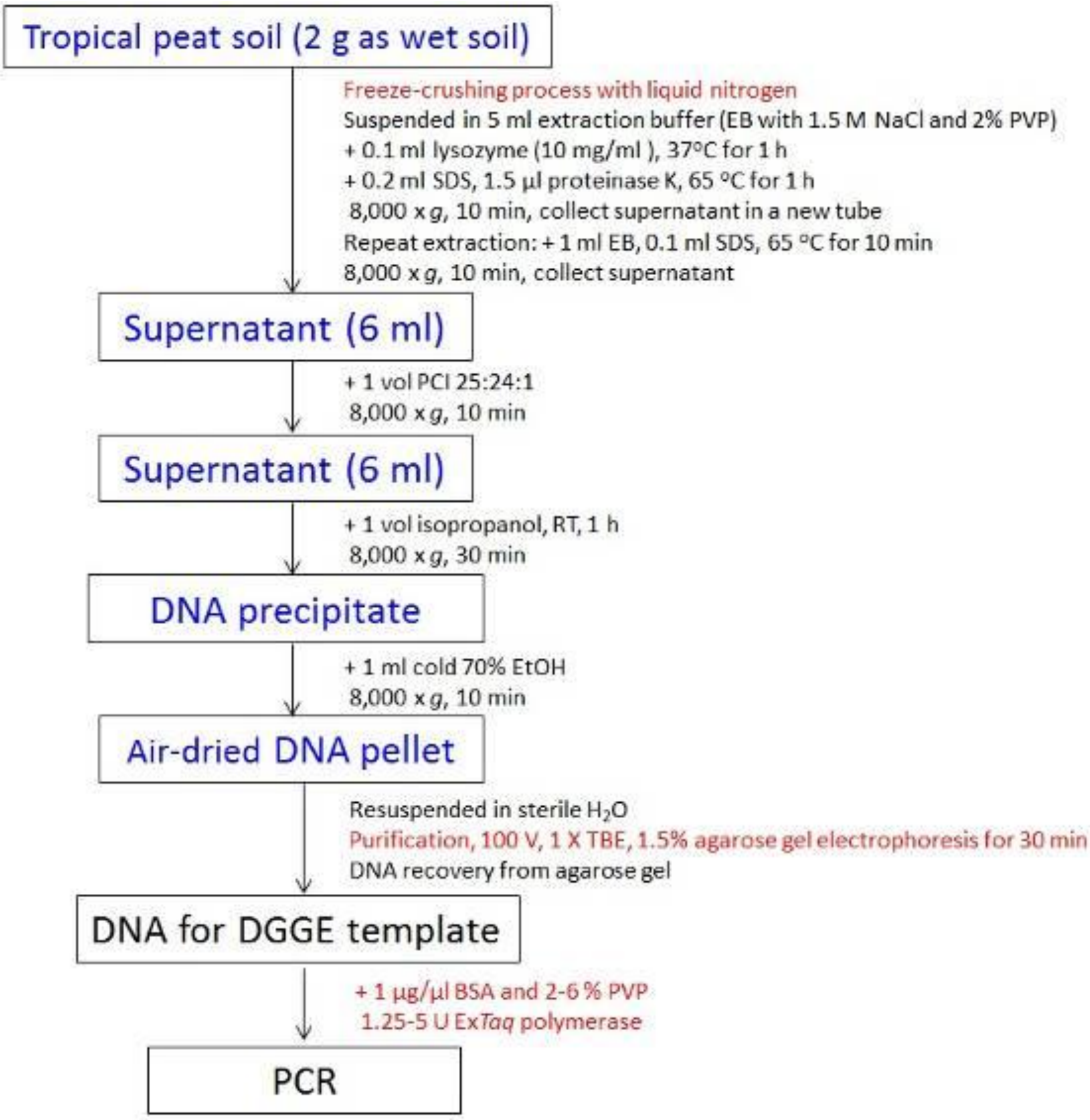

Figure 2

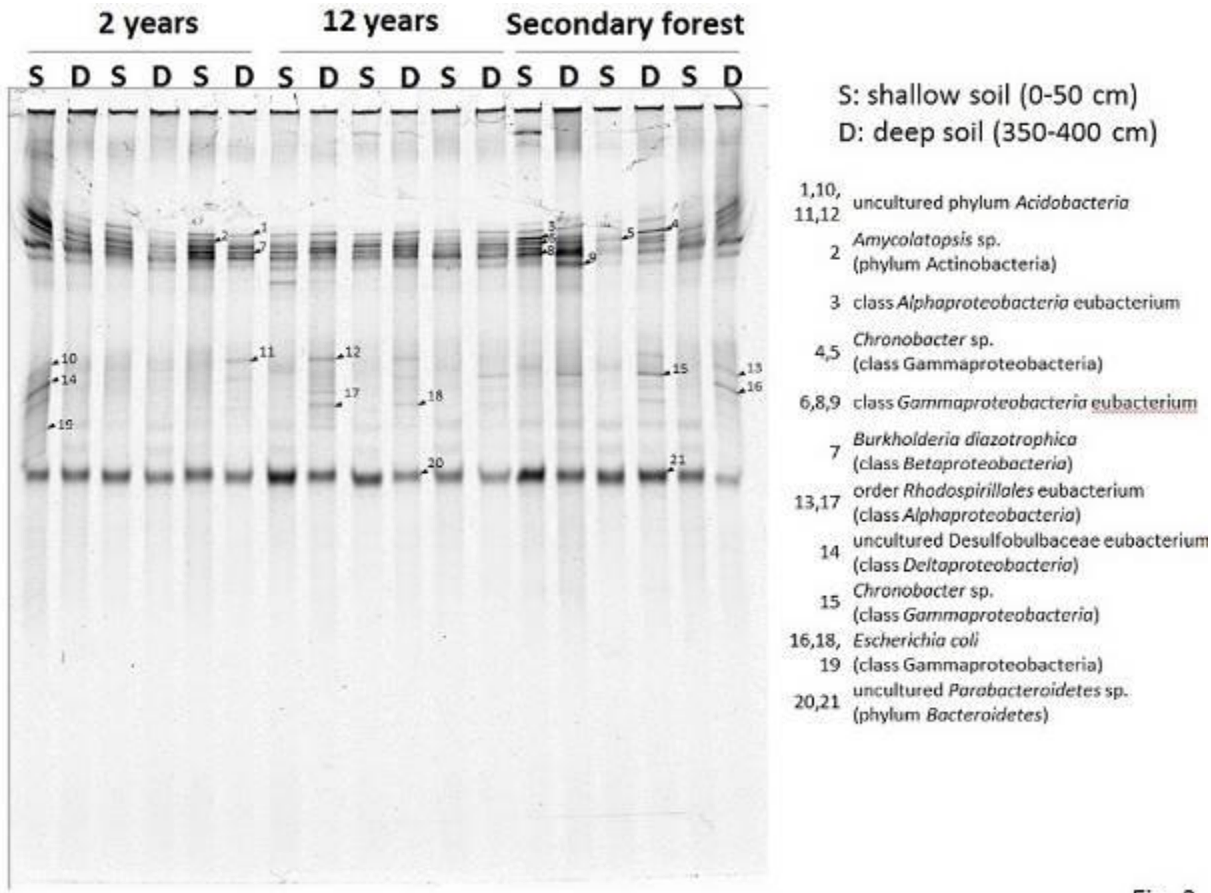

Fig. 2

P 1.3.15

Human impact on soil - faecal inputs to inaccessible and grazed soils in the Andes, Peru

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The ecological impact of man on soil cannot be denied, however, its degree is hardly detectable, since places without any kind of land use are rare. We here investigate how land use, i.e. about 4000 years of grazing, changed soil steroid contents due to the input of faeces in the Andes, Peru. This is compared to inaccessible sites with comparable factors of soil formation (climate, substrate, vegetation). Sterole, stanole and bile acid contents were analyzed as markers for faecal input in soil depth profiles in forest, grassland and rangeland biomes. Soil organic carbon stocks increased from about 15 to 21 kg/m² between inaccessible and grazed sites (Heitkamp et al., 2014). We assume that in grazed ecosystems the input of faeces contributes to increasing concentrations of soil organic matter, likely due to a change of its composition and stability.

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P 1.3.16

Quantifying the dynamics of amino-acids in soils: results from stable carbon isotope approaches

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Introduction: A better control of the Earth nitrogen cycle is critical for both future food security and environment quality. Soil Proteinaceous compounds constitute the main terrestrial nitrogen pool and is the first reserve of nitrogen for plants, but their dynamics and stabilization are still poorly understood.

Materials and methods: To quantify these dynamics, we initiated a new approach by tracing the carbon atoms of the nitrogenous compounds in soils. We first developed an original calibration for stable ^{13}C analysis of individual amino-acids by combined gas chromatography-combustion/isotope ratio mass spectrometry (GC-C/IRMS) of their *n*-tert-butyl dimethylsilyl (TBDMS) derivatives. Six topsoils with varied physical-chemical properties, soil type, climate, vegetation and land usewere selected from different places.

Results: In a first approach of short-term dynamics, we quantified the rate of amino-acid biosynthesis from ^{13}C-labelled substrates (Phenylalanine, Glycine, Glucose, wheat straw, European beech leaves) for 2, 7, and 28 days respectively.

Amino-acids represented about 7 % of organic carbon in these soils. Forty percent of the simple substrate carbon was converted into microbial biomass and metabolites, of which 3 to 8% were retrieved as amino-acids depending on the substrate: 7.74%, 4.58%, 3.45%, 5.98%, 2.88% derived from Phenylalanine, Glycine, Glucose, wheat straw, European beech leaves respectively. The distribution of individual amino-acid in bulk soil proteins was very close to that of newly-formed proteins, indicating their microbial origin, with the exception of aspartate, probably from vegetal origin.

In a second approach of long-term dynamics, we applied the natural 13C labelling technique on sites with a C3 to C4 vegetation change (maize plots cultivated in France after 20 years of deforestation) or vice-versa (30 years of Eucalyptus plantation on a former savannah in Congo). In the eucalyptus plantation, the proportion of new carbon (turnover) of amino-acid carbon was lower than that of the bulk soil. In contrast, it was a little higher in the cultivated soil.

Conclusion: These results confirm that amino-acid carbon belongs to the "old" pool of organic matter, with a mean age of several decades. This can be the result of either a stabilization of proteinaceous material, or an active recycling of amino-acids by microbes. This turnover of amino-acid carbon may be modulated by the intensity of nitrogen fertilization.

These results of amino-acid carbon turnover at two timescales will be used for the parameterization of a dynamic model of the representation of soil organic matter chemical compounds.

Keywords: Amino- acid, incubation, C3/C4 vegetation change, ^{13}C, GC-C-IRMS

IT 2.1

Roots contribute relatively more to soil organic matter than above-ground residues according to analysis of long-term agricultural field experiments in Sweden

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1. Introduction

Soil organic carbon (SOC) balances in croplands are strongly influenced by management practices. There is also evidence that SOC balances are controlled by inputs rather than outputs. However, certain C inputs may stimulate decomposition of 'old' carbon through priming; but will priming have an effect over the long term and how will chemical properties of C input affect SOC balances? If it is true that root-derived C input contributes relatively more to SOC than that from above-ground crop residues, use of straw as a bioenergy source could be sustainable under certain conditions.

2. Objectives

Our objectives were to synthesize recently published and unpublished results exploring the effect of different management practices on SOC stocks. The main focus of this paper was to compare C retention from above-ground vs. below-ground crop residue inputs.

3. Materials & methods

Data series from long-term field experiments were analysed in order to quantify effects of fertilization, crop residue handling, cover crops, rotations including perennial leys and annual crops, and the recycling of organic wastes on SOC balances. For the study of below-ground C inputs, the Ultuna soil organic matter experiment, started in 1956, was of special interest since all above-ground material is removed, non-crop C inputs are controlled and a wide range of yields are produced due to application of different nutrient rates. Root-derived C was estimated using allometric functions and the 'equivalent soil mass' concept was applied to estimate SOC stock changes considering changes in bulk density in all treatments. Sensitivity analysis was applied accounting for the uncertainty in input calculation. Furthermore, since silage maize is grown as monoculture since 2000, recently formed SOC from maize roots could be estimated from the ^{13}C signal introduced by maize.

4. Results

Retention of C was highest for compost and peat added to soil, intermediate for sewage sludge, farmyard manure, sawdust and root-derived materials, and lowest for above-ground crop residues. Retention of root-derived C was more than two times higher than that of above-ground residues. The results were not too sensitive to the allometry used for calculating root inputs from crop yields. The relatively high retention of root-derived C was also confirmed by ^{13}C analysis showing that 4-8% of SOC was derived from maize roots after 10 years corresponding to about 30% of the calculated maize root C input as compared to 0-15% often observed for above-ground C inputs. In many experiments, SOC changes in the upper part of the subsoil resembled the same trend as observed in the topsoil. No net priming effects were observed. High production (fertilization) and a high allocation of C to roots (perennial crops, cover crops) increased SOC.

5. Conclusion

Our findings and those from several other studies using different methods strongly support the hypothesis that roots contribute more to relatively stable soil C pools than the same amount of shoot-derived crop residues. In our studies, roots contributed more than twice as much to SOC than the corresponding amount of aboveground crop residues. Thus, the SOC contribution from perennials (in rotations or as cover crops) having high production and a higher root/shoot ratio than annuals was considerable. However, the mean root/shoot ratios used in the allometric functions to estimate annual root-derived C inputs to soil for different species are not very abundant in the literature and highly uncertain. Averaged over ten experiments, more than one kilogram of carbon was sequestered for each kilogram of nitrogen applied as mineral fertilizer. Thus, farming practices that lead to increased crop yields also resulted in increasing SOC stocks.

In fields where SOC is not critically low, it may be a reasonable practice to export more harvest residues for bioenergy, particularly if the frequency of cover crops or perennial crops in the rotations is increased.

O 2.1.01

Soil organic carbon stock depletion after phosphorus fertilization - Evidence and involved mechanisms

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1. Introduction

Stocks of soil organic carbon (SOC) are mainly determined by the balance between carbon inputs in the form of plant residues and exudates, and outputs via heterotrophic respiration. Nitrogen is a known driver for changes in SOC through its influence on net primary productivity, but little is known from the net effect of other main plant nutrients such as phosphorus (P) on SOC balances. Recent reports indicate that P fertilization can increase heterotrophic respiration, but our mechanistic understanding of this phenomenon is still very poor.

2. Objectives

This study investigated the effect of three different levels of phosphorus and potassium (PK) fertilisation on SOC stocks in the absence of nitrogen by analysing data from 10 Swedish long-term field experiments (>45 years). In addition, the involved mechanisms of a potential P effect on SOC cycling were studied at three selected sites.

3. Materials and Methods

Data series of a metareplicated long-term experiment, of which five sites were located in Central Sweden and the other five in Southern Sweden, were analysed. Three sites were resampled to set up a range of different experiments and measurements: i) a pot experiment with spring barley to test the effect of P on crop root to shoot ratio, ii) a respiration experiment combined with calorimetric measurements was established to determine P effects on SOC decomposition and iii) a real time quantitative polymerase chain reaction (qPCR) to quantify the abundance of arbuscular mycorrhiza was used to evaluate the influence of fertilization regimes on fungal community composition.

4. Results

We found average SOC losses for all PK levels, ranging from -0.04±0.09 Mg ha^{-1} yr^{-1} (ns) for the lowest to -0.09±0.07 Mg $ha^{-1}yr^{-1}$ (p=0.008) for the highest P level, while crop yield and thus estimated carbon input increased with PK fertilization by 1, 10 and 13% as compared to the unfertilised control. This is essentially new. We attributed this to three known mechanisms, whereby P fertilization either: i) stimulates heterotrophic respiration, ii) reduces the abundance of arbuscular mycorrhizal fungi or iii) increases the crop root to shoot ratio, which leads to reduced root-derived carbon inputs. The relative importance of these three individual mechanisms for SOC dynamics is unknown, which encouraged us to investigate all potential mechanisms on the same set of soil samples. Our preliminary results suggest a pronounced positive effect of P on heterotrophic respiration, and currently we are investigating the possibility of the latter two potential mechanisms.

5. Conclusion

A net negative effect of P fertilization on SOC stocks has not been observed before and the mechanisms behind it are rarely understood. This finding underlines the upcoming awareness that soil nutrient levels are important for SOC cycling and might have to be considered in ecosystem models. For a holistic understanding of underlying processes, the approach of investigating several potential mechanisms at the same time on the same samples is promising and necessary.

O 2.1.02

Incorporation of ^{13}C labelled root-shoot residues in soil in the presence of *Lumbricus terrestris*: An isotopic and molecular approach

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Litter from plant biomass deposited on soil surface can either be mineralized; releasing CO_2 to the atmosphere, or transferred into the soil as organic compounds. The two pathways depend on biotic factors such as litter characteristics and the activity of soil organisms. During the last decades, many studies have focused on the origin of organic matter, with a particular attention to the fate of root and shoot litter (Mambelli et al., 2011). It is generally admitted that roots decompose at a slower rate than shoots, resulting in a higher carbon sequestration in soil for compounds originating from roots (Rasse et al., 2005; Steffens et al., 2015). Earthworms play a central role in litter decomposition and carbon cycling, ingesting both organic and mineral compounds which are mixed, complexed and dejected in the form of casts at the soil surface or along earthworm burrows (Blouin et al., 2013). The simultaneous impact of earthworms and root-shoot on soil carbon cycling is still poorly understood.

This study aimed at **(1)** defining the rate of incorporation of root and shoot litter with or without earthworms and **(2)** characterizing the evolution of the molecular composition of soil organic matter upon litter decomposition. A mesocosm experiment was set up to follow the incorporation of ^{13}C labelled Ryegrass root and shoot litter in the soil, in the presence of anecic earthworms (*Lumbricus terrestris*). Soil samples were collected at 0-20 and 40-60 cm, as well as surface casts, at the beginning and after 1, 2, 4, 8, 24 and 54 weeks of experiment. Organic carbon content and $\delta^{13}C$ values were determined for all the samples with Elemental Analysis - Isotope Ratio Mass Spectrometry. Lipids extracted from soil and casts samples were analyzed with Gas Chromatography-Mass Spectrometry.

Roots and shoots were incorporated in the 0-20 cm soil layer during the year of experiment, the carbon from labelled litter (C_{lab}) reaching 11.4 % after 54 weeks (**Fig.1**). On the contrary, no significant incorporation was observed in the 40-60 cm layer. An earthworm effect on litter incorporation was observed in casts from the very first weeks of experiment (C_{lab} from 34.8 to 51.4 % after 2 weeks - **Fig.2**) and in soil after 24 weeks (**Fig.1**). Earthworms accelerated root and shoot decomposition in soil. Roots decomposed at a slower rate compared to shoots. However, after one year, earthworms erased the difference between residue types in casts (**Fig.2**) and to a lesser extent in soil (**Fig.1**), revealing their capacity to decompose both roots and shoots. To address the role of the chemical composition of root and shoot litter in these processes, the evolution of molecular biomarkers in soil and casts is under study.

Fig.1. Carbon from labelled litter measured in soil samples at the 0-20 cm layer, for the seven time steps, in mesocosms with labelled residues (n=3). A significant difference between mesocosms was revealed after 24 weeks, thus the letters above histogram bars represent statistical results of Kruskal-Wallis test; different letters indicate significant difference between mesocosms, for a given time step. Root and Shoot: mesocosms with roots and shoots litter, respectively. E: with earthworms, NE: without earthworms.

Fig.2. Carbon from labelled litter in casts sampled in mesocosms containing roots (Cast-Root) or shoots (Cast-Shoot) (n=3). Letters above histogram bars represent statistical results of Kruskal-Wallis test, different letters indicate significant difference between mesocosms, for a given time step.

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Figure 1

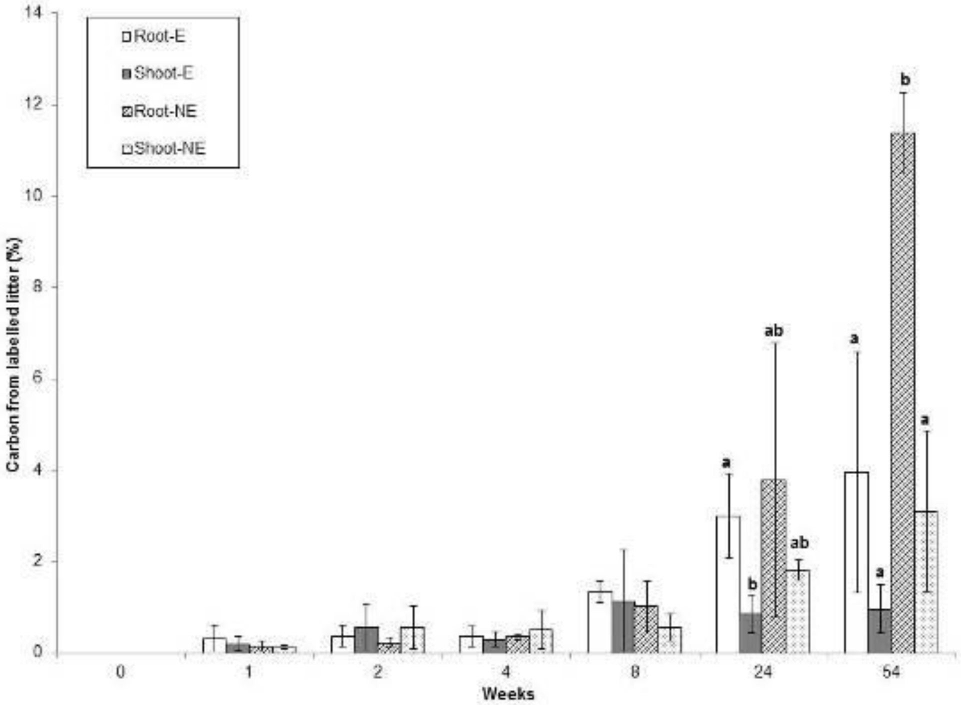
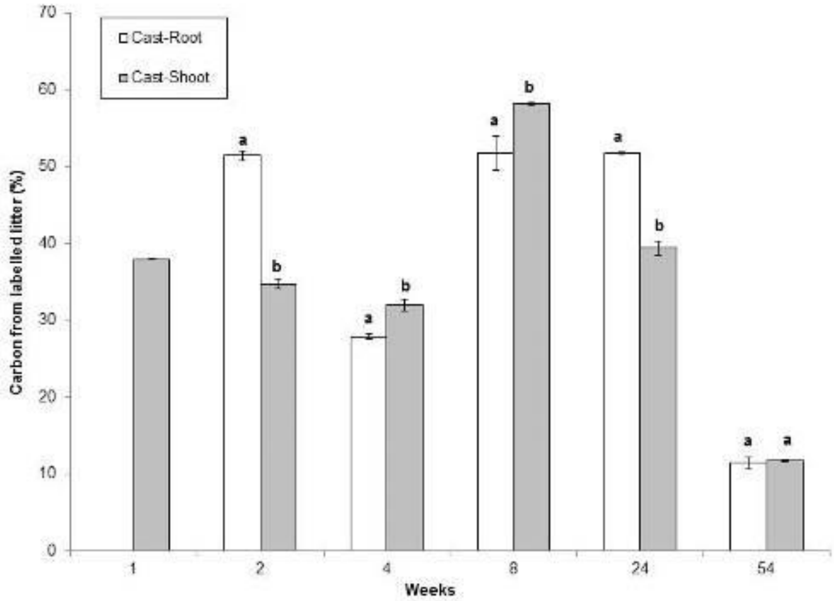


Figure 2



O 2.1.03

Soil nitrogen availability alters rhizodeposition carbon flux into the soil microbial community

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Question: Soil microorganisms are important in the cycling of plant nutrients. Soil microbial biomass, community structure and activity are mainly affected by carbon substrate and nutrient availability. The objective was to test if both the overall soil microbial community structure and the community utilizing plant derived carbon entering the soil as rhizodeposition were affected by soil C and N availability.

Methods: A ^{13}C-CO_2 steady state labelling experiment was conducted in a ryegrass system. Four treatments were established: control; amendment with carboxymethyl cellulose (CMC); amendment with ammonium nitrate (NF); combined CMC and NF. Soil phospholipid fatty acid (PLFA) and ^{13}C labeling PLFA were extracted and detected by isotope ratio mass spectrometer.

Results: The application of inorganic N fertilizer combined with organic C significantly enhanced soil microbial biomass C and N, but had lower soil inorganic N concentrations. There was no significant difference in soil PLFA profile pattern between different treatments. In contrast, most of the ^{13}C was distributed into PLFAs 18:2ω6,9c, 18:1ω7c, and 18:1ω9c, indicative of fungi and Gram-negative bacteria. The inorganic-only treatment was distinct in ^{13}C PLFA pattern from the other treatments in the first period of labelling. Factor loadings of individual PLFAs confirmed that Gram-positive bacteria had relatively greater plant-derived C contents in the inorganic-only treatment, but fungi were more enriched in the other treatments.

Conclusions: Amendments with appropriate stoichiometric C and N ratios can improve N transformation processes, and the ryegrass rhizodeposition carbon flux into the soil microbial community is strongly modified by soil N availability.

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Figure legends

Fig. 1 Relative abundance (mol %) of total PLFAs (a) and 13C-PLFAs (b) at the end of labelling. CK: control; CMC: organic carbon alone; NF: N fertilizer alone; CMC+NF: combined organic carbon and N fertilizer. Values are means ± s.d. (n = 3)

Fig. 2 Principal component analysis of the relative abundance (mol %) of 13C PLFAs of individual soil samples after labelling 5 days (a), 10 days (b), and 15 days (c). CK: control; CMC: organic carbon alone; NF: N fertilizer alone; CMC+NF: combined organic carbon and N fertilizer. Values are means ± s.d. (n = 3).

Figure 1

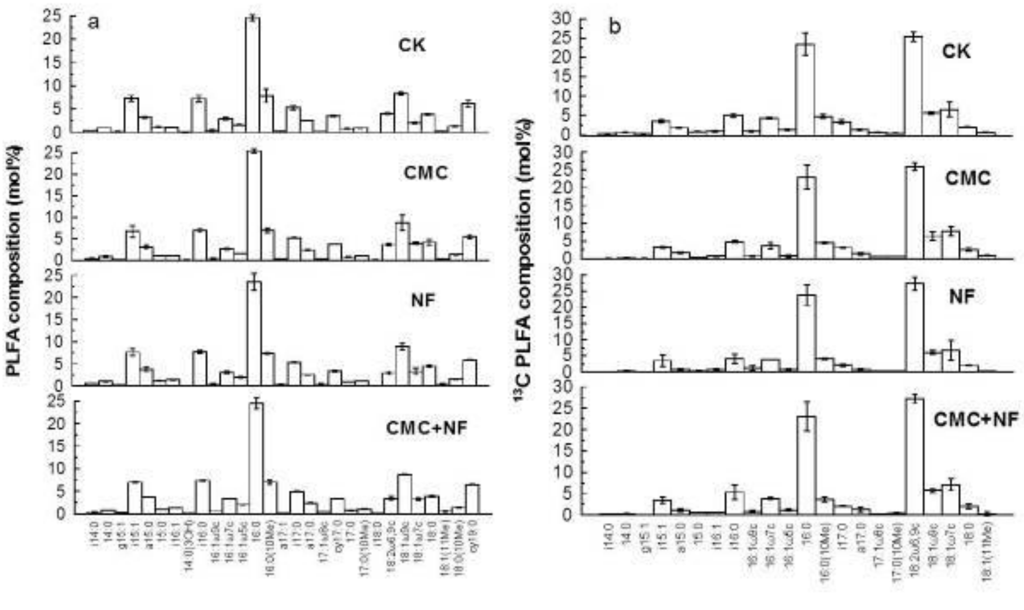
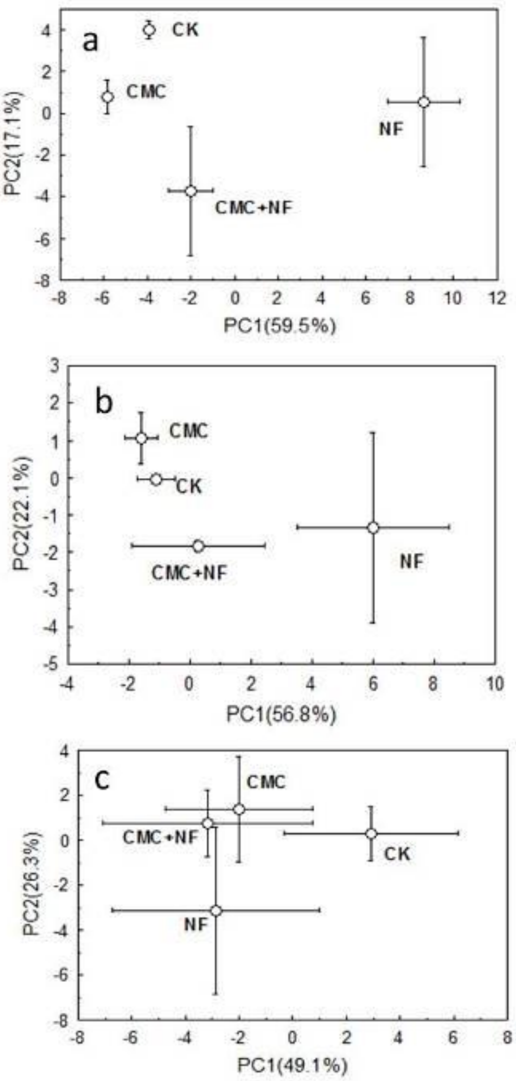


Figure 2



O 2.1.04

Long-term irrigation affects root growth and decomposition in a drought stressed Alpine Scots pine forest

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Introduction

Predicted future climatic shifts are expected to result in intensified drought periods. The inner Alpine Valleys of Switzerland are well known for intense drought periods during the summer months which have led to increased mortality of native Scots pines (*Pinus sylvestris*). Tree roots have the important task of water uptake. Therefore, root adaptation and acclimation to drought are a crucial element for survival. Not much is known about long-term acclimation and root plasticity potential of mature trees to drought. Increasing mortality leads to an increase of root litter, which is an important carbon input to soils. Thus, decomposition of root litter becomes decisive for carbon sequestration. Abiotic factors like water availability are known to change decomposition rate, less well studied are the impacts of the biotic factors (e.g. microbial community).

Objectives

We aim to detect pine fine root acclimation to long-term drought and reactions to drought release. Following the root decomposition with focus on involved microorganisms, we attempt to trace the microbial succession from early to late stage decomposers. With a focus on the recalcitrant lignin in the roots the decomposition state of the roots is monitored.

Materials & methods

An irrigation treatment in a Scots pine forest ('Pfynwald', Valais, Switzerland) was induced to release drought stress during the summer months. Irrigation has been running for 12 years. Fine root biomass was measured by soil coring at various time points. Rooting depth was recorded down to 2 m soil depth. Irrigated and control roots have been sampled after 11 years irrigation. Mean fine root age was addressed by ^{14}C radio carbon dating. For a decomposition study, two types of roots (fine, coarse) were buried (5 cm depth) in 1 mm mesh nylon litterbags. Every 3 months during summer period the litterbag roots and soil samples have been collected and analyzed. The remaining weight of root litter was measured. The lignin fingerprint using cupric oxide extraction was measured with gas chromatography-mass spectrometry (GC-MS, Duboc *et al*., 2014). The colonizing and decomposing bacteria and fungi have been identified using next-generation sequencing (Rime *et al*., 2015) and compared to the present soil community.

Results

In comparison to aboveground traits, the acclimation of belowground traits was relatively small and slow (Brunner *et al*., 2009; Herzog *et al*., 2014). Irrigation did not result in a shift in rooting depth but in an increase of fine root biomass in the topsoil after 9 years irrigation. The irrigation initiated new roots to grow, which reduced the mean root age from 10 to 5 years. By combining the results from shifting lignin fingerprint of decomposing roots with shifts in the microbial communities, conclusions to the functioning of specific microbial groups can be drawn.

Conclusions

Tree roots provide a vast amount of carbon to the soil system and largely contribute to the formation of soil organic matter. Decreasing water availability influences root litter quality and decomposition and, therefore, can affect the carbon sink potential positively. The importance of root derived carbon input is mostly underestimated and needs more consideration in the overall carbon budgeting.

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O 2.1.05

In situ assessment of belowground carbon allocation, and turnover and stabilization of 'new' root-derived organic matter in soil using novel ^{13}C-^{15}N pulse labelling of contrasting crop management systems

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Introduction

Improved crop management practices can increase soil carbon (C) by increasing plant-derived organic matter (OM) input to soil and by decreasing the turnover rate of relatively 'new' plant C inputs and 'old' native soil C. This understanding can be enhanced through an *in situ* integrated assessment of belowground allocation of recently assimilated C, turnover of 'new' root-derived and native soil C, and stabilization of 'new' root- and microbial-derived C and nitrogen (N) in soil aggregates under contrasting crop management systems.

Objectives

The objectives of this study were to evaluate the influence of tillage intensity and/or N fertilisation influence, under *in situ* field conditions, on (i) assimilate partitioning in canola and wheat systems, including belowground C allocation; (ii) fate and stabilization of 'new' root-derived OM in soil aggregates and/or (iii) turnover of 'new' root-derived and 'old' native C in soil.

Materials & methods

We conducted *in situ* pulse labelling of crop-soil systems, with $^{13}CO_2$ (5 or 10 L 99 atom% $^{13}CO_2$ *via* plant fixation) and ^{15}N-urea (1 or 2 kg ^{15}N ha^{-1}), covering an area of 1.5 × 2.0 m or 1.8 × 2.0 m under field conditions in New South Wales, Australia. The experimental sites include (i) a one-year old crop rotation trial (established in 2012) in Wagga Wagga, and (ii) a 16-year old farming system trial (established in 1998) in Condobolin. In Wagga Wagga, the pulse labelling of the canola crop on a Red Kandosol was conducted during the flowering stage (9-11 September 2013) across four management treatments *i.e.* a factorial combination of conventional tillage (CT), no-till (NT), and 0 and 100 kg urea-N ha^{-1} treatments. In Condobolin, the pulse labelling of the wheat crop on a Red Chromosol was conducted during flowering (15-16 September 2014) across two management treatments (CT *vs.* reduced tillage, RT). After pulse labelling, plant and soil samples were collected for 45−49 days for total C, total N, $\delta^{13}C$ and $\delta^{15}N$ analyses in various pools (plant parts, soil microbial biomass, whole soil and soil aggregates). A dry sieving method was used to separate soil into large macro- (2−6.5 mm), small macro- (0.25−2 mm), and micro-aggregates (in situ static-chamber alkali absorption method was used to determine soil CO_2 efflux and associated ^{13}C to partition the efflux into autotrophic (root) and heterotrophic (soil) respiration using a two-pool (soil and root) C isotopic model.

Results

In the Wagga Wagga site, soil $\delta^{13}C$ and $\delta^{15}N$ were enriched by 1.6−2.5‰ and 70−240‰, respectively, 2−3 days after pulse labelling, and remained consistently enriched over 45 days. Soil C and N concentrations and soil C-to-N ratio were higher under CT, especially in the fertilised treatment, than NT. However, the dynamics and magnitude of 'new' soil C and N, as well as microbial biomass C and N, were similar across the management treatments.

In the Condobolin site, wheat leaf and stem were rapidly $\delta^{13}C$ enriched one day after $^{13}CO_2$ pulse-labelling, with the leaf $\delta^{13}C$ of 480−540‰ and stem $\delta^{13}C$ of 491−494‰ on the first day. This was followed by a rapid decrease in the leaf $\delta^{13}C$ to 90−100‰ within 16 days, which was then stabilized, suggesting a rapid allocation of the recently fixed C from leaves to the other above- and below-ground compartments. The initial wheat stem $\delta^{13}C$ decreased relatively slowly to *ca.* 340‰ until harvest. The wheat stem was significantly $\delta^{13}C$ enriched under CT than RT after labelling. The level of $\delta^{13}C$ enrichment became similar across the CT and RT treatments at harvest, thus suggesting greater C allocation from wheat stem to other plant parts under CT than RT.

The management practices (CT and RT) did not affect soil C and N concentrations. Microbial biomass C was either similar or lower in RT than CT. In the static-chamber study, preliminary results showed similar C emission rates from different components (roots + soil, soil, roots) across the management treatments.

Conclusions

The results showed a rapid and significant labelling of the crop-soil system using *in situ* ^{13}C and ^{15}N pulse labelling to allow tracking of 'new' C and N in plant components and soil fractions. In both sites, preliminary results suggested a lack of effect of crop management practices on the dynamics and magnitude of 'new' C and N in the whole soils. Further isotopic analysis of soil microbial biomass, aggregate fractions and CO_2 efflux will provide insights into whether the crop management practices influence (i) stabilization of root- and microbial-derived C and N in soil aggregates, and (ii) *in situ* turnover of native soil C associated with root-derived OM input.

O 2.1.06

Decomposition of tree roots over a decade is dependent on species and temperature

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1. Introduction

The first step of the transformation of root litter to soil organic matter is the decomposition of the roots. This process is rather long-lasting and dependent on many factors such as the tree species or the temperature. However, decomposition experiments over a decade are rather rare.

2. Objectives

Here we present quantitative and qualitative data on the decomposition of tree roots in dependence on the temperature over a decade. Hence, litterbag studies were conducted in three different forest types in Switzerland, in European beech (*Fagus sylvatica*), in sweet chestnut (*Castanea sativa*), and in Norway spruce (*Picea abies*) forests.

3. Materials & methods

At five forest sites, including two elevation gradients ranging from 600 to 1200 m (beech) and from 1200 to 1800 m a.s.l. (spruce), respectively, litterbags containing 1 g of dried fine root material were buried at 5 to 10 cm soil depth into the topsoil of the corresponding forest types. Per forest site and altitude, four plots were installed, and per time point, five litterbags were excavated. Temperature loggers were installed at every site and altitude. After 0, 1, 2, 5, and 10 years the litterbags were excavated, the dry-mass weighed, and C, N, and lignin contents measured. Of selected samples, lignin monomers after CuO oxidation were analysed.

4. Results

After ten years of decomposition, the remaining mass of the initial root material was between 5% and 18%. Spruce roots tended to decompose faster than the roots of the broad-leaved trees, and the roots in general tended to decompose slower with increasing altitude. After a decade of decomposition, the remaining lignin of the root litter was between 7% and 23% of the initial lignin content. The tree species, the temperature, and the lignin/N ratio seem to be major factors in the determination of the decomposition rates. First results of the early-stage decomposition were published by Heim and Frey (2004), and modelling approaches using the carbon model Yasso07 by Didion et al. (2014).

5. Conclusion

The gradient study offers useful insights into root and lignin decomposition patterns under future warming scenarios, and suggests that the highest elevation may be most susceptible to global warming.

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O 2.1.07

Mycorrhizas: Pipeline or Director of Belowground C Fluxes?

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Understanding the fate of carbon (C) allocated to the soil is important to influence C sequestration in ecosystems. Roots direct resources in form of carbohydrates to nutrient patches, and both their biomass and exudates fuel carbon compounds into the soil spaces they are exploring. What role do their root symbionts mycorrhizal fungi play? Do arbuscular mycorrhizal fungi (AMF) constitute a nutrient patch for the plant on a root cellular level? Can AMF be viewed as the extended phenotype of the root, or do they give additional attributes to the carbon distribution and stability in soil?

We found that AMF, or roots through AMF, directed 5-fold more ^{13}C to OM patches, compared to plain soil in a field experiment. While in a pot experiment AM fungal colonization did not alter the total amount of ^{14}C belowground allocation of the model grass species *Brachypodium distachyum*, there was a strong preferential C allocation to the AM colonized root part of split-root systems, receiving double the amount of C than the non-colonized root system side. This preferential carbon allocation to mycorrhized roots stopped abruptly when P limitation of the plant was lifted, demonstrating the differential, targeted C belowground allocation during nutrient foraging of the plant.

While these results point to a plant directed C flux to nutrient patches via AMF on a centimeter scale, we also found evidence that on micrometer scale there may be processes in C allocation which are special to AM fungi: We found that the ^{13}C coming from a donor plant to an AM fungus was substantially allocated to the intraradical mycelium in a neighboring C-starved root. This could be interpreted as using a C-starved root as a storage space safe from predators. We also found hyphae colonize remote pore spaces of black carbon particles which are inaccessible for plant roots, and likely unattractive to decomposers. Such carbon compounds may become ‘protected’ against decomposers, and may be more recalcitrant simply due to its location in soil space. Thus, we want to discuss the importance of the spatial location of sequestered C in soil aggregate space for its long-term stability.

O 2.1.08

Long-term controls of soil C and N stabilization dynamics in a temperate forest

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Introduction. While the factors controlling plant litter decomposition rates in soils are increasingly well understood, the controllers and pathways of the litter-derived carbon (C) and nitrogen (N) from decay to stable soil organic matter (SOM) formation remain unclear.

Objectives. In this study, we addressed how litter type (fine roots *versus* needles) and placement depth in the soil (O *versus* A horizon) affect C and N retention and stabilization among SOM fractions in a temperate conifer forest soil after 5 years *in situ*.

Materials & methods. We followed the fate of dual $^{13}C/^{15}N$-enriched fine roots and needles placed either in the O or in the A horizon within soil mesocosms and among SOM fractions isolated from the A 14C-MRT = 5 y), the humic fraction (i.e., accessible ionizable mineral-associated SOM; ^{14}C-MRT = 140 y) and the humin fraction (i.e., mineral-associated SOM forms that are non-ionizable or physically inaccessible due to mineral assemblages or micro-aggregation; ^{14}C-MRT = 260 y).

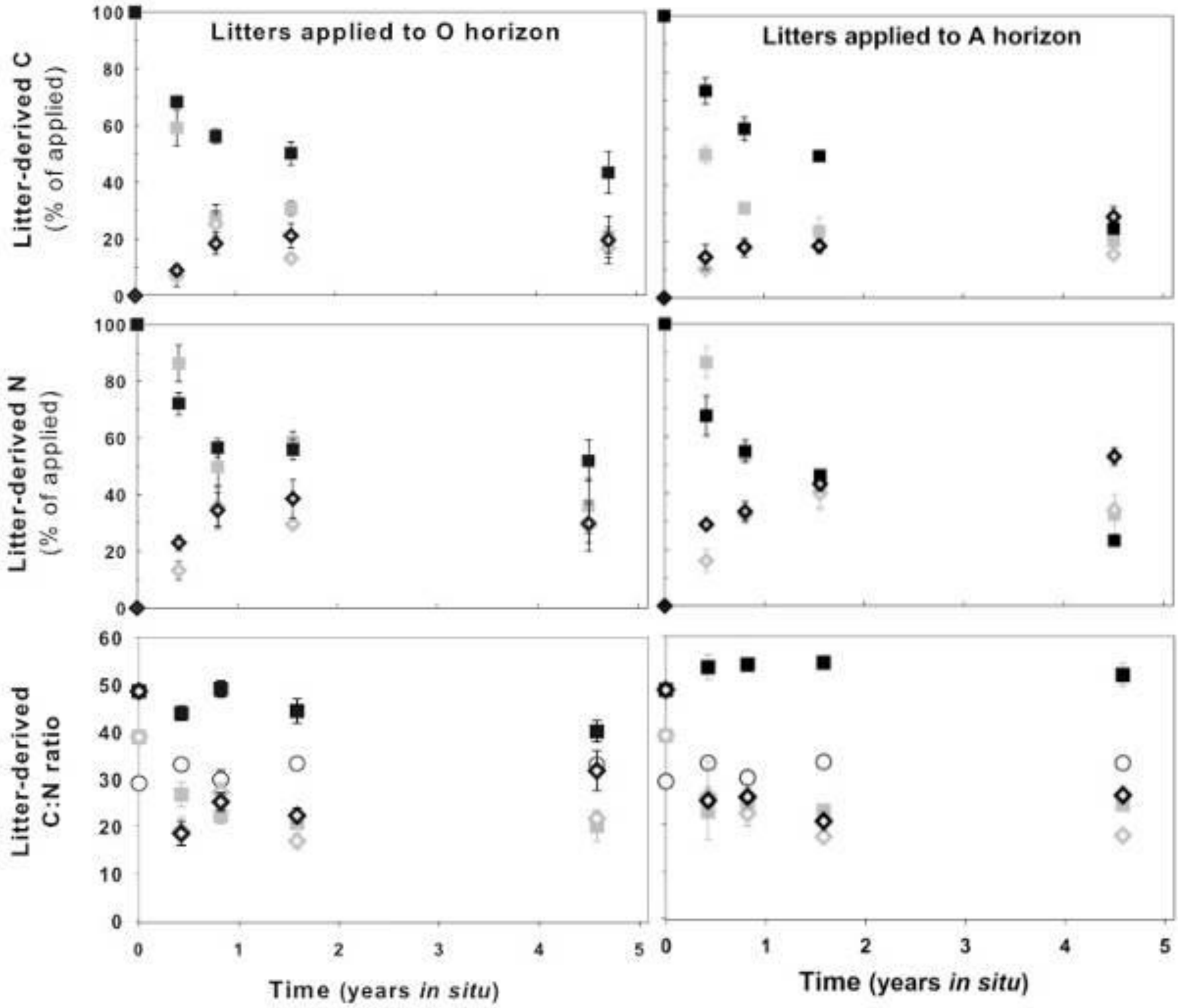
Results. Litter type rather than placement-depth controlled soil C and N retention after 5 years *in situ*, with belowground fine root inputs greatly enhanced soil C (x1.4) and N (x1.2) retention compared with aboveground needles (Fig. 1). Fast-cycling fine root fragments alone explained the greater fine root C and N recoveries. Litter type controlled the pathways to stable SOM formation by determining the accumulation rate into the mineral bulk soil (Fig. 1), the partitioning and the stabilization dynamics among SOM fractions with distinct degrees of stability. While the proportions of added needle and fine root-derived C and N recovered into stable SOM fractions were similar, they followed different transformation pathways into stable SOM fractions: fine root transfer appeared slower than for needles, but proportionally more of the remaining needle-derived C and N was transferred into stable SOM fractions (+192 and +64 %, respectively) than for fine roots (Fig. 2). The stoichiometry of litter-derived C *versus* N within individual SOM fractions revealed the presence at least two pools of different turnover times (per SOM fraction) and emphasized the role of N-rich compounds for long-term persistence. Finally, a model generated from the first 1.5 years data successfully predicted fine root-derived C recoveries after 5 years, but underestimated soil C retention by 21% and 45%, for needles placed in the O and A horizon.

Conclusion. Fine roots and needles followed different stabilization dynamics and pathways from decay to stable SOM formation, with the delayed transfer of fine roots to stable SOM fractions and the relatively greater contribution of needle to stable SOM. We show that decadal predictions of needle C dynamics in soils should account for the fact that once the labile C is exhausted, the remaining C is relatively stable to not underestimate soil C retention. Our results suggest that current models may underestimate soil C retention from litter with fast decomposition rates.

Figure 1. Fine root (black symbols) and needle (grey symbols) derived C, N and C:N ratios in particulate litter >2mm (squares) and in the soilin situ. Litter-derived C and N are expressed as percent of applied. Circles represent the native soil C:N ratios measured at each of the 4 sampling dates. Data are shown as means ± standard errors (N = 4 field replicates).

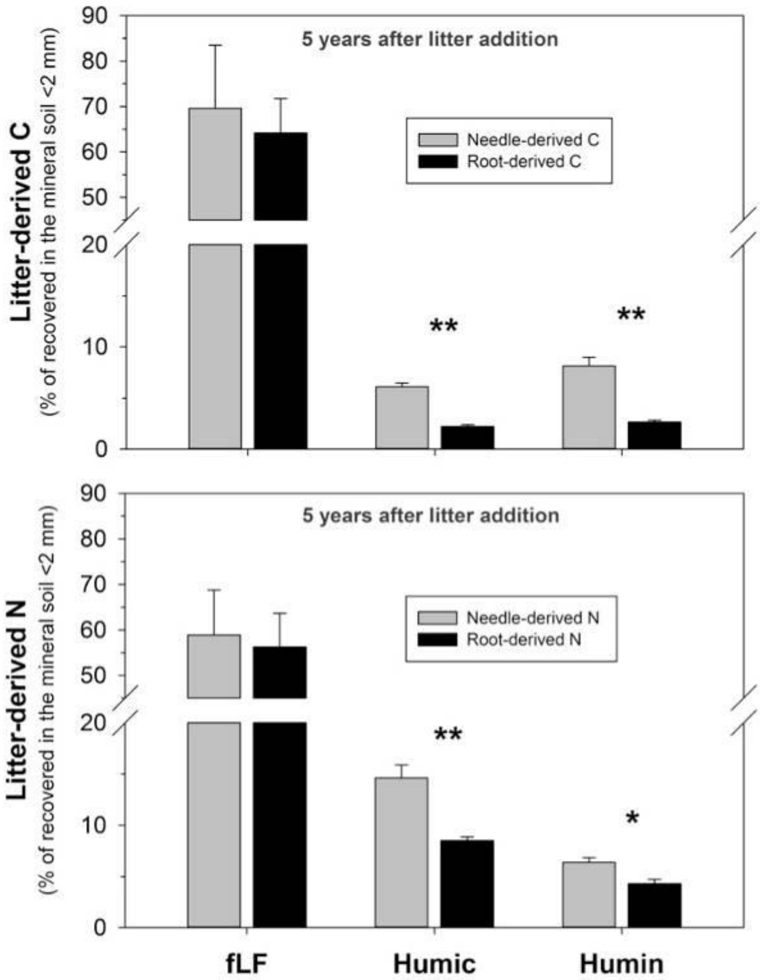
Figure 2. Litter-derived C (upper panel) and N (lower panel) among SOM fractions expressed as percent of litter-derived C or N recovered in the mineral bulk soil (Ain situ. Needle-derived C and N are shown in grey bars. Root-derived C and N are shown in black bars. fLF means free light fraction. Statistical differences with a significance level of P

Figure 1



Litters applied to O horizon
Litters applied to A horizon
Litter-derived C
(% of applied)
Litter-derived N
(% of applied)
Litter-derived
C:N ratio
Time (years *in situ*)
Time (years *in situ*)

Figure 2



5 years after litter addition
Needle-derived C
Root-derived C
Litter-derived C
(% of recovered in the mineral soil <2 mm)
**
**
5 years after litter addition
Needle-derived N
Root-derived N
Litter-derived N
(% of recovered in the mineral soil <2 mm)
**
*
fLF
Humic
Humin

O 2.1.09

Dynamics and stability of SOM of Chinese fir plantation forest in Subtropical China

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In order to understand soil organic carbon dynamics and the underlying mechanisms in subtropical plantation forest, we investigated the soil organic carbon pool and the active pool in plantation forest stands in chronosequence during transformation of natural forest into conifer plantation of single species and introduction of broadleaved tree species into conifer plantation using the regional survey and space-time substitution methods; analyzed the contribution of aboveground litter and underground roots to CO_2 efflux and organic carbon pool in plantation using DIRT experiment, probed the biomarker of different carbon source for soil formation through plant chemistry and metabonomics method. We also studied the relationship between external organic carbon addition and native soil organic carbon stability through ^{13}C-stable isotope tracer. The microbial community and its role in soil organic carbon turnover and the distribution of added organic carbon in different microbial groups were examined by ^{13}C-PLFA method.

Our regional survey illustrated the soil organic carbon dynamics and the mechanisms during the vegetation conversion in subtropical China. The declines in SOC pool during the conversion of natural forest into plantation is mainly attributed to the unreasonable management practice, such as land preparation and slash burning. Using the regional survey data, we demonstrated for the first time that the development of Chinese fir plantation is a process of SOC accumulation on the whole, but SOC pool showed a significant decline after establishment, and then an increase after middle-age stage, indicating that soil carbon sequestration would benefit from an extension of current rotation after middle age. In addition, introduction of broadleaved tree species into plantation forest can enhance SOC pool to a certain degree.

DIRT results showed that the contributions of aboveground litter and roots to the total soil CO_2 efflux are similar at 22.3% and 20.1%, respectively, and root C input has greater influence on soil microbial community composition than the aboveground litter C input. Through plant chemistry and metabonomics method we found that Chinese fir alcohol and acids were species-specific, could be used as a biomarker of aboveground C input into soil, and flavanol with spiro dimmers could serve as the biomarker of underground C input.

^{13}C-stable isotope experiment showed that the extent of priming effect is related to the external organic carbon type and the inorganic nitrogen form. The microbial demand for nutrient, such as N and P, is the mechanisms for SOC stability and priming effect. The stability of SOC in deep soil is mainly caused by the lack of fresh litter input. ^{13}C-PLFA results show that microbes with 16:0 and 18:1w9c have higher utilization of labile substrate, and play an important role in SOC stability and priming effect.

O 2.1.10

Shoots and roots chemical composition controls on microbial physiological and metabolic responses during their decomposition

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Introduction

A more explicit description in model of the microbial-mediated process of decomposition of plant litter is essential to better predictions of ecosystem evolutions. Microbes secrete extracellular enzymes into the environment that are substrate-specific, catalyze degradation of plant litter polymers and they assimilate soluble products of substrate degradation. Shoot and root litters show contracted chemical composition controlling nutrients availability for microbial life (Amin et al. 2014). Interesting frameworks have been proposed to unravel the physiological (stoichiometry, growth, assimilation) and metabolic (substrate affinity, panel of enzyme secreted) aptitudes of microbes interacting during decomposition (Moorhead and Sinsabaugh 2006, Moorhead et al. 2012), but parameter values are now expected for these models.

In this work we designed an experiment to characterize simultaneously some physiological aptitudes, metabolic investments in key hydrolytic and oxidative enzymes and “return on investment” gained by microorganisms. We used a model microorganism, a filamentous fungus selected because it belongs to one of the major functional groups of decomposers.

Materials and methods

Microcosms with 5 g DM of maize leave, stem and root litter were inoculated with the basidiomycete *Phanerochaete chrysosporium* and incubated at 25°C during 18 weeks. C mineralized was measured in CO_2 traps changed regularly. After 14, 28, 56, and 126 days of incubation, 3 replicates of each litter type were collected for the analyses of fungal biomass, enzymes activities, and chemical composition of the remaining litter. Fungal biomass was quantifying using ergosterol content. Enzymes assayed were endo-1,4-ß-glucanase (EG), endo-1,4-ß-xylanase (EX), 1,4-ß-glucosidase (BG), L-leucine aminopeptidase (LAP), N-acetyl-glucosaminidase (NAG), and laccase (LAC). Specific enzyme activities (in µmol h^{-1} mg^{-1} fungal-C) were calculated dividing enzyme activities by fungal C. Efficiencies of EG, EX, and BG enzyme activities were calculated dividing enzyme activities by cumulative CO_2 mineralized. Ratios of hydrolytic C-acquiring enzyme (EG, EX, BG) and N-acquiring enzyme activities (NAG, LAP) were calculated. Chemical analyses included C, N, soluble, cell wall sugars, and klason lignin contents.

Results

Phanerochaete chrysosporium colonized the litters and mineralized respectively 29, 14, and 13 % of initial C of maize leaves, stems and roots after 18 weeks (Fig. 1). At its maximal state of growth, it represented respectively 211, 47, 41 mg fungal-C g^{-1} DM for leaves, stems and roots, with a C:N ratio of 7.1. The leaves induced high fungal C assimilation (CUE), high C mineralization thus low specific respiration while the stems and roots induced low assimilation and C mineralization. Specific enzyme activities were the highest when the fungus grew on roots (except for LAP) showing its strong investment in enzyme activities whereas stems induced the lowest investment in enzyme acquisition. The production of CO_2 per unit of enzyme secreted (enzyme efficiency) was the highest on stems and lowest on roots. These contrasted physiological and metabolic features between the leaves, stems and roots could be explained by the differences in chemical compositions of the litters (Fig 2), the dissolved organic N and C, arabinose and lignin contents mainly explaining the strategies the fungus adopted on different litter types.

Conclusion

An increasing number of models representing mechanistic interactions between plant litters and microorganisms during decomposition have been proposed. Acquiring parameter values for these models is challenging, in particular for their physiological and metabolic features. For these reasons, we designed an experiment selecting a basidiomycete as a model microorganism and we characterized its growth strategies on litter shoots and roots with contrasted chemical composition.

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Moorhead, D.L., Lashermes, G., Sinsabaugh, R.L., 2012. Soil Biology & Biochemistry 53, 133-141.

Fig 1. C mineralized (mg CO2 g^{-1} substrate-DM) and fungal C (mg fungal C g^{-1} substrate-DM) dynamics during incubation of the basidiomycete *Phanerochaete chrysosporium* on maize leave, stem and root litters (n=3).

Fig 2. Biplot of a redundancy analysis (RDA) representing the physiological and metabolic behaviors of *Phanerochaete chrysosporium* incubated on maize leave, stem and root litters.

This study was supported by the Environment and Agronomy division of the National Institute of Agronomic Research (INRA) and the University of Reims Champagne Ardenne (URCA).

Figure 1

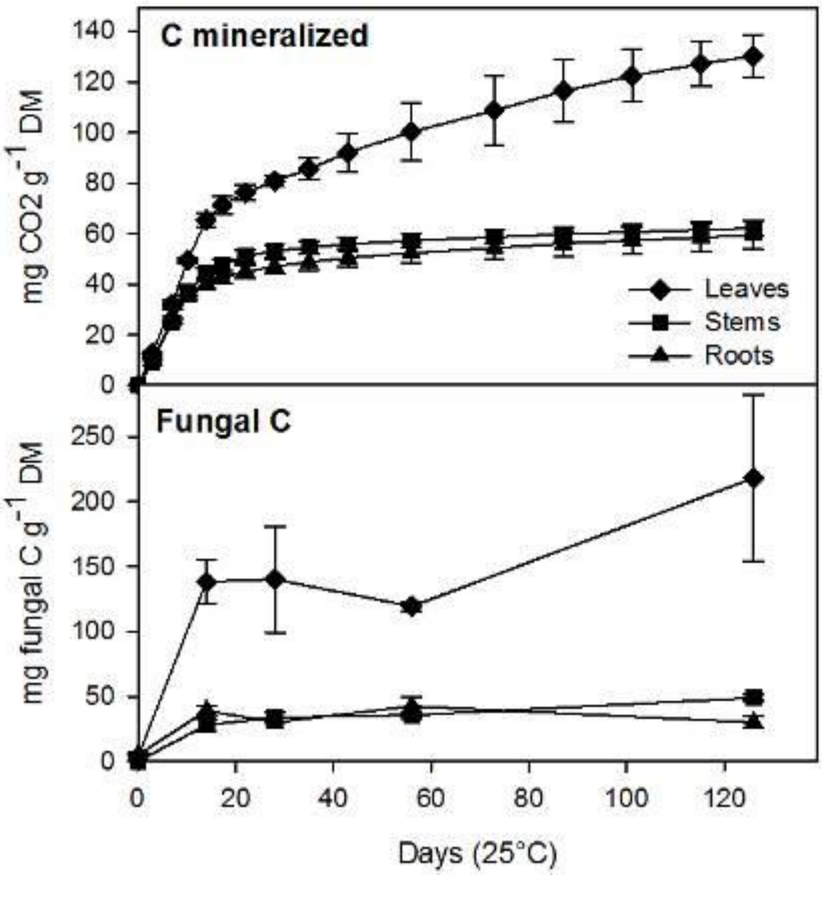
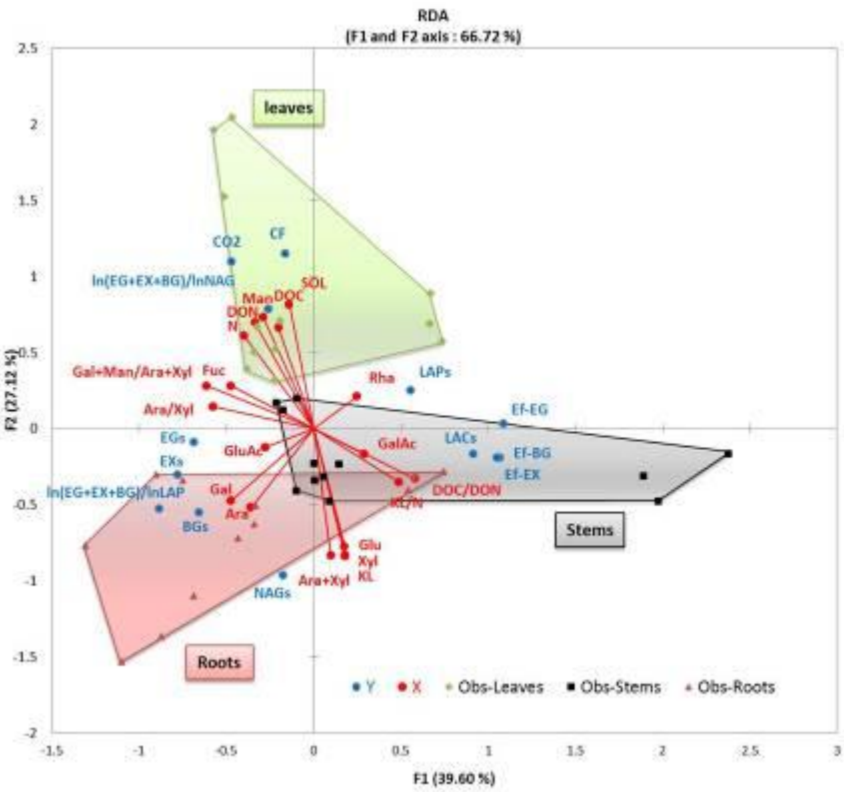


Figure 2



Y variables : C mineralized (CO2), Fungal C (CF), specific enzyme activities (EGs, BGs, EXs, LAPs, NAGs, LACs), enzyme efficiencies (Ef-EG, Ef-BG, Ef-EX), relative enzyme investments for C or N acquisition (ln(EG+EX+BG)/lnNAG or lnLAP).

X variables : dissolved organic C (DOC) and N (DON), total N (N), Van Soest soluble (SOL), arabinose (Ara), glucose (Glu), xylose (xyl), galactose (Gal), rhamnose (Rha), mamnose (Man), fucose (Fuc), glucuronic (GluAc) and galacturonic (GalAc) acids, klason lignin (KL).

O 2.1.11

Application of infrared spectroscopy for assessing the mass proportions of different plant species in root biomass samples and peat soil

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Fine root production is a major carbon flux in many peatland ecosystems but least understood because of methodological difficulties. Species-level information on fine root biomass and production is very limited. This is partly due to practical constraints for visual identification. Recently, applications for identifying roots of different plant species in root mixture using infrared spectroscopy have been reported (e.g., Roumet et al. 2006, Picon-Cochard et al. 2009, Lei & Bauhus 2010, Laiho et al. 2015). Infrared spectroscopy is a fast and easy method to study chemically complex samples. Infrared spectra can be utilized either for directly interpreting the absorbance intensities at different wavelengths, or, as is more commonly done in ecological applications, for building so called calibration models based on calibration data consisting of samples with known composition; these models may then be used to predict the composition of unknown samples.

Our objective was to build calibration models for predicting mass proportions of 18 common forest and peatland plant species, both arboreal and herbaceous, in root mixtures. For peat soils, we also tested the possibility to predict the mass proportions directly in soil samples, i.e. without separating the roots.

Infrared spectra were measured from dried and powdered samples. About 1200 of artificial mixed samples containing known amounts of fine roots of different plant species (and peat soil) were prepared for model calibration and validation purposes. Partial least squares (PLS) regression was used to build the calibration models.

The models estimated the proportion of each species in root mixtures with good accuracy (standard error of prediction generally <10%). In addition, the models also provided satisfactory estimates of root mass directly in soil samples. We suggest that use of infrared spectroscopy for estimating the mass proportion of roots saves time and manual work and may be applied in inventorying fine root production in peatlands.

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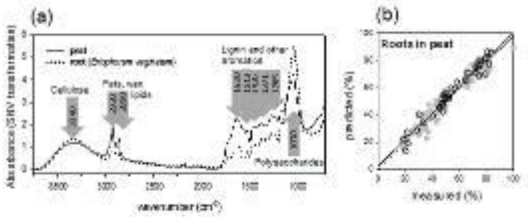
Figure 1.

a) Example of infrared spectrum of peat (full line) and root (dotted line), with interpretation of the main absorbtion bands. b) Model estimating root proportion in peat. Gray symbols represent the calibration samples, black symbols the validation (testing) samples.

Figure 1



O 2.1.13

^{13}C and ^{14}C tracer techniques for studies of crop and soil management effects on soil organic matter constituents

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Inputs of organic carbon from crops and crop residues are a critical resource for sustainable agricultural production. Their retention in agricultural soils is the primary means of sustaining levels of soil organic matter and for enhancing the diversity and activity of soil organisms. Recently, there has been an increased interest in crop residue management and its role in soil organic carbon (SOC) dynamics because of its potential for sequestering atmospheric C, thereby slowing the rate of increase in atmospheric CO_2 concentrations, and because alternative uses for these residues as biofuels and bio-products have been proposed. Adoption of conservation tillage practices has been recommended as a management practice to increase SOC levels compared to conventional mouldboard ploughing and other intense tillage practices. With adoption of conservation tillage there is a redistribution of SOC within the surface soil layers, with higher concentrations at the soil surface and much lower concentrations below. Since the stocks of soil organic C (SOC) are controlled by (i) the amounts of crop residue returned to the soil, (ii) the rate of decomposition of crop residues, and (iii) the rate of decomposition of native soil organic matter (SOM), measurements of the effects of tillage management on residue decomposition are essential for understanding the effects of tillage on SOC dynamics.

Much of our understanding of crop residues decomposition is derived from studies that have utilized C isotope (^{14}C- and ^{13}C-labelled crop residues) tracer techniques to investigate the decomposition rate of crop residues, the stabilization of the decomposition products and the turnover of soil organic matter. This presentation will describe research on the effects of tillage management and cropping systems on the decomposition of crop residues and on the turnover of soil organic C in the sub-humid continental climate of southern Ontario, Canada.

A long-term study was initiated in 1990 to quantify the effects of tillage practices on the residue decomposition rate of five commonly grown crops under conditions simulating farm practices, and ii) to derive constants for kinetic models describing crop residue decay. The study was initiated by pulse-labelling five annual agricultural crops: corn (Zea mays L.), soybean (Glycine max L.), winter wheat (Triticum aestivum L.), winter rye (Secale cereale L.) and tobacco (Nicotiana tobaccum L with ^{14}C-CO_2 during the entire growing season. Mature above- and below-ground ^{14}C-labelled plant residues were contained in microplots and typical farm management, conventional mouldboard plough/disc (CT) or conservation tillage (RT), was practiced. The amounts of crop residue-derived C remaining in soils were measured at intervals since. Decomposition of the residue C was greater under CT than under RT during the initial phase of decomposition, indicating that the incorporated residues were exposed to a more favourable environment for microbial activity compared with surface-applied residues. Kinetic analysis of residue decomposition showed that residues managed under CT had a larger labile component with a faster rate of decay and a smaller resistant component with a slower decay rate than RT. The equation, $C_t = 81.8\ e^{-1.45t} + 18.2\ e^{-0.0769t}$, was proposed to model residue decomposition in conventionally tilled systems. Models describing crop residue decomposition in RT systems were significantly different from those describing decomposition in CT systems. Residues managed under RT had a slower decomposition rate than crop residues managed under CT during the initial period of rapid decomposition. For all crop residues, surface applied residues (RT) had a smaller labile pool with lower rates of decomposition and a larger resistant pool with faster rates of decomposition than residues incorporated into the soil (CT). As an example, decay of corn stover under RT can be described by $C_t = 75.1\ e^{-1.29t} + 24.9\ e^{-0.077t}$. Based on the decay rates of the more resistant C remaining, the C retained in RT was stabilized to a lesser degree than that remaining in CT by the end of the study.

Total organic C and $\delta^{13}C$ of soil were measured in the experiments involving corn cropping to determine the effect of tillage practices on SOM dynamics. RT altered the distribution of C_4-C in soil, causing the surface (0-5 cm) to have higher amounts of C_4-C compared to CT. However, the total amount of corn-derived C in the 0 to 50 cm soil and the turnover of C_3-C in soil were not significantly affected by the tillage practices.

P 2.1.01

Effects of Forage Legume Covers on Soil Organic Matter Content in the Northern Guinea Savanna of Nigeria

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The emphasis of this work was to ascertain the effect of some legume residues incorporated into the soil on soil organic matter content. To accomplish this, greenhouse and field studies were conducted in the Northern Guinea Savanna zone of Nigeria. In the greenhouse foliage residues of six (*Centrosema pascuorum, Chaemocrista rotundifolia, Cajanus cajan, Centrosema brasilianum, Stylosanthes hamata* and *Luecaena leucocephala*) and Maize Stover were incorporated into pots at two levels of 2.5 and 5.0 t ha $^{-1}$. A control of no amendment was maintained. The experimental design was a Randomized Complete Block Design and replicated three times. The materials were incubated for two weeks and Maize (Oba super II) was planted. In the field five legume species (*Centrosema pascuorum, Chaemocrista rotundifolia, Cajanus cajan, Centrosema brasilianum* and *Pueroria phaseoloides*) were grown for two years in a Randomized Complete Block Design and replicated three times. The residues found on each plot were incorporated into the soil manually using a hoe. The direct and residual effects were observed at the first and second year (2010 and 2011) respectively. Results from the two studies showed that, residues incorporation significantly ($P > 0.05$) increased soil organic matter than the control treatment. Among the legume species treatments, differences in soil organic matter were observed and it must have been as a result of differences in the quality of the legume residues incorporated. The application rate of 5.0 t ha $^{-1}$ gave higher soil organic matter content than 2.5 t ha $^{-1}$rates in the Greenhouse. This suggests that it may be more beneficial to incorporate after two years of growth than one year because of the quantity and quality of materials that will be available for incorporation.

P 2.1.02

Distribution of Root-derived Carbon in Particle-size Fractions of Soil from a Paddy Treated with Rice Cultivars

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The purpose of the research was to help solve the food security problems for the rapid growing population of the world. Super rice with high yield and root biomass has been gradually expanding its use in agriculture. Moreover, higher root biomass can promote soil stabilization. Topsoil (0-15 cm) and rhizosphere soil were sampled at the harvest of different rice (*Oryza sativa* L) cultivars in the middle and lower reaches of the Yangtze River. The collected soil samples were separated into four particle-size fractions. After removal of free lipids with sequential extraction, the residual bound lipids in the soil were obtained with saponification and derivatisation, the a, ω-dicarboxylic acids (diacids) from the lipids, were quantified by gas chromatography. Diacids were used as biomarkers for root-derived carbon to assess the input of organic carbon (OC) into soil from the tested crops. The diacids content in fine sand (200-20 µm) and silt sized (20-2 µm) fractions contributed by over 80% to preservation of the total diacids in the soil. There was a significant correlation of the diacids to OC contents of individual size fractions for the rhizosphere samples (*p*

P 2.1.03

Maize root-derived C in soil and role of physical protection in its relative stability over shoot derived C

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1. Introduction

Due to the increasing demand for biomass the focus has been directed towards currently non-harvested crop residues and this raises the importance of belowground residues within the soil organic carbon (SOC) balance. Several meta-analyses of field experiments have indicated that the on the long run SOC levels often remain unexpectedly unaffected by the removal of the aboveground biomass from the field. This has triggered several investigations into the relative stability of above- vs. belowground biomass derived SOC, most often considering maize as model crop. From these research efforts it is now clear that root-derived C remains about two times longer in the soil as stabilized SOC than shoot-derived C (Rasse et al., 2005).

2. Objectives

The importance of several hypothesized mechanisms responsible for the stabilization of root-derived C and the interactions with agricultural management are still not well understood. Our objective is to specifically investigate the role of physical protection of root-derived C in microaggregates. We hypothesize that intimate contact of maize roots during growth preferentially promotes physical occlusion and stabilization of root-derived C in microaggregates, when compared to above-ground maize derived C. We furthermore hypothesize that both soil texture and maize cultivar determine total root biomass.

3. Materials and methods

We compared plough layer SOC from selected crop rotational treatments of three long-term European maize-based crop rotation field experiments, viz. the 32y Puch Field trial (South-Germany), the 22y Tetto Frati platform (North-western Italy) and the 12y Bottelare trial (North Belgium). All sites specifically included non-manured objects to exclude input of ^{13}C-enriched organic matter from other sources than below- or above-ground maize biomass. To investigate our primary hypothesis, we used a physical fractionation scheme based on Virto et al. (2008) to specifically isolate physically protected C. Maize root DM was furthermore assessed in three Belgian field trials (sandy, sandy loam and clay) for 8 maize cultivars.

4. Results

The physical fractionation combines mild disruptive wet-sieving with glass beds, sedimentation-aspiration and density fractionation at 2.4g cm^{-3} and this has resulted in isolation of free sand sized C, silt-sized intra-microaggregate particulate organic matter, and free silt sized C and clay sized C. Specific preferential accumulation of maize root-derived C (as indicated from the C-isotope ratios) in micro-aggregate organic matter over maize shoot-derived C would confirm our hypothesis. We currently compare silage and grain maize rotations to investigate this. Maize root dry matter differed significantly amongst the three textures and was not affected by cultivar, although the included cultivars originated from three different vendors.

5. Conclusion

At present, ^{13}C/^{12}C-analysis of soil fractions is on-going and complete results for all three experimental sites will be presented at the Göttingen SOM conference. A faint interactive effect between the factors soil texture and cultivar seems to suggest that root biomass response to texture was cultivar specific. At present maize root systems have been successfully visualized in 12 soil monoliths by X-ray CT scanning. The on-going quantification of their architecture will further elucidate differences in root systems in these cultivar/soil texture combinations.

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P 2.1.04

Particulate Organic Matter and its Relation with Enzyme Activity in a Semiarid Alfisol under different Management Systems

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Conservation Agriculture has been recognized as a sustainable management system in semiarid areas as it tend to improve soil structure, to increase labile organic carbon content and to induce microbial community shifts towards more stable communities. Rainfed cropping in these areas frequently suffers of water scarcity due to low and irregular rainfalls. Semiarid soils are often coarse textured with low soil organic matter (SOM) content and they are prone to degradation. A better understanding of the processes involved in SOM stabilization and its related C-cycle enzymes are key factors for improving C sequestration and nutrient availability.

Our objective was to study the effect of tillage practices on particulate organic matter (POM) content and on those enzymes directly related to SOM breakdown, like β-glucosidase and FDA hydrolysis.

The present study was conducted in a long term split-plot experimental design located in Spain. Soil was classified as a *Calcic Haploxeralf*. Different tillage practices (Conventional Tillage (CT), Minimum Tillage (MT) and No Tillage (NT)) have been tested since 1994. In October 2013 we collected soil samples (0-7.5 and 7.5-15 cm depth) and we measured Soil Organic Carbon (Walkley and Black, 1934), Particulate Organic Carbon (Cambardella and Elliot, 1992), β-glucosidase activity (Strobl and Traunmüller, 1993) and FDA hydrolysis (Green et al. 2006). Analysis of variance was performed using PROC GLM (SAS Institute) to asses management influence on the measured parameters. Significant mean effects were separated with a lsm post hoc test with Tukey adjustment (α=0.05)

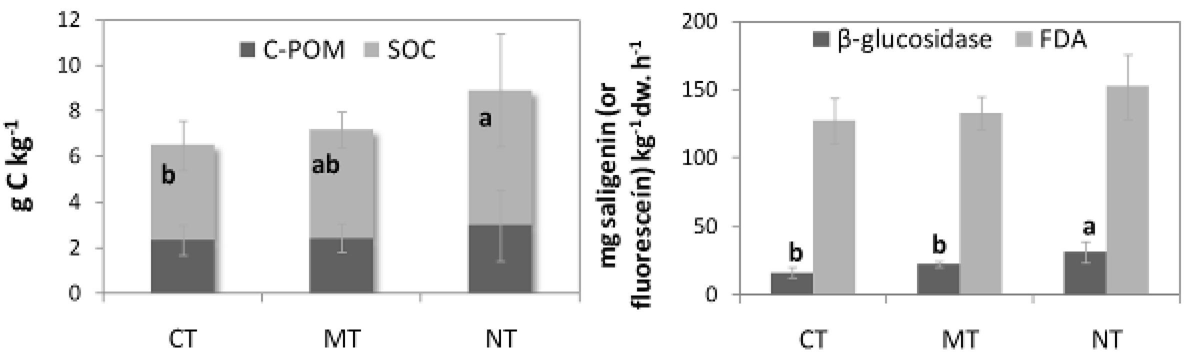
Depth was the more influencing effect on the measured parameters with lower values in the deeper layer (Table 1). All the parameters were higher on the surface under NT but only SOC content and β-glucosidase activity showed significant differences within tillage practices (Fig 1). Low C-POM content under ML and NL may have been the result of low crop residue incorporation from previous harvest. Pearson correlation coefficients showed that C-POM better correlated with SOC and β-glucosidase activity than with FDA hydrolysis. Both β-glucosidase and FDA hydrolysis were highly correlated.

Long term NT promoted higher SOC accumulation compared to CT, which in turn enhanced C-cycle enzymatic activity and SOM stabilization processes.

Figure 1

	SOC	C-POM	C-POM/SOC	β-glucosidase	β-glucosidase/SOC	FDA
				Pr > F		
Tillage	0.1877	0.5247	0.0065	0.0005	0.01	0.3989
Depth	0.0004	0.0003	0.0003	<0.0001	<0.0001	<0.0001
T*Depth	0.0047	0.0371	0.2133	<0.0001	0.0003	0.0211

Figure 2



g C kg-1
C-POM
SOC
b
ab
a
12
10
8
6
4
2
0
CT
MT
NT
mg saligenin (or fluorescein) kg-1 dw. h-1
β-glucosidase
FDA
200
150
100
50
0
b
b
a
CT
MT
NT

P 2.1.05

The relationship between tree above- and belowground C inputs and cutin and suberin presence in soil

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In western North America, climate change and management have promoted the encroachment of conifers into aspen forests. Aspen soils in Utah contain more stable soil organic carbon (SOC) than nearby conifers, and it is unclear how conifer encroachment will affect size and stability of current SOC pools. The contribution of tree foliage and root turnover to SOC stocks can vary by tree species due to differences in inputs, redistribution and chemistry of detritus. In Utah precipitation occurs mainly as snow and snowmelt may be a major pathway of C redistribution and stabilization of foliage and root C.

The goal of this study is to characterize the above- and belowground C inputs to aspen and conifer soils in Utah, their redistribution via snowmelt water, and the relationship between these fluxes and storage and stabilization of root and shoot derived C in the mineral soil.

Soils, roots, foliage litterfall and soil pore water from snowmelt were sampled in montane aspen and conifer forests in Utah. Soil samples (0-50 cm; in 10 cm increments) were fractionated into a light and two mineral SOC fractions. Organic C was analyzed in each fraction and bulk soil. Dissolved organic C (DOC) was analyzed in soil pore water. Fine root distribution was determined from root cores and foliage litterfall was collected with multiple littertraps. Origin (foliage vs roots) of SOC was determined from cutin and suberin derived lipids, extracted from soil and tissue samples with alkaline hydrolysis and analyzed with gas chromatography-mass spectrometry.

If hydrological redistribution of debris is minor then we expect cutin-derived lipids (indicative of foliage) to be most abundant in the topsoil decreasing with soil depth, and suberin-derived lipids (indicative of roots) to follow root distribution. If, however, snowmelt water is important to C redistribution then conifer stands could have a higher cutin abundance with depth compared to aspen due to higher DOC concentrations in the soil pore water. However, higher DOC concentrations under these conifers have not resulted in higher bulk SOC stocks, potentially suggesting a greater importance of roots in SOC stabilization in these systems. Our results will allow us to clarify the effect of tree species on SOC stocks and potential changes due to vegetation shifts.

P 2.1.06

Soil organic carbon turnover and straw decomposition under different nitrogen regimes on a calcareous soil revealed by ^{13}C labelling

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Crop straw incorporation and nitrogen (N) fertilization, two typical practices in the intensive farming system of China, could effectively impacted the soil organic carbon (SOC) turnover. However, there are much difficulties in tracing the fates of external and native C due to the high carbonate content in this region and the possible interactions between SOC and soil inorganic carbon (SIC). A 224-day laboratory incubation was implemented with different application rates of ^{13}C labeled maize straw (0, 1×, 3× and 5× of maize straw yield) and N(0, 300 and 600 kg N ha^{-1} a^{-1}) to investigate the decomposition of external straw carbon (C) and native SOC, as well as the effects of C and N input rate on ^{13}C allocation in different sized aggregates on a calcareous soil. The research found that maize straw was rapidly rapid decomposed after being added into the soil, and the decomposed amount in the first 10 days accounted for about 50% of that within the 224-day incubation period. CO_2 emissions from the maize straw can be simulated by a logarithmic equation. N input had a significant retardation effect on maize straw decomposition. Maize straw incorporation resulted a significant positive priming effect on native SOC in the first 2 weeks after the incubation, and decreased to a low level thereafter. Native SOC decomposition was highly correlated with the external straw C input. Within the 224-day period, there was about 6.4%, 8.7%, 11.7% and 14.4% of native SOC loss due to the priming effect. The higher native SOC decomposition was found in middle level N input (300 kg N ha^{-1} a^{-1}) than in N levels of 0 and 600 kg N ha^{-1} a^{-1}. Straw incorporation significantly increased the mass proportion of macro-aggregates (0.25-2 mm) but decreased the silt+clay fraction (<0.053 mm) in the bulk soil. Straw and N both did not have significant effects on SOC change in macro- and micro-(0.053-0.25 mm) aggregages but both and straw×N have significant impacts on SOC level of silt-clay fraction. Within a short term, contribution of external straw C to SOC was mainly attributed to macro-aggregates. Sequestration rate of C associated with silt+clay fraction and bulk soil decreased with the increase of external straw C, suggesting that there might be a threshold of carbon saturation in the soil. These findings indicated that in intensive farming system, straw incorporation and high N fertilization may have coupled effects on SOC turnover and should be integrated on the development of optimized farming practices .

Keywords: ^{13}C, priming effect, straw incorporation, N fertilizer, calcareous soil

P 2.1.07

Digging the deep soil food webs

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Organic carbon in deep soil horizons contributes strongly to the total carbon storage and dynamics (Ekblad et al., 2013; Fontaine et al., 2007; Schmidt et al., 2011). It is usually assumed that soil invertebrates regulate microbial processes that control soil carbon turnover, but deep soil is rarely studied by soil zoologists. Meanwhile, several specialized taxa of Collembola, Oribatida, Diplura, Protura, and other groups may be relatively abundant in deep soil layers (Andre et al., 2002). These small arthropods inhabit voids and burrows created by earthworms, other larger animals and especially by decomposing plant roots. Indeed, a large amount of carbon is allocated belowground by the plant roots, and this carbon largely drives deep soil biological activity (Fontaine et al., 2007; Rumpel and Kögel-Knabner, 2011). Deep soil animals are therefore expected to be linked to the “root carbon” as the main energy source. Nevertheless, trophic links of soil animals in deeper horizons are virtually unknown.

Here we report preliminary results of a study on the trophic interactions of deep soil animals. We aimed to reveal (1) do different groups of deep soil animals differ in their trophic niches; (2) to which extent deep soil animals are trophically linked to plant roots; and (3) do certain taxa of soil animals retain the same trophic position in upper and deeper soil layers. These questions were addressed using bulk stable isotope composition of carbon and nitrogen. Patterns of the stable isotope fractionation at basal levels of detrital food webs are relatively well understood. In this study, we relayed mainly on the consistent difference in the stable isotope composition between plant roots and SOM, between plant roots and associated microorganisms, and between soil animals and their food sources.

Samples were collected in a deciduous Oak forest and in a small Padus grove in forest steppe. At each site, soil profiles were excavated and soil samples taken with an interval of 10 cm down to the depth of 180-200 cm. Animals were extracted using Tullgren funnels. Along with animals, samples of soil and roots were taken. Stable isotope analysis was conducted using a Thermo-Finnigan Delta V Plus continuous-flow IRMS. Stable isotope composition expressed in delta units ($\delta^{13}C$ and $\delta^{15}N$). Soil samples were subsequently divided into “upper soil” (leaf litter and 0-20 cm of mineral soil) and “deep soil” (30-200 cm of mineral soil).

The $\delta^{13}C$ and $\delta^{15}N$ values were higher in SOM relative to plant roots. The difference in $\delta^{13}C$ values between roots and soil was more pronounced in the deciduous forest, while the difference in $\delta^{15}N$ values was more pronounced in the forest-steppe. The $\delta^{15}N$ values in SOM and animals were 1-2.5‰ higher in deep soil relative to those in the upper soil, though the differences in $\delta^{13}C$ values were relatively small. In both ecosystems animals were enriched in ^{15}N relative to roots by about 4‰. In the deciduous forest the difference in $\delta^{13}C$ values between animals and roots averaged 3.1 ± 1.2[SD]‰, while in forest steppe it was only 1.8 ± 0.8‰. As a rule, enchytraeids were slightly but significantly enriched in ^{13}C relative to collembolans. In the upper soil layers of the deciduous forest, $\delta^{15}N$ values were significantly higher in poduromorph than in entomobryomorph collembolans (8.1 ± 1.8 and 3.2 ± 2.6‰, respectively). In contrast, in the deep soil Poduromorpha were depleted in ^{15}N relative to Entomobryomorpha (6.8 ± 1.3 and 10.2 ± 1.1, respectively). In the forest steppe the isotopic difference between Poduromorpha and Entomobryomorpha was not pronounced.

Overall, these data indicate that (1) studied groups of animals (poduromorph and entomobryomorph collembolans, and enchytraeids) differ in trophic niches, which suggests the presence of a spectrum of food strategies/resources available for deep soil inhabitants. (2) The enrichment of animals in both ^{13}C and ^{15}N as compared to plant roots may indicate a participation of SOM in their C and N nutrition. It is however more likely that this enrichment is created by feeding on the root-associated microorganisms. (3) Trophic position of certain groups of soil animals can differ considerably in the upper and lower soil horizons. In particular, isotopic evidence suggests that entomobryomorph collembolans feed mainly on saprotrophic microorganisms in the upper soil, but on the mycorrhizal fungi in the deep soil.

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P 2.1.09

Stabilization of root-derived organic matter by physical and chemical association with soil minerals

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Although much recent research has indicated that root organic carbon is preferentially stabilized in the soil compared to aboveground biomass, its stabilization mechanisms in soil and its contribution to the soil carbon stock are still relatively unknown. In this study, we combine physical density separation and isotopic (CHN) analysis to understand how root derived organic matter is stored in soils, whether freely or stabilized within aggregates and/or by organo-mineral associations in upper soil horizons (up to 1 m). Here, we will present results on compound specific analyses (lignin phenols, amino acids, etc.) of roots and soil organic matter in physical and chemical association with soil minerals to infer on stabilization potential of root-derived organic matter in soil. The study is being conducted on a climosequence in the southern Sierra Nevada Mountain range (USA). Preliminary results at our lowest elevation site indicate that the isotopic signature of root organic matter is more reflected in the occluded soil fractions compared to the faster cycling free-light soil fractions, which is likely more influenced by above-ground biomass. This suggests that mineral association is an important mechanism for root organic matter stabilization and possibly less so for shoot organic matter stabilization.

P 2.1.10

Morphology, biomass and changes in C and N contents of different root order fine root in sub-tropical *Cunninghamia lanceolata* forest

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Question: Fine root systems (diameter < 2 mm) as an important component of plant roots absorb water and nutrients from the soil to meet the needs of plant transpiration and photosynthesis.It can be affect plant growth and morphogenesis, and paly an important role in nutrient cycling ,carbon allocation, energy flow and material cycles in ecosystems.Chinese fir(*Cunninghamia lanceolata*)(CF) is one of the dominant, timber and afforestation tree species in subtropical, many studies have shown that there are some differences in the structure, function and nutrient content of Chinese fir artificial(ACF) and natural(NCF) forests. There also have studies showed that certain differences in decomposition, biomass, and spatial distribution of fine root in ACF and NCF forest.

Methods: This study was conducted in Jiangxi province, sub-tropical China, aiming to understand the morphology(include Diameter, Specific root length:SRL,Root length density:RLD and Root number per unit:RN), biomass and changes in C and N contents of fine root of different root order(1-5) in sub-tropical artificial middle-aged and natural mid succession CF forest.

Results: ⅰ) Biomass,diameter and C content was increasing, but the N content, SRL、RLD and RN was decline with the increasing of fine root order in ACF and NCF forest; ⅱ) Biomass of each fine root branch order has significantly different from artificial in ACF and NCF forest. and the biomass of different fine root branch order NCF forest had a incresing than the ACF forest;ⅲ)Each branch order diameter of fine root the ACF larger than NCF forest, and the front four root branch order diameter of fine root increased by 64.0%, 37.1%, 37.2% and 21.3%;ⅳ) the lower branch order(1、2、3) of fine root have a significantly different in diameter, SRL、RLD and RN, But the higher have no significantly different ; the C and N content of first-order fine root have a significantly different in ACF and NCF forest; ⅴ) Biomass of each fine root branch order in different soil layer have a significantly different in ACF and NCF forest; fine root diameter, SRL、RLD、RN and C、N content in the lower two root orders(1、2) have a significantly different in ACF forest, but these results shows in the lower three root orders(1、2、3) of NCF forest.

Conclusions: There have a significantly different in morphology and nutrient content compare the the lower root orders(1、2) fine root with the higher; and the lower root orders fine root that have absorption function which show high SRL、RLD and N content; and the higher order fine root (4,5) have a larger diameter and a higher C content, biomass in ACF and NCF forest. The lower root orders fine root of two different forest types and each forest type of different soil layer have a significantly different in morphology(include diameter, specific root length:SRL,root length density:RLD and root number per unit:RN), biomass and C、N contents.

Figure 1

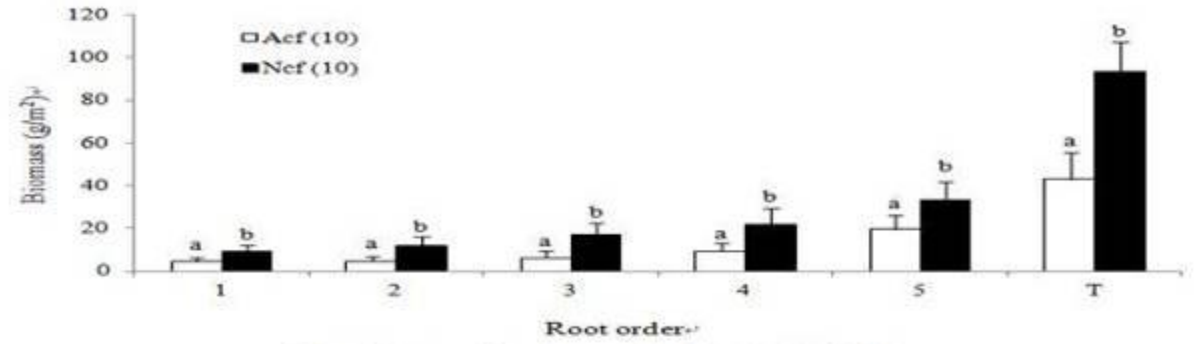

Fig.1 Biomass of each root order fine root in CF forest.

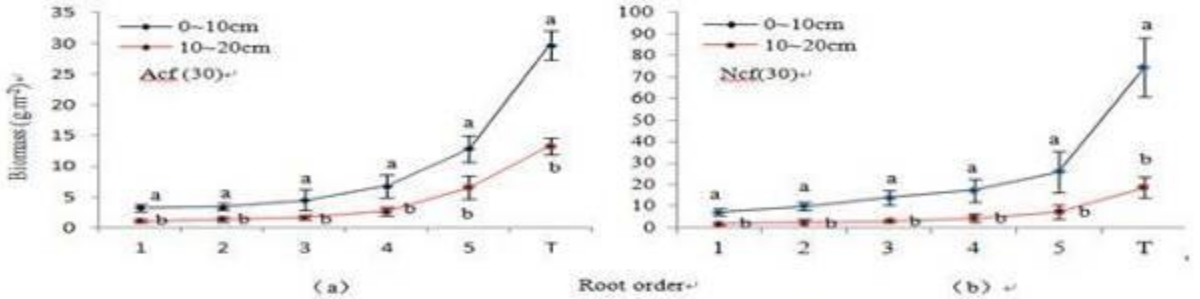

Fig.2 Each root orders fine root biomass in different soil layers of CF forest

Figure 2

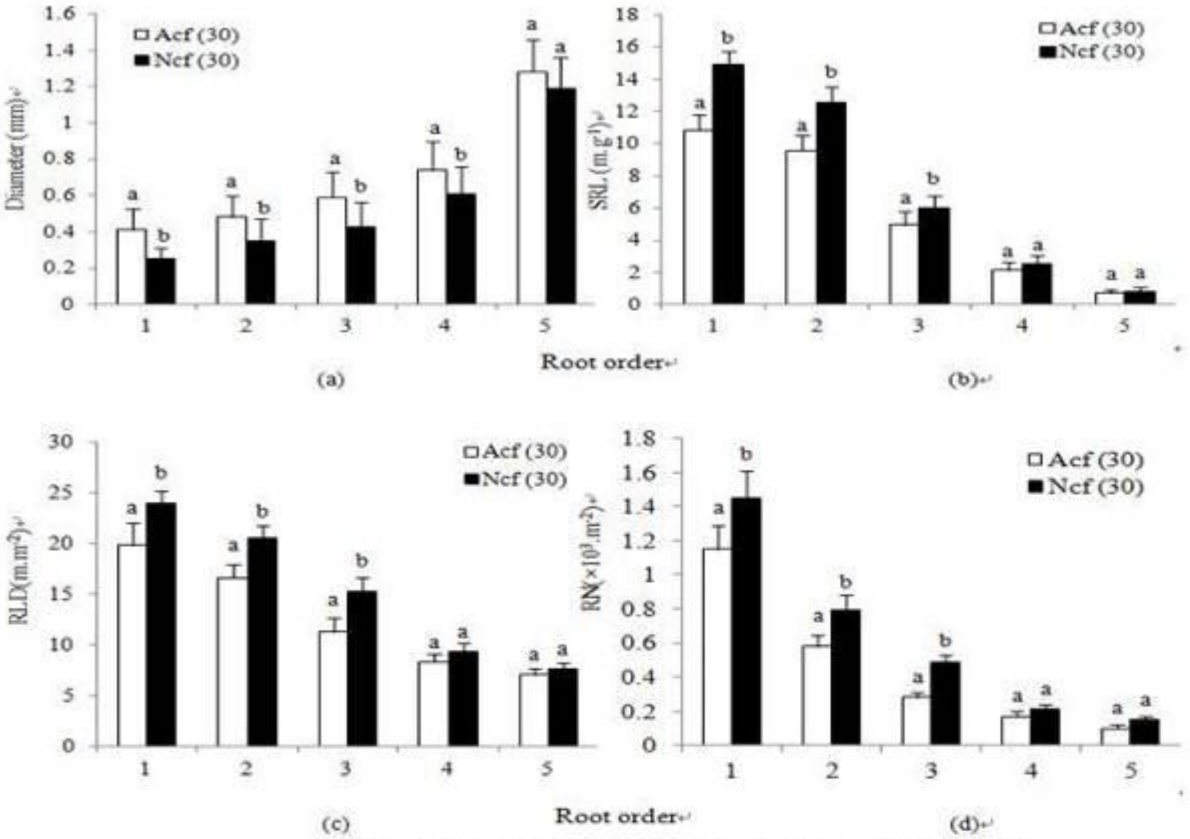

Fig.3 Morphology indicators of each root order fine root in CF forest

P 2.1.11

Do soil animals feed on mycorrhizal fungi?

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Large amounts of C are allocated belowground through the plant roots/mycorrhiza channel, but the fate of this C is unclear. In boreal and temperate forest soils, ectomycorrhizal (ECM) fungi constitute an important component of the belowground microbial biomass (Wallander et al., 2001, 2004) and play a crucial role in ecosystem functioning. Main part of root-derived carbon is respired by biotrophic and saprotrophic microflora in the rhizosphere, but it was demonstrated that extramatrical mycelium of ECM fungi contributes significantly in the formation of soil carbon storage (Clemmensen *et al.*, 2013; Ekblad *et al.*, 2013). Fungivorous invertebrates strongly influence the composition of soil fungal communities (Parkinson *et al.*, 1979; Crowther *et al.*, 2011) and can affect C reallocation among ecosystem pools by preferential feeding on mycorrhizal or saprotrophic fungi. Elucidating the role of ECM fungi in soil food webs is therefore of crucial importance for understanding the mechanisms controlling C cycling in ECM-dominated ecosystems. Surprisingly, very little is known on the participation of extramatrical mycelium of ECM fungi in detrital food webs.

In this study we used published and original data to elucidate the importance of ECM fungi as a food source for soil animals in temperate and boreal forests. We consider three lines of evidence that used different experimental approaches.

(1) Direct experiments in field or laboratory settings estimated the reaction of certain groups of soil organisms (mainly microarthropods) on the interruption of the carbon flow from trees to ECM fungi (e.g. by girdling). These experiments demonstrated that only a small subset of animal taxa reacted negatively to the decreased resource supply via ECM fungi (e.g. Remen et al. 2010).

(2) Direct experiments using whole-tree isotope labeling monitored the consumption of the root-derived carbon by various groups of soil animals. Earlier experiments of this kind (e.g. Pollierer et al. 2007) demonstrated a very pronounced inclusion of the “root carbon” in soil food webs. Nevertheless, detailed mechanisms and pathways linking soil animals with plant roots remain unknown. Root carbon can be incorporated by direct phytophagy, feeding on mycorrhizal fungi, feeding on saprotrophic root-associated microorganisms in the rhizosphere, or a combination of these pathways. Indeed, a recent study of Pollierer et al. (2012) showed that root carbon can reach soil animals via both, bacterial and fungal energy channel.

(3) Field observations on the stable isotope composition of soil animals at natural abundance ($\delta^{13}C$ and $\delta^{15}N$ values) can be used for estimating the participation of ECM fungi in soil food webs. Such estimation relays on the consistent difference in the stable isotope composition of plant roots, ECM fungi, and saprotrophic fungi. Mycorrhizal fungi are in general enriched in ^{15}N and depleted in ^{13}C compared to roots and to saprotrophs (Hobbie et al., 1999; Mayor et al., 2009). In turn, saprotrophic microorganisms are enriched in ^{13}C compared to ECM fungi, roots and bulk SOM, which leads to strongly increased $\delta^{13}C$ values in detritivorous soil animals (Potapov et al., 2013). The isotopic differentiation of ECM-feeding soil animals from those feeding on saprotrophic microorganisms should be therefore relatively clear. Published data on the isotopic composition of soil animals as well as original data collected in different boreal forests show consistently that a great majority of soil fungivores are relatively enriched in ^{13}C, but not in ^{15}N. This suggests low importance of ECM fungi in detrital food webs. This suggestion remains somewhat speculative, as the information on the $\delta^{13}C$ and $\delta^{15}N$ values in the extrametrical mycelium of ECM and in vegetative mycelium of saprotrophic fungi is strongly limited.

Overall, our analysis indicates that the importance of ECM as a food source of soil invertebrates is lower than usually assumed. Several mechanisms of ECM fungi protection from grazing by microarthropods can be suggested including chemical and mechanical defences (Böllmann et al. 2010; Duhamel et al., 2013). Besides, ECM fungi are foraging in deeper soil horizons than saptotrophs (Lindahl *et al.*, 2007) and are partially isolated from litter-dwelling fungivorous microarthropods. This study was supported by the Russian Science Foundation (project #14-14-01023).

P 2.1.13

Is dominant vegetation good predictor of quantity and quality of soil DOM?

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Soil dissolved organic matter (DOM) characteristics were studied in spruce swamp forests (SSF) in the Central Europe. SSF are mostly found in boreal zone but they are also present rarely in mountains in the temperate zone. The SSF are unique in high spatial heterogenity and, consequently, high biological diversity. This high internal heterogenity is affecting presence of different vegetation dominants and vice versa: Eriophorum vaginatum (EV), Vaccinium myrtillus (VM) and Sphagnum girgensohnii (SG). Each vegetation dominant prefers habitat with different water table level (SG>EV>VM). Aim of this work was to show if dominant vegetation is a good predictor of DOM characteristics and so if dominant vegetation may be used as indicator of DOM quantitative and qualitative characteristics.

The study sites were located in the Bohemian Forest (Šumava National Park) which is an important peatland region in Central Europe (Czech Republic). Three SSF study sites were chosen for research which are very similar to each other in all important characteristics like geological substrate, water level, soil parameters, vegetation cover and climatic conditions. Soil was sampled from the upper soil layer (0-30 cm) under three vegetation dominants (EV, VM and SG), in four replicates for each dominant on each study site, on three occassions during vegetation season 2014. Basic soil physico-chemical and biological parameters were determined for each soil sample. At the same time, soil solution was extracted from peat monolites by centrifugation-drainage technique and filtered through 0.2 µm filter. Concentrations of carbon, nitrogen and phosporus forms were measured using FIA and LiquiTOC. DOM quality was analysed using size exclusion chromatography and HPLC. DOM biodegradability was measured in soil extracts after filtration and inoculation with suspension prepared from soil mixed sample from all study sites. Soil extracts were incubated for 6 weeks in the gas-tight vials, half of replicates under oxic and half under anoxic conditions. DOM biodegradability was measured as carbon dioxide production, which was analyzed in the headspace of incubation vials using gas chromatography in regular intervals.

Although the plots with dominant vegetation were quite different in water level and some other soil parameters, no differences in basic DOM characteristics between the plots were found (concentrations of total C, total N, DOM biodegradability). However, some differences were found for mineral nutrients forms (nitrogen or soluble reactive phosphorus concentration). Effect of date of sampling on DOM characteristics was more important than the effect of the plot with dominant vegetation, on which soil solution was sampled. Almost all DOM characteristics showed significant temporal changes during the vegetation season. The variability of DOM parameters was similar within the relatively homogeneous plots with the same dominant vegetation as compared to variability of DOM on the whole study site.

P 2.1.14

Leaves contirbute more than roots to soil organic matter formation and stabilization in a short-term slurry incubation

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Recent studies suggest that roots contribute more carbon (C) and nitrogen (N) to soil organic matter (SOM) formation and stabilization than do leaves. This may be due in part to the fact that root material is generally in closer contact with soil mineral surfaces than leaf material. The question remains as to whether roots and leaves would contribute equally to SOM formation and stabilization if they had comparable contact with soil mineral surfaces. We investigated this question using a slurry incubation to minimize the influence of soil structure and maximize contact between plant material and soil. We incubated isotopically labeled (^{13}C and ^{15}N) roots or leaves of Big Bluestem (Andropogon gerardii) with isolated silt or clay soil fractions, and tracked the contribution of leaf- and root-derived C and N to newly formed, silt- and clay-associated SOM over 60 days. In addition, we measured the release of leaf- and root-derived CO_2, allowing a comparison of the 'efficiency' of SOM formation between roots and leaves. We found that when contact with soil surfaces was maximized, leaves contributed more C and N to SOM than roots. The formation of leaf-derived SOM was also more efficient, meaning that less CO_2 was respired per unit SOM formed. We suggest that these results are driven by chemical and structural differences between the leaf and root material, while the contrasting results of previous field studies are driven by differences in proximity of roots and leaves to soil mineral surfaces, contributions of root exudates, and greater contribution of roots to aggregate formation.

P 2.1.15

Managing below ground carbon inputs? - Effects of agricultural management on root biomass and carbon rhizodeposition of field grown maize and wheat

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Below ground carbon (BGC) inputs by agricultural plants into the soil are an important variable in soil carbon (C) modelling (Bolinder et al. 1997). The sources for BGC inputs are dead root biomass and C rhizodeposition (C release by living roots) and are mostly estimated from above ground biomass. Agricultural management practices affect above ground biomass considerably; however, their effects on BGC inputs are only poorly understood. Previous studies on the response of root biomass to different fertilization intensities revealed contradicting results: With increasing intensification, root biomass has been observed to increase (Swinnen 1994), decrease (Hill et al. 2007), or simply be redistributed within the soil profile (Otto et al. 2010). Management effects on C rhizodeposition are also difficult to specify although C release into the rhizosphere is a means of plants to react to the nutrient availability in the soil. The proportion of C allocated below ground of totally assimilated C seems to be more clearly linked to agricultural management (Nguyen 2003) but the extent to which it is affected is still unknown.

Our aims are therefore to determine management effects on below/above ground C ratios, total root biomass, C rhizodeposition, and vertical root distribution of field grown maize and wheat. We hypothesise that, with increasing management intensity, (i) total root biomass is not affected but (ii) below/above ground C ratios, C rhizodeposition, and deep root biomass decrease.

We conducted a comprehensive field study on the 2 Swiss long-term field trials “DOK” (near Basel) and “ZOFE” (Zurich) with maize in 2013 and wheat in 2014. Silage maize was grown in 3 different management treatments on the “DOK” site and grain maize and winter wheat were grown in 4 different fertilization treatments on the “ZOFE” site. The treatments on both sites were characterised by increasing management/fertilization intensity and consisted of 4 field replications. In each field plot, one microplot (steel tube of 50 cm depth) was inserted covering an area of 0.1 m^2. The microplot plants were pulse-labelled with ^{13}C-CO_2 in weekly intervals throughout the respective growing season. After harvest, the microplot soil was sampled in 3 layers to 0.75m depth, coarse and fine root biomasses were determined by picking and wet sieving, and all samples were analysed for their $\delta^{13}C$ values. Carbon rhizodeposition was calculated according to Janzen & Bruinsma (1989).

The maize 2013 results reveal a decrease of below/above ground C ratios with increasing management intensity on both sites and range from, on average, 0.38 to 0.22 on the “DOK” site and 0.32 to 0.18 on the “ZOFE” site (trends only). Total root biomasses and C rhizodeposition do not differ between treatments on both sites. While the proportion of subsoil (0.25-0.75m) root biomass of the total (0-0.75m) root biomass decreases with increasing management intensity on the “DOK” site, this trend is not visible on the “ZOFE” site. Further results will be presented for wheat 2014.

Our findings show that BGC inputs cannot easily be estimated from above ground biomass and input data for soil C models should be differentiated according to the management system.

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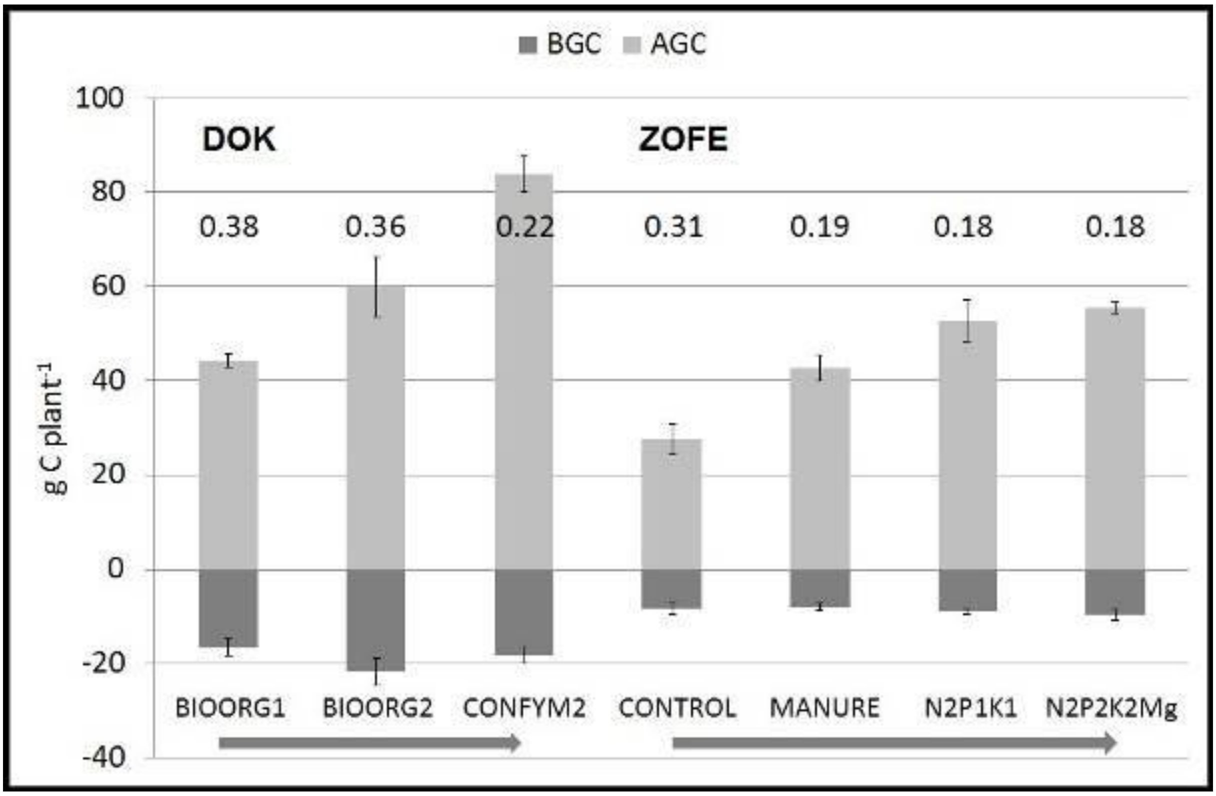
Figure legend:

Below- and above ground C of field grown maize in different management treatments in the 2 Swiss long-term field trials “DOK” and “ZOFE”. Error bars: standard errors of the means of 4 field replications. Numbers: means of below-/above ground C ratios. Arrows: increasing management intensity.

Figure 1



P 2.1.16

Compost production from organic waste and its effect on SOM and N & Caffeine content in tea green leaves

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In tea gardens, N and SOM reduce annually due to harvest of tea green leaf as yield, pruning, soil erosion and nutrients leaching. Amount of OC and N in soil and caffeine in leaves is very important in quantity and quality of tea production. In north of Iran, there is 32000 hectares of tea garden and about 128 tea factory which produce black tea from tea green leaves. Also there is wood-paper factory (WPF), which produces paper. These two factories have a lot of organic waste material for composting in trade level. Providing nitrogen from organic source and its effect on soil properties has been examined in this research. Waste materials were collected from tea and wood-paper factories and mixed with cow dung with ratio of 45, 45 and 10 percent, respectively and 200 local earthworms were added. Irrigation and aeration has been done in control condition, weekly, till vermicompost has been processed. Vermicompost were first class in the case of C/N, pH, EC, and total N, but poor in P and K. In first class vermicompost, amount of P2O5 and K2o should be more than 1 %. For selection of tea garden, in west of Guilan province, one tea garden with 30 hectare area, loamy sand texture, OC= 3.4% has been selected. After separating of plots with 20 m2 area and pruning, vermicompost were mixed with subsoil thoroughly in the rates of 0, 0.5 and 2 %. After six months, tea green leaves and topsoil samples were collected in each plot for analysis. The results shown an increase in soil EC (0.36 to 1.2 dS/m), CEC (from 26 to 30 c.mol/kg), microbial respiration, porosity (from 52 to 58%), moisture (33 to 39%) in the plots treated with vermicompost. SOC increased from 3.4 to 4.31%. Jelik et al. (2004) has been reported increase in soil organic matter due to compost and vermicompost application. Total N% increased from 0.18 to 0.34, without application of chemical fertilizer. Bahrami et al (2010), has been shown that changes in soil total N is similar to soil organic carbon. In this tea garden, P content is high and vermicompost application could not affect its level in soil. Because, P is low (0.03 %) in this manure, also C: P ratio is high and it seems that mineralization of organic P is lower than immobilization. In acid soils under tea cultivation, p can be blocked. K increased from 165 to 191 ppm. N increased in third leaf from 4.46 to 4.69 % in treated soils. It seems that mineralization of organic N, can provide sufficient N for the uptake of tea plants and it can reduce chemical fertilization in tea gardens. On the basis of standard norms, 5 % N is normal in tea third leaf (Willson, 1999). Nitrogen is one of the most important elements in chlorophyll, amino acid and protein in leaves. Tea green leaves, consider as a yield and N in adequate level is very important for its economical production. Vermicompost application could not affect P content in tea leaves; however, P content in leaves (2%) is more than normal level (0.5%) in all treatments. It seems that mineral P which can be provided by mineralization of organic manure isn't important in this condition because soil is rich in mineral P and it's sufficient for optimum growth of tea. Vermicompost application increased K content from 2.37 to 2.5 in leaves but it could not reach in normal level (3%). Caffeine content increased due to vermicompost application from 2.5 to 2.8 %. Caffeine is a factor to make tea, strong and it is very important in assessing tea quality. It can reach about 3 % in tea green leaf in normal condition. Nitrogen is one of the components of caffeine, so application of organic source of N can increase caffeine content in tea green leaves. In caffeine, there are five nitrogen atoms which can show the role of N for its synthesis in tea leaves. This result has been approved that organic waste material in tea and wood-paper factory can be used for vermicompost production and this manure can be used in tea garden to improve soil organic matter (SOM) and provide N for optimum growth of tea and try for production of organic tea in Guilan, Iran.

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Figure 1

Fig. 1: Tea garden after pruning and before vermicompost application

Figure 2

Fig. 2: Vermicompost application after pruning

P 2.1.17

Role of soil pore characteristics in decomposition of particulate organic matter

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Conceptually, the importance of soil pore characteristics for decomposition, protection, and sequestration of soil carbon (C) is well recognized. However, *in situ* experimental evidence and specific information about which pore characteristics are of relevance to the fate of soil C are still lacking. By combining CO_2 respiration measurements of intact soil samples with X-ray computed micro-tomography (µCT) images of their pores and particulate organic matter (POM), we demonstrated the crucial role of atmosphere-connected soil pores with >13 µm diameter in soil C's, and especially POM's, decomposition/protection. In presence of such pores losses in POM were 3-15 times higher than in their absence. Moreover, the greater was POM decomposition the greater was the subsequent increase in atmosphere-connected pores; an evidence of a feed-forward relationship between soil C decomposition and pore connections that enhance it. These findings emphasize the magnitude of the influence that pore structure can exert on soil C losses.

P 2.1.18

A model of interacting microbial and litter quality controls on litter decomposition

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The decomposition of plant litter in soil is a dynamic process controlled by interacting substrate chemistry and microbial activity. We simulated this interaction with a microbial Guild-based Decomposition Model (GDM; Moorhead & Sinsabaugh 2006), using reverse Michaelis-Menten equations (Schimel & Weintraub 2003) to calculate short-term (112 days) decomposition of roots from four genotypes of *Zea mays* that differed primarily in lignin chemistry (Machinet et al. 2009). A co-metabolic relationship between the degradation of lignin and holocellulose (cellulose+hemicellulose) linked decay rates to lignin concentration (Moorhead et al. 2013) consistent with the level of arabinan substitutions in arabinoxylan chains (i.e., arabinan to xylan or A:X ratio) that cross-link hemicellulose and lignin in plant cell walls (Chesson et al. 1988). This control was apparent from the start of decomposition for all genotypes and during the progressive decomposition of each genotype. We also discovered it necessary to divide the Van Soest soluble (labile) fraction of litter C into two pools: one that rapidly decomposed and a second that was more recalcitrant (Kalbitz et al. 2003). Simulated microbial production was consistent with recent studies suggesting that more rapidly decomposing materials can generate greater amounts of potentially recalcitrant microbial products despite the faster loss of litter mass (Smith 2007). Sensitivity analyses failed to identify any model parameter that consistently explained a large proportion of model variation, suggesting that feedback controls between litter quality and microbial activity in the reverse Michaelis-Menten approach constrained model behaviors to those closely tracking decomposition patterns. Model extrapolations to an independent set of data derived from the decomposition of 12 different genotypes of maize roots (Machinet et al. 2011) and were within <3% of observed respiration rates and total cumulative CO_2 efflux over 112 days.

Figure 1. Model carbon flow diagram. Litter pools are Van Soest soluble decomposable (C_{1D}) and resistant (C_{1T}) fractions, acid hydrolysable (C_2) and non-hydrolysable (C_3) fractions, and microbial guilds of opportunists (G_1), cellulolytic decomposers (G_2), and lignolytic decomposers (G_3).

Figure 2. Relationships between observed and simulated: a. decay rate coefficients (k_2) for litter pool C_2 and lignocellulose index (LCI) of litter (solid line from Moorhead & Sinsabaugh [2006], dashed line from Moorhead et al. [2013]), b. relationship between arabinan:xylan (A:X) and LCI contents of decaying litter. Open circles are initial litter chemistry (day 0) and solid circles are following decomposition.

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Figure 1

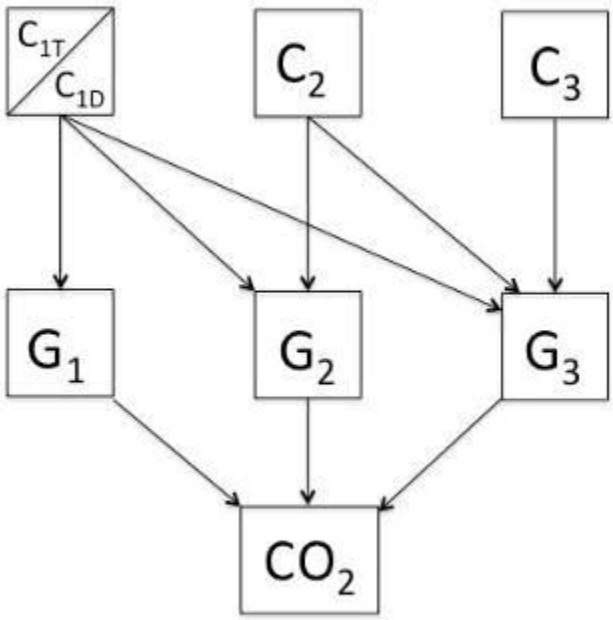
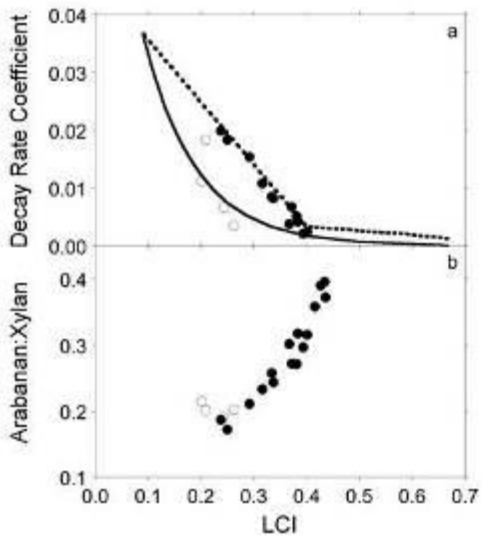


Figure 2



P 2.1.19

Polychlorinated Biphenyls in the Soils of Vancor Oil-and-Gas Field

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Vancor oil-and-gas field is situated in Western Siberia in the lower reaches of Taz and Pur rivers. The north of the field is occupied with tundra and forest-tundra landscapes, the south of the field - with taiga and permafrost-taiga landscapes. According to soil-geographic zonning [1,2] area of the field is located on the boundary of subarctic zone with tundra type of soils (Northern-Siberian province) and north-taiga subzone of gley-podsolic soils (Western-Siberian province).

Analysis on polychlorinated biphenyls was implemented by method of extraction with dichloromethane in Soxhlet apparatus. For purification of extracts was used activated copper and column chromatography with florizil. Identification of compound was implemented by method of chromatography-mass spectrometry using chromatography-mass spectrometer Varian Saturn 4D MS/MS.

By the present day in Russia is not established maximum allowable concentration of total content of polychlorinated biphenyls in soils. At the same time is established a guideline in which approximate-admissible concentration is defined [3]. Appropriate guidelines are already established in some European countries and Canada [4, 5].

In the table 1 is shown results of statistical data processing based on content of polychlorinated biphenyls in soils and ground sediments of research area. While the processing were considered only the samples which contanis more polychlorinated biphenyls than analysis method can detect.

Table 1. Statistical characteristics based on content of polychlorinated biphenyls

Compound (sum)	Soil, mkg/kg of dry weight					ground sediments, mkg/kg of dry weight				
	Number of samples	Min.	Max.	Average	SD	Number of samples	Min.	Max	Average	SD
Σdichlorbiphenyls	22	0.03	0.37	0.15	0.09	5	0.03	0.94	0.37	0.44
Σ trichlorbiphenyls	25	0.02	1.20	0.26	0.35	11	0.03	0.66	0.29	0.19
Σ tetrachlorbiphenyls	36	0.02	3.00	0.55	0.69	21	0.03	1.40	0.44	0.33
Σ pentachlorbiphenyls	37	0.05	3.82	0.63	0.69	20	0.06	1.03	0.31	0.25
Σ geksachlorbiphenyls	34	0.03	1.83	0.24	0.35	12	0.02	0.54	0.12	0.14
Σ geptachlorbiphenyls	12	0.02	0.10	0.04	0.02	6	0.01	0.17	0.05	0.07
Σ oktachlorbiphenyls	0	<0.02	<0.02	<0.02	N/A	1	0.03	0.03	0.03	N/A
Σ nonachlorbiphenyls	0	<0.02	<0.02	<0.02	N/A	0	<0.02	<0.02	N/	N/A
Σ decachlorbiphenyls	0	<0.04	<0.04	<0.0	N/A	0	<0.04	<0.04	N/A	N/
Total content of polychlorinated biphenyls	37	0.22	7.70	1.68	1.60	21	0.31	2.9	1.07	0.72

According to presented data in none of soil or ground sediment samples revealed excess of approximate admissible concentrations established in Russia both by total content of polychlorinated biphenyls and by sum of separate groups of polychlorinated biphenyls with 3, 4, 5 atoms of chlorine in molecule. Maximally revealed total content of polychlorinated biphenyls in soils is 7,7 mkg/kg while guideline of approximate admissible concentrations is 60 mkg/kg. It should be noted that average total content of polychlorinated biphenyls in soils and ground sediments in research area coincide with background concentrations of polychlorinated biphenyls in soils of Russian Arctic [6].

According to both russian guidelines and of Western countries soils and ground sediments of explored area should be classified as uncontaminated with polychlorinated biphenyls (Level 1, permissible).

Research was conducted in 2005 year before the started development of Vancor field and these results can serve as a "starting point" for further researches.

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P 2.1.20

Effect of different stages of cover crop cultivation on soil aggregate distribution, N leaching and C dynamics

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In recent years, most studies dealing with winter cover crops have examined longer term effects on soil parameters. However, much less is known about the effects of different stages of cover crop cultivation, such as growing and freezing of the plants as well as the subsequent degradation of the resulting organic material. The objective of this study was to quantify the influences of different stages of cover crop cultivation and different residue locations after plant death on water-stable aggregates and microbial biomass carbon (C_{mic}) in an incubation experiment. Furthermore, CO_2 emissions as well as dissolved organic carbon (DOC) and mineralized nitrogen ($N_{min)}$ leaching were determined during the plant degradation period. For the incubation experiment, four cover crop species (mustard, phacelia, clover, oilradish) were sawn in soil columns and grown for 12 weeks. Afterwards the columns were frozen at -10 °C for 10 days and subsequently incubated for 12 weeks at 10 °C, with the plant material either incorporated or surface-applied. Columns without plants (fallow columns) were included and treated in the same way. Among the plant species, no differences in the aggregate distribution could be found. After plant growth, concentrations in medium and large macroaggregates were approximately doubled compared with the fallow columns, which can be attributed to a positive effect of root growth. The subsequent freezing event led to a decrease of these two aggregate size-classes, presumably due to ice crystals expanding in soil pores. The decrease was stronger in the planted than in the fallow columns, which might hint at positive effects of dead roots on soil aggregate stability. However, after the following incubation the large macroaggregates decreased 3.6-fold stronger in the planted than in the fallow columns, leading to similar macroaggregate concentrations at the end of the experiment. No differences in aggregate distribution between the treatments with surface-applied and incorporated plant material were found. No difference in C_{mic} concentration was found among the various stages of cover crop cultivation, which might be due to a high amount of organic material in the soil in the form of wheat residues from the field. The CO_2 emissions were higher in the planted columns in comparison with the fallow columns during the 12 weeks incubation period after plant death. The comparison of the columns with incorporated and surface-applied residues did not show a consistent pattern of C_{mic} concentrations or CO_2 emissions, presumably because small particles of organic material were washed from the surface into the soil and the differences in organic material might not have been as strong as expected. Comparing the fallow and cover crop columns after plant death, the N_{min} losses were lower in the cover crop columns and the DOC losses were generally lower in the fallow columns, with no difference between the columns with surface-applied or incorporated plant material. This study showed that a one-time cultivation of cover crops had positive effects on soil aggregates. However, shortly after the death of the plants the concentrations of macroaggregates were already approximating those of the fallow columns. The results also suggest that cover crops generally affect leaching losses of N_{min} and DOC, however, the cover crop species was of minor importance for these parameters.

P 2.1.21

Live versus dead plant carbon: tracing the inputs of an invasive grass into soil carbon pools

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Introduction

Plant shoots and roots are the primary sources of carbon (C) to soil organic carbon (SOC) pools. Historically, aboveground plant sources (shoots) were thought to dominate C supply to SOC pools. An emerging body of research highlights the previously underestimated role of the belowground pathway (roots). However, few experimental field studies have directly isolated and tracked the contributions of root versus shoot C inputs into different SOC pools. The few experimental field studies that have attempted to isolate different plant C inputs into the soil typically use litterbags with labeled root and shoot litter. The drawback of this technique is that it excludes the substantial C contributions from living plant roots - specifically from root exudates, mycorrhizae, and fine root turnover. While methodologically challenging to measure, these 'Live' inputs may indeed form the dominant supply of plant C to SOC pools. To capture these Live C inputs, as well as 'Dead' inputs from decaying root and shoot detritus, it is thus necessary to: 1) track the C inputs from living plants, and 2) capture plant C contributions over multiple years, as different types of inputs are incorporated into SOC pools across a range of time scales.

Here, I present the first two years of data from a manipulative field study of the invasive grass species *Microstegium vimineum* - one of the most prolific invasive species in deciduous forests of the eastern United States. As an annual C-4 species that invades forest ecosystems otherwise containing only C-3 species, I use its unique isotopic signature to track the relative contributions of Live versus Dead C inputs into particulate organic C (POC; >53 um) and mineral-associated organic C (MIN C; <53 um) pools. I also ask how this invasive species may be driving changes to different SOC pools through its Live and Dead C pathways.

Objectives

The first objective of this study is to examine the relative importance of Live versus Dead plant inputs in supplying POC and MIN C pools. Understanding the roles of these two pathways is important to accurately model the terrestrial C cycle, as the link between plants and SOC pools is one of the most substantial yet poorly understood portions of the C cycle. The second objective of this study is to examine a specific mechanism by which *M. vimineum*, already known to alter SOC dynamics, may be driving these changes to the soil. I hypothesize that chemically labile Live plant inputs should enlarge the MIN C pool, while more recalcitrant Dead litter inputs will enlarge the POC pool. Due to its small root biomass (2-8% of total biomass), I hypothesize *M. vimineum* will drive changes to SOC dynamics primarily through its Dead inputs.

Materials & Methods

This study was established in October 2011, in an advancing invasion front of *M. vimineum* in North Branford, Connecticut, USA. Six experimental blocks were established, each block containing 4 treatment subplots: (1) only Live root plant C inputs (live *M. vimineum* plants, all shoot and root litter removed at senescence in the Fall) (2) only Dead litter C inputs (dead shoot and root litter from treatment 1 and deposited on soil surface every Fall) (3) Live + Dead inputs (undisturbed *M. vimineum* plants), and (4) a Control plot with no *M. vimineum* C inputs. SOC pools were measured using a physical fractionation method. The proportion of *M. vimineum*-derived soil carbon in each SOC pool was determined using natural abundance ^{13}C stable isotope analysis. Response variables (SOC pools) were analyzed using linear mixed effect models.

Results

After two years, *M. vimineum* treatment significantly affected both total SOC and the proportion of *M. vimineum*-derived C in POC pools. Both Live and Dead inputs alone caused an increase in total SOC. Total SOC was 38% greater in Dead plots compared to Control plots, and 39% greater in Live plots compared to Control plots. The proportion of *M. vimineum*-derived C in the POC was pool was 32% greater in Live plots compared to Dead plots. The proportion of *M.vimineum*-derived C in the MIN C pool was not significantly different between treatments (at $p<0.05$).

Conclusions

Contrary to expectations, Live and Dead inputs of *M. vimineum* drove similar increases in total SOC after two years. These results highlight the importance of the Live root pathway in SOC formation, even in a plant with a very small root biomass. Furthermore, a greater proportion of Live *M. vimineum*-derived C was found in the POC pool compared to Dead *M. vimineum*-derived C in the POC pool. Live *M. vimineum*-derived C is thus primarily entering the soil through the POC pool, not through the MIN C pool.

P 2.1.22

Controls on SOC stability and temperature sensitivity with increased aboveground litter input at forests in different successional stage

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Understanding of the mechanisms that control the balance between input rates and the preferential loss/preservation of plant litter has important implications for future global changes in climate, land management, as well as ecosystem disturbances such as invasive species. In order to determine how soil carbon pools responses to enhanced aboveground litter addition, we conducted a long-term multi-temperature laboratory incubation study of soils from different age forests and under ambient and elevated wood and litter input at the Smithsonian Environmental Research Center, MD, USA.

The results showed that the incorporation of wood amendments stabilized C in both young and old forest soils. However, in old forest soils the effect was achieved by change in active C pool, while young forest soils slow pool was more affected. Although no significant change was observed in SOC content, increased leaf litter input also had a significant effect in stabilizing SOC with interactions with forest age. Specifically, with leaf amendments, C pool of old successional forests shifted to a proportionately smaller slow pool with longer MRT, and in young forests, leaf amendments shifted soil C to a larger slow pool with similar MRT. The different effects caused by litter amendments in young and old forests could be explained by the different earthworm abundance and community composition, which influenced pattern of the incorporation in both physical distribution and chemical trajectory.

With elevated incubation temperature, no change in temperature sensitivity of C mineralization with different types of amendments was observed in our study. These results indicated the importance of availability/accessibility of SOC as well as microbial acclimation rather than biochemical recalcitrance in controlling temperature sensitivity of SOC dynamics. Thus, models that explicitly take account of the factors that controls the impediments and accessories of C in soil matrix should improve prediction of SOC dynamics under a changing world with enhanced aboveground litter input and elevated temperature.

O 2.2.01

Drivers of Priming Effect intensity depend on climatic gradients in Madagascar

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Introduction: Malagasy agriculture is mainly rainfed and based on organic amendments mainly as manure and plant residues. Its productivity depends therefore strongly on soil ecological processes involved in organic matter mineralization and nutrient recycling, and on how those processes will be impacted by climate change. Soil microorganisms are the principal actors of these processes. They constitute a great species pool (10^6 bacterial and fungal species per g soil), most of them being heterotrophic and responsible of at least one step in organic matter decomposition. Some of them are especially involved in the Priming Effect (PE) phenomenon, which contributes to the balance between soil carbon storage and mineralization, but they have not been clearly identified yet. As microbial species have all their own optimal growth or activity conditions, climate change can induce a shift in microbial communities composition.

Objective: In our study, we aimed to understand how much modification of soil physicochemical parameters and microbial community composition by climate changes may relate to PE intensity.

Materials and methods: To achieve this goal, 60 soils were sampled in Madagascar Highlands along climatic gradients, allowing to separate mean annual temperature from rainfall effect, on the same type of ferrallitic soils and under the same vegetation (natural savannas called bozaka, composed mainly of Aristida species). Soil samples were incubated during one week at a constant temperature and humidity and in the presence of ^{13}C-labelled wheat-straw as fresh organic matter (FOM) to measure the potential PE induced by microbial communities in each sample. This potential PE was linked to physicochemical (texture, bulk density, exchangeable cations, pH, CEC, AD, total and available C, N and P) and biological (microbial and microfaunal biomass, fungal/bacterial ratio and fungal-bacterial community composition assessed by pyrosequencing techniques) parameters.

Results: While labelled wheat-straw mineralization appeared to be limited by soil available P and correlated to annual rainfall, soil organic carbon (SOM) mineralization and PE were positively correlated to soil organic carbon, microbial biomass, soil C:N and all those parameters were driven by annual temperature.

Conclusion: Microbial populations were classified into three distinct functional groups on the basis of their proportion in correlation with (1) wheat straw mineralization, (2) SOM mineralization and PE intensity, and (3) SOM evolution degree expressed by C:N ratio. Each group is proposed to play a different role in organic matters dynamic and PE generation.

O 2.2.02

Assessing the interaction between soil organic carbon and added plant residues with contrasting C:N ratio

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The addition of plant residues to soil is a potential way to increase soil organic carbon (SOC) content. Decomposition of plant residues in soil can be influenced in different ways depending upon chemical composition e.g. carbon (C):nitrogen (N) ratio, physical accessibility and protection, and microbial functional capacity to degrade that litter. The C:N ratio of plant residues may also impact the decomposition of soil native organic C during the decomposition of the added substrates, a phenomenon known as the priming effect (PE). We examined the interaction between SOC and added organic C with both the added OC and SOC having contrasting C:N ratios.

Soil incubation experiments were carried out in a laboratory for 30 days using ^{14}C pulse labelled wheat residues of six different C:N ratios, with roots having C:N ratios 12.9, 16.0, and 22.0, and shoots having C:N ratios 8.3, 12.4 and 18.4. Two soils with differing C:N ratios (13.1 and 18.7) were used in this study. To measure the PE, total CO_2 and $^{14}CO_2$ produced were measured periodically after trapping in NaOH solution in sealed Schott bottles. Soil microbial biomass C and available nutrients were also measured at different times of incubation period to evaluate PE as a result of the different litter and soil C:N ratios.

The high C:N residues generally increased PE whereas the low C:N residues decreased PE, which was possibly due to increased microbial N availability in the soils treated with the low C:N residues. In contrast, the PE was found to be higher in the low C:N soil than the high C:N soil, which correlated with higher dissolved organic C (DOC) and microbial activity in the low C:N soil. Although the use of pulse labelled plant residues may add uncertainty to our results, our findings broadly follow those of other studies, which indicate that the ^{14}C label was well distributed through plant tissues.

We conclude that PE is influenced by the C:N ratios of both litter and soil, which appeared to be dependent on N availability, microbial activity and DOC in the system. Therefore, PE is dependent upon litter quality and soil biochemical properties, with concomitant effects on SOC storage.

O 2.2.03

Effect of carbon availability on rhizosphere priming in soils of contrasting mineralogy

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Rhizosphere priming effect (RPE), the acceleration or retardation of decomposition of native soil organic matter (SOM) by root activity is an important component of soil carbon (C) dynamics linked to C availability for soil microorganisms. In the present study, we have evaluated the C availability in different physical fractions impacts on the intensity of RPE and determine the most primed physical fractions in two soils with different mineralogy, allophanic and metamorphic, developed under pristine old growth temperate rain forest in Southern Chile. The RPE was assessed in physical fractions (light, intermediate 50-2000 µm and mineral < 50 µm fraction) isolated from two soils (allophanic and metamorphic) on RPE by growing maize (*Zea mays*) in a pot experiment. The soil-derived C to total soil respiration was partitioned and ^{13}C natural abundance at four growing stages was measured. The results supported the hypothesis that the available C in different fractions of different mineralogy controls the RPE. The cumulative soil-derived CO_2-C was higher in allophanic (724 mg C kg^{-1}) then in metamorphic soil (516 mg C kg^{-1}). The recalcitrant SOM in the MF of allophanic soil were less primed (258 mg C kg^{-1} soil) than that in metamorphic soil (784 mg C kg^{-1} soil). Our results also showed that RPE increased as the developmental stages of maize increased, indicating that available C from root exudates greatly stimulates recalcitrant SOM decomposition of MF.

O 2.2.04

Soil organic carbon exerts particle size fraction-specific effects on microbial community structure and the mineralisation of organic pollutants

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Soil particle size fractions (PSF) differ in quantity and quality of soil organic carbon (SOC, Christensen, 1992) and harbour distinct microbial communities (Neumann *et al.*, 2013, Hemkemeyer *et al.,* 2014). Further, SOC affects microbial degradation of organic pollutants in bulk soils (Neumann *et al.*, 2014). This work elucidates the importance of PSF-associated SOC for corresponding microbial communities and functioning. Soil was taken from the Askov long-term experiment (Denmark); we used plots that were kept unfertilised, dressed with mineral fertiliser or with animal manure for 117 years. Using gentle sonication, wet sieving and centrifugation, soil was separated into four PSF: a sand-sized fraction (63-2000 µm) including particulate organic matter (POM), coarse silt (20-63 µm), fine silt (2-20 µm), and clay (<2 µm). Population sizes of PSF-associated bacteria and fungi were determined by quantitative PCR, and bacterial amplicons were sequenced using dual-index paired-end multiplexing on the Illumina platform. Fungal communities were compared by genetic fingerprinting. Further, individual PSF were mixed with sterile quartz in proportions corresponding to that bulk soil and mineralisation of ^{14}C-phenol was monitored by $^{14}CO_2$ trapped in NaOH. The distribution of ^{14}C-phenol within the soil was examined in adsorption studies and subsequent fractionation. SOC content negatively correlated with particle size and was highest with organic fertilisation. When based on soil dry weight, microbial populations increased with decreasing particle size. Generally population sizes were highest for organic fertilisation with coarse silt being most responsive. When based on PSF-SOC content, fungal population sizes became highest in the sand-sized fraction, while bacteria were still highest with clay. But for both domains, differences between the respective other three fractions and between fertilisation treatments diminished. The coarser PSF were the preferred microhabitat of *Proteobacteria*, while *Acidobacteria* and *Firmicutes* preferred smaller-sized PSF. *Gemmatimonadetes* was most abundant in coarse silt, *Actinobacteria* in fine silt and *Planctomycetes* in clay. Organic fertilisation increased populations of *Actinobacteria*, *Firmicutes* and *Gammaproteobacteria* but decreased the presence of *Acidobacteria*, *Deltaproteobacteria*, *Planctomycetes* and *Verrucomicrobia*. The impact of organic fertiliser on microhabitat preference was demonstrated for *Clostridia* increasing from clay to coarse silt and for clay-dominated *Acidobacteria* Gp5 losing any PSF-preference. Also fungal communities showed clear differences for both PSF and fertilisation. Phenol mineralisation correlated positively with microbial abundances, except for the sand-sized fraction with higher rates than expected, suggesting an impact of POM. Highest mineralisation rates were found for the organic fertilised soil. This was related to phenol adsorption being smallest in this treatment, leaving more phenol bioavailable. Our study demonstrates microhabitat-specific effects on microbial diversity and on mineralisation potentials of PSF, as also affected by SOC.

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O 2.2.05

Plant, soil and microbial controls of soil organic matter mineralisation: Is it possible to predict and manipulate priming effects?

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It is increasingly recognised that inputs of labile organic matter (e.g. root exudates) to soil can substantially affect rates of native soil organic matter (SOM) mineralisation. Such priming effects are an intrinsic component of soil C-cycles, and function to couple plant and soil microbial processes. Key consequences of this coupling between the plant and microbial components of ecosystems are (i) that factors affecting the magnitude of plant inputs to soil, and that shift systems from steady state equilibria with respect to the balance between C inputs and outputs from soil, will also affect rates of existing SOM mineralisation. Therefore, predictions of effects of climate and management change on soil C-stocks should take account of priming effects. (ii) As SOM is also the dominant store of nutrients essential for plant growth, priming effects function to couple C and nutrient cycles in soil, and therefore represent an important feedback to plant growth. It seems probable that plant-mediated priming could be employed as a strategy to maintain productivity in natural, nutrient-limited systems, but it is unclear to what extent modern crop cultivars, selected for growth under nutrient replete conditions, exploit root-microbe interactions affecting element cycling in soil. In a series of experiments employing stable isotope (^{13}C and ^{15}N) approaches we have investigated the plant, soil and microbial controls of priming effects. We have demonstrated that basal SOM mineralisation (i.e. that occurring in the absence of exogenous inputs of labile C) and primed SOM mineralisation are subject to different controls and function as distinct fluxes. For example, whereas the basal flux was insensitive to the composition of microbial communities and was not affected by the availability of mineral nutrients, the primed flux was dependent on microbial community diversity and was suppressed by high availability of N. Further, under conditions supporting priming (high C availability, low N availability) combined use of ^{13}C labelling and ^{15}N pool-dilution approaches demonstrated that the primed mineralisation flux was derived from N-rich components of SOM (relative to the basal flux which had a larger mean C-to-N ratio). We found that the magnitude of priming was variable across soil types, and while the causes of this variation are not fully understood, a consistent finding was that the capacity of soils to support priming was positively related to the capacity of the soils to support plant growth. We have also found that in addition to inter-specific variation in the capacity of plants to promote SOM mineralisation, variation can also be quantified within germplasm of a single plant species (barley, *Hordeum vulgare*). As these experiments were done with defined genetic mapping families of barley and differential effects were also correlated with impacts on the soil microbiome composition and activity, this raises the possibility of plant breeding directed to manipulation of nutrient supply from SOM in agricultural systems. An overall aim of our research has been to understand priming effects within a theoretical framework and to test proposed mechanisms underpinning them. The presentation will discuss our results in the context of potential mechanisms and will attempt to highlight where uncertainties remain and limit the establishment of a unified view of priming processes.

O 2.2.06

Priming of soil organic matter and fungal ecology: is there a link?

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Priming effect (PE) is defined as a short-term change in the turnover of soil organic matter (SOM) caused by the addition of relatively easily degradable organic compounds to the soil. This process is recognized to be large enough to be taken into account into the ecosystem carbon balance. By following the dynamics of SOM decomposition as well as that of microbial community structure and activities, information can be obtained on the causes of PE. It has been suggested that fungi might play a major role in PE since they are able to make a spatial connection between easily-available carbon and stable SOM via their hyphae. Yet, the exact mechanisms of PE are still unknown.
In the current study we addressed the following questions: 1) What is the main mechanism controlling the PE? and 2) Which fungal taxa are mainly causing PE? To answer these questions, three isotope-labelled PE-triggering substrates, which differ in structure and degradability, were added to a natural grassland soil in a mesocosm approach. After four weeks of incubation we found significant differences between the treatments in the cumulative CO2 release and in PE. The most recalcitrant compound gave the highest PE, and this might be explained by the activation of micro-organisms that synthetized specific extracellular enzymes able to decompose both the triggering substrate and the SOM. In general, nitrogen addition also influenced PE and these results will be discussed. To answer the second question, we are currently running DNA-SIP analysis with which we will be able to track fungal taxa that are actively involved in PE.

Keywords: Priming effect, soil organic matter, fungal communities, stable isotope probing, carbon turnover.

O 2.2.07

Which fraction of soil organic matter is more vulnerable to rhizosphere priming effect?

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Question: Rhizosphere priming effect is defined as the stimulation or suppression of soil organic matter (SOM) decomposition by living roots. Although recent studies have shown the important role of rhizosphere priming effect in SOM turnover, we still do not know which fraction of SOM (e.g., fast or slow component of SOM) is more vulnerable to rhizosphere priming.

Methods: We conducted two experiments in continuous $^{13}CO_2$ labeling growth chamber and greenhouse to compare the intensity of rhizosphere priming effect for the active (or labile) vs. slow (or recalcitrant) SOM. A sandy loam (Alfisol) was incubated at 20^{o}C and 80% water holding capacity for different periods, which created a gradient in the relative proportion of active vs. slow SOM in the remaining soils. We then grew sunflower (*Helianthus annuus*) and soybean (*Glycine max*) in these remaining soils for 50 days under the same environmental conditions to compare the rhizosphere priming effect of these two plant species on the decomposition of soils that varied in the lability of SOM.

Results: In both experiments, as the incubation proceeded from 1 to 8 to 14 months (in experiment 1) and the soil changed from freshly-sampled soil to two-year-incubated soil (in experiment 2), we found some consistent patterns: (1) soil mineral N (ammonium and nitrate) accumulated, but to a lower extent in the planted soils; (2) microbial biomass carbon declined, but to a lower extent in planted soils; (3) sunflower root biomass increased slightly, but soybean root biomass decreased slightly; (4) root-derived CO_2 showed similar trend with root biomass; (5) soil-derived CO_2 declined greatly in unplanted soils, but declined slightly or even recovered in planted soils; and (6) most importantly, rhizosphere priming effect, quantified in either absolute or relative change in soil-derived CO_2 between planted and unplanted soils, increased significantly. As soils decreased in lability and the source of CO_2 changed from active-SOM-dominated in the earlier incubation period (or the freshly-sampled soil) to slow-SOM-dominated in the later incubation period (or the two-year-incubated soil), the intensity of rhizosphere priming effect increased significantly even after accounting for the changes in root biomass or root-derived CO_2.

Conclusions: These results suggest that the slow (or recalcitrant) fraction of SOM is likely more vulnerable to rhizosphere priming compared to the active (or labile) fraction of SOM. Although the underlying mechanisms of this finding await further investigation, our study clearly shows that the main component of SOM (slow or recalcitrant SOM, decadal turnover) is vulnerable to rhizosphere priming. Therefore, the rhizosphere priming effect has the potential to substantially regulate both short-term and long-term soil carbon dynamics.

O 2.2.08

What is the significance of priming as a process for long-term SOC dynamics? Results from a long term field experiment

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Introduction Short time scale (~days to year) soil incubation experiments have evidenced that mineralisation rate of soil organic carbon could be increased by higher fresh organic matter (FOM) inputs. This process could affect global soil C stocks but its importance has yet to be assessed at decennial or centennial time-scales.

Materials and Methods In this study, we analysed soil organic carbon (SOC) data from a 52-years old bare-fallow experiment in Grignon (France) where plots received no organic matter, or only fresh straw or composted straw. Treatments receiving fresh or composted straw showed no significant difference in SOC stocks dynamics over the 52 years, suggesting no long-term impact of priming effect. To go further, we evaluated whether soil organic matter (SOM) mineralisation rates differed between plots with no input and plots with FOM inputs, using simple models of SOC dynamics based on the Hénin-Dupuis formalism.

Results Using a model with 3 SOC pools, we showed that estimated mineralisation rates were 3 to 4 times slower for the plots with no input, suggesting an important role of priming effect. However, a 4-pools model with first order kinetics could satisfactorily fit all the data using a same set of parameters.

Conclusion Our results did not assess the absence of priming effect on SOC stocks dynamics at decennial timescale, but suggest that priming effect is not necessarily a relevant process to explain long-term SOC dynamics. It would be worthwhile to test our modelling approach on other long-term datasets, in particular from more nitrogen-limited experiments and using other data giving complementary information on mineralisation rates, such as ^{14}C.

O 2.2.09

Increased N mineralization occurs through shifts in nematode and microbial community structure following organic inputs

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1. Background & Objectives

Organic matter decomposition and nutrient cycling is a microbial process that is primarily regulated by bacteria and fungi (Six et al., 2006). The activity of these microbes is in turn influenced by interactions with several biotic and abiotic factors such as soil fauna, and nutrient inputs particularly carbon (C) and nitrogen (N) from plant roots and externally added organic residues. Previous studies focused on the effects of interactions between microbes and nutrient inputs on the decomposition processes (e.g. Chen et al., 2014). Research has shown that soil fauna, particularly the microfauna, profoundly regulate the activities of the microbes, and thus the OM decomposition process. Only a few studies investigated the effects of interactions between microbes, nutrient inputs and fauna concurrently. We aimed to investigate the effects of these interactions on organic matter decomposition and nutrient cycling. Nematodes were selected as a model fauna because they are one of the most abundant and diversified soil metazoans, and regulate the root, bacterial and fungal energy channels.

2. Materials & Methods

We extracted and reinoculated the entire free living nematode community into defaunted soil using low doses of gamma irradiation that was proven to leave the microflora largely intact (Buchan et al., 2012). Two incubation experiments were conducted in planted microcosms with Italian ryegrass as a model plant. Three treatments: CTR (unirradiated control soil), -Nem (defaunated) and +Nem (defaunated and reinoculated with nematodes) were compared with and without grass-clover (C:N 10.7) amendment in each experiment. All cores were incubated at 18 $^{\circ}$C at constant and optimal water content (50% WFPS) for three months. Mineral N, microbial biomass carbon (C_{mic}), PLFA, enzymes, nematode abundances and identification were determined at each sampling point over time. The interaction effect of nematodes on N mineralization was calculated by the simple differences in the mean total mineral N concentrations at each sampling time between +Nem and -Nem samples.

3. Results & Discussion

The nematode trophic composition was dominated by both herbivores and bacterivores (each between 40-47%) at the beginning of the incubation, but at the end, herbivores dominated in both experiments. However, the diversity and abundance of endoparasitic nematodes such as *Meloidogyne*, which cause C rich rhizodeposit were significantly (pmic nor the total PLFA concentration which is an indicator of the active microbial biomass. In grass-clover amended microcosms, however, the presence of nematodes tended to increase total PLFA concentration during most of the incubation period with significant differences on day 24 (+19.65 nmole g^{-1} dry soil, p=0.025) and 47 (+20.04 nmole g^{-1} dry soil, p=0.021). PLFA biomarkers for both saprophytic and arbuscular mycorrhizal fungi (AMF) were also higher in the presence of nematodes during the latter stages of the incubation showing that interactions between nematodes and grass-clover particularly stimulated the fungi community. The presence of nematodes in the unamended microcosms did not affect N mineralization, but in grass-clover amended microcosms their presence increased net N mineralization by +23%.

4. Conclusion

Our results suggest that soil fauna (particularly nematodes) interact with externally added OM and exert an important influence on OM decomposition and N mineralization. Shifts in nematode and active microbial communities may explain the mechanism behind the accelerated OM decomposition and N mineralization. The high availability of external C and N enhanced the N mineralization process in the presence of nematodes, but further investigation is needed to determine whether this increased N mineralization was from the added amendment or the native soil OM.

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O 2.2.10

Elevated atmospheric CO_2 concentrations results in increased CO_2 emissions by priming in a temperate heathland soil

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Elevated CO_2 concentrations commonly result in at least a temporary increase in primary production and also in higher belowground allocation and exudation of recently fixed plant C. Evidence regarding the role of plant C allocated belowground for soil C sequestration and respiration are contradictory. On one hand there is evidence to suggest that plant C immobilized in mycorrhiza and other soil microorganisms significantly contribute to soil organic matter (SOM) formation. Other evidence suggests that root exudates can act as 'primers' that stimulate the decomposition and respiration of SOM. However, this is not always the case, since there are also instances where the microbial community preferentially assimilates the exuded C, resulting in decrease decomposition of soil organic matter

The aim of this experiment was to determine if increased belowground production in response to elevated CO_2 selects for a microbial community adapted to growing directly on the exuded C, or alternatively, a microbial community that use the exuded C to enhance SOM decomposition. Two scenarios can be conceived, 1. Increased root exudation results in preferential use of the exuded C, leading to decreased respiration of recalcitrant SOM (negative priming), and 2. Increased C exudation result in increased respiration of SOM (positive priming).

To test these alternative hypotheses we examined the magnitude and kinetics of priming in soil collected at a temperate heath/grassland in North Zealand, Denmark, that had been exposed to elevated CO_2 (+120 ppm) for 7 years. The maximum potential priming rate (V_{max}) and the half saturation constant (Km) was determined by adding ^{13}C-labelled glucose in varying concentrations (ranging from 0.06-4.0 mg glucose per gram soil) and fitting Michaelis-Menten saturation curves to the observed priming response.

Priming occurred at all soil depths in both treatments. The potential priming (Vmax) was 10-20 times higher in the top soil (0-10 cm) compared to the two deeper depths (10-30 and 30-50 cm). There was no difference between elevated and ambient CO_2 treatments with respect to the maximum potential priming (V_{max}) in the top soil. In contrast, the half saturation constant (Km) was lower in the elevated CO_2 treatment compared to the control. These results differed significantly from the two deeper soil layers. At these depths the priming was saturated already at the lowest glucose concentration. Furthermore, at these depths priming was higher in the control compared to elevated CO_2 treatment.

The results demonstrate that 7 years of elevated CO_2 significantly altered the belowground C cycling at the site. In the top soil the microbial community utilized the glucose to prime the decomposition of SOM with a higher efficiency compared to the control treatment, suggesting that CO_2 emissions caused by priming increased in response to the elevated CO_2 treatment. The same was not the case for the deeper soil layers, but since the vast majority of priming occurred in the top soil the results suggest that CO_2 emissions from soil caused by priming can be expected to significantly increase in a high CO_2 world.

P 2.2.01

Screening for allelochemical stress on cytoplasmic protein synthesis pattern of selected plants

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- **Background and aims**: Determining the mode of action of allelochemicals is one of the challenging aspects in allelopathic studies. Recently, allelochemicals have been proposed to cause differential protein expression in target tissue and inhibit the early growth. Phenolic acids, one of the common allelochemicals emitted from rhizosphere soil is known for its growth-inhibitory activity. The aim of the present study was to determine the inhibitory effect of Phenolic acids on seedling growth, dry biomass, total protein content and expression levels of proteins.
- **Methods:** Effects of allelochemicals on early seedling growth and dry biomass were studied in three test species, *Glycine max* Willd., *Lycopersicon esculentum* L. and *Lantana camara* L. Total protein content and their differential expression were studied in the leaves of test species. Rhizosphere soil was analysed for the detection of phenolic acids.
- **Key Results:** The root length, shoot length and dry biomass were significantly reduced in rhizosphere soil as compared to control soil. SD-PAGE analysis showed different protein expression in three species on exposure to rhizosphere soil. Protein banding pattern not only differ between the control soil and rhizosphere soil, but also among test species. The protein content was increased in *Glycine max*, and *L. esculentum* while it was decresed in *L. camara* in response to rhizosphere soil. Rhizosphere soils contained significantly higher amount of phytotoxic phenolics as the putative allelochemicals, which were ferulic acid, vanillic acid, p-coumaric acid and benzoic acid.
- **Conclusion:** The study concluded that *C. procera* roots and rhizosphere soil exerted allelopathic effect on test species by releasing water-soluble phenolic acids as putative allelochemicals in soil which will act as a structural substitutes for synthetic herbicides.

    - **Key words**: Allelopathy, seedling growth, dry biomass, total proten content, Differential protein expression, Phenolic acids.

P 2.2.02

Efficiency of Arbuscular Mycorrhiza in the control of tomato damping-off caused by *Pythium ultimum* Fungi in the Syrian coast

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The effect of Arbuscular Mycorrhiza Fungi (AMF) on limiting the infection of *Pythium ultimum,* causing tomato damping-off, was studied in a pot experiment during the 2013 year. Five treatments varied in the infection of soil by fungus were used. In the first treatment, soil was inoculated only with *Pythium* (Py), in the second, with Mycorrhiza only (My): in the third with *Pythium* and Mycorrhiza at seed planting (My+Py): in the fourth, with *Pythium* and two weeks after seed planting by Mycorrhiza (Py-My): and in the fifth, with Mycorrhiza and two weeks after seed planting with *Pythium* (My-Py). The disease index was evaluated and the percentages varied significantly between treatments and the control (C). They were 97.91%, 81.25%, 64.58% and 31.25% for Py, Py-My, Py+My, My-Py respectively. The impact of treatments on growth criteria showed a significant increase in My and My-Py treatments for plant height (by 35.35% and 28%), Leave's number (by 18%), and the wet vegetative weight (31.44% and 26.44%), respectively. Py-My and My+Py affected the dry weight of the canopy causing a decrease by 89.05% and 35.09% respectively. PY-MY and PY reduced the wet and the dry weight of roots (by 85.26 and 98.94% for wet weight and 94.11 and 99.7% for dry weight, respectively). My+Py and My increased significantly the root volume by 18.6% and 45.56%. Stem diameter was superior in all treatments over Py and Py-My. Root mycorrhization was estimated and the highest value was detected in My, followed by My-Py (76.6% and 70%, respectively). The interaction between My and Py was very efficient in protecting tomato seedlings from infection. My-Py showed the highest rate of protecting based on most studied criteria.

Key words: Arbuscular Mycorrhiza Fungi (AMF), *Pythium ultimum,* Tomato, Syrian coast

P 2.2.03

Impact of farmyard manure inputs on soil microbial diversity - Consequences on volatile organic compound emissions and carbon cycle

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By being involved in the decomposition of soil organic matter (SOM) and delivering nutrients readily accessible to plants, soil microorganismsare key players in agricultural soils. In addition to CO_2 and CH_4 emissions, it has recently been shown that microbial SOM breakdown generates volatile organic compounds (VOCs) which take part in greenhouse gases production in the atmosphere. The VOC emission rates from soil to atmosphere are still poorly documented compared to CO_2 and CH_4 fluxes. They depend on both SOM status and microbial diversity and functions involved.

The objectives of this study were to i) determine the response of soil microorganisms to farmyard manure inputs (pig slurry (PS) and methanised pig slurry (MPS)) and the consecutive diversity of VOCs emitted and ii) understand the link between SOM, active soil microorganisms and C-gas emissions (VOCs, CO_2, CH_4). Soil mesocosms were constructed with or without PS or MPS and incubated for 2 months. Control mesocosms with only PS or MPS were performed in parallel. Every 10 days the diversity of the VOCs emitted was determined (PTR-MS) and CO_2 and CH_4 emissions were quantified (µGC-MS). At the meantime soil was sampled to quantify and determine the composition of the SOM and analyse the active microbial community structure (T-RFLP based on RNA). Preliminary results allowed us to identify five main VOCs: acetone, 2-butanone, dichloromethane, 2-pentanone and toluene. Moreover, the VOC diversity emitted by the soil with the farmyard manures was significantly different to the gases produced by the PS and MPS alone indicating an impact of the soil microorganisms through SOM decomposition. Both SOM composition and microbial diversity structure analyses are currently running. These results will bring new insights into the impact of organic amendments on the soil components (SOM, microorganisms) and the consequences on C-gases emissions and C fluxes between soil and atmosphere.

P 2.2.04

Soil Carbon Stabilization in Temperate Cereal-Legume Intercrops and Sole Crops

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Understanding the process and capacity of long-term soil organic carbon (SOC) stabilization is one of the major challenges in soil science. The primary goal of this study was to evaluate the flow of carbon (C) from added C_3 or C_4 residues in soil from two differently configured cereal-legume intercrops and in cereal and legume sole crops. This was achieved through a short-term incubation study using the $\delta^{13}C$ natural abundance method. With time, SOC in C_3 or C_4 residue amended and control (non-residue amended) treatments decreased significantly (p3 or C_4 residue amended treatments compared to the control. LF-C derived from new C sources was significantly greater (p3 or C_4 residue had a significantly greater (p2 derived from old C sources was significantly lower (p4residue amended treatments. The fractionation factor was significantly different (p13C, became depleted midway, before becoming enriched again at the end of the incubation. Our results demonstrate that cereal-legume intercropping is a more sustainable land management practice with respect to soil C transformations and C stabilization.

Figure 1

Figure 1 Schematic of the incubation experimental design with three (n=3) replicates per treatment.

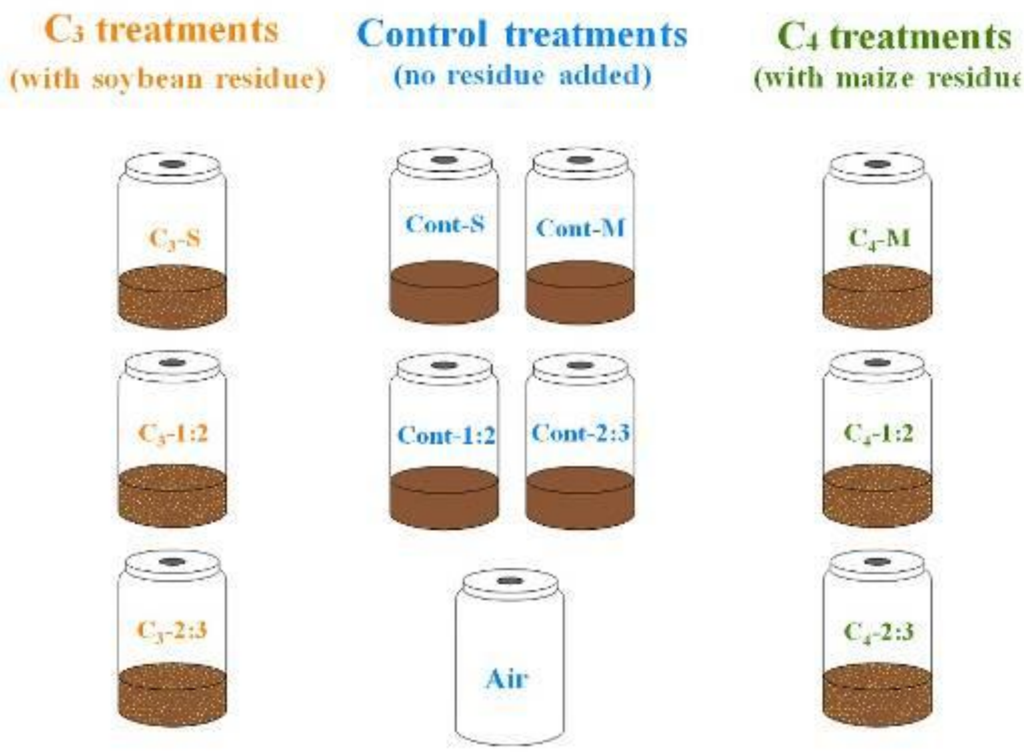
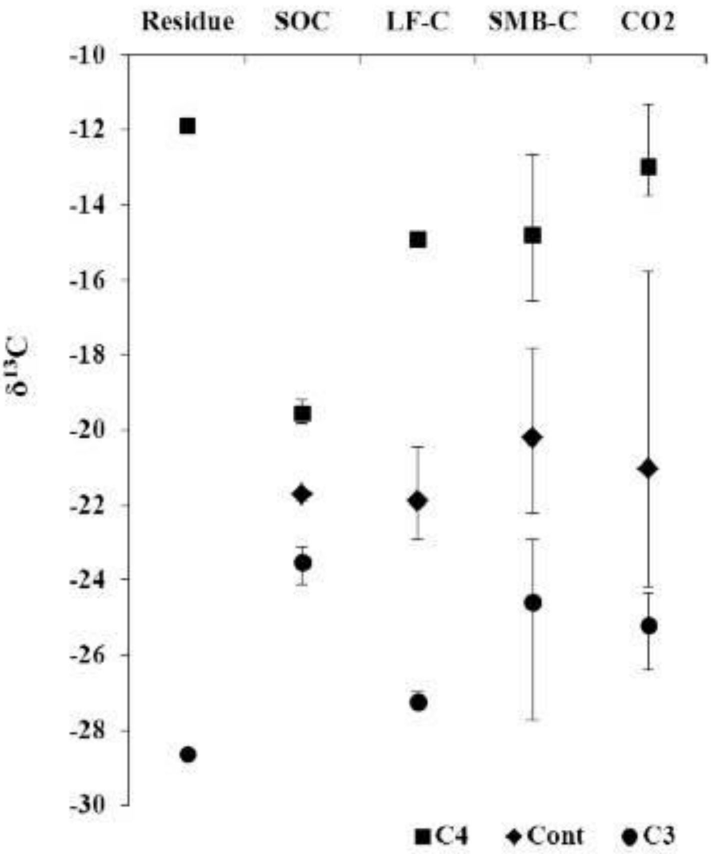


Figure 2

Figure 2 Mean values of δ^{13}C (‰) of maize and soybean residues, soil organic carbon (SOC), soil light fraction carbon (LF-C), soil microbial biomass carbon (SMB-C), and carbon dioxide (CO_2) for all treatments [Control (Cont), C_3 (soils amended with C_3 residues) and C_4 (soils amended with C_4 residues)].



P 2.2.05

Changes in content of nitrogen and phosphorus in living and dead biomass of *Calamagrostis epigejos* during succession in two different old sites after coal mining

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Introduction

The litter decomposition is a critical step in the mineralization and nutrients turnover. The main drives of decomposition are generally temperature, water availability and litter chemical composition. The mineralization and plant growth are limited by availability of nitrogen and phosphorus. Nitrogen and phosphorus are the most common limiting elements, both individually and in combination. The amount of nitrogen and phosphorus in leaf litter does not depend only on nutrient status of plant but also on reabsorbation of nutrients before senescence. The tall grass *Calamagrostis epigejos* plays an important role, especially in disturbated habitats including post-mining sites. *C. epigejos* can effectively suppress other plant species especially by high production of aboveground biomass and a thick layer of undecomposed litter. After senescence only a small part of litter falls on the soil surface and a large proportion of dead biomass remains standing for several months without contact with soil which limits microbial breakdown.

Objectives

The main objective of this study was to access the role of dead biomass on the turnover of nitrogen and phosphorus from the living aboveground plant biomass of *C. epigejos* during senescence in two different old sites in the post-mining areas.

Materials and methods

Plant biomass of *C. epigejos* was collected every two month during the vegetation season in 2007. Aboveground biomass was collected from five squares (0.5x0.5 m) in the young (15 years) and old site (45 years). Biomass was classified into the three pools: living, dead standing and dead lying biomass. Concentration of nitrogen and phosphorus was analyzed in dried and mashed samples.

Results

We found that a larger share of dead standing biomass were produced in the old site in contrary to the young site. It was also observed retranslocation of nutrients from living biomass during the vegetation season especially before senescence of leaves. The greatest amount of nitrogen (20.5 $mgN \cdot g^{-1}$) in living biomass was found in the early period of the vegetation season. The values in leaves before senescence were close to values of dead biomass (6.6 $mgN \cdot g^{-1}$) and consequent losses by decomposition were lower then reabsorbtion. Nitrogen content of dead lying biomass was in most terms higher compared to dead standing biomass in both sites. Similarly there were observed a greater values of phoshorus in the old site in all pools of biomass than in the young site. The content of phosphorus in living biomass reached the highest values in April (2.5 $mgP \cdot g^{-1}$). The lowest values were observed in October. It is also clear from N:P ratio that *C. epigejos* was limited more by nitrogen than phosphorus on the both sites. The eficiency of nitrogen showed also results of C:N ratio in living biomass especially in the midle of the growing season in August and in October when C:N ratio reached up70 in the young site, resp.50 in the old site.

Conclusions

In conclusion, the aboveground plant biomass of *C. epigejos* was limited on the both sites more by nitrogen and that could explain a larger reabsorption of nitrogen during senescence when amount of nitrogen decreased to the lower values than other previous studies observed. However both of sites are still young in the development of soil and the increase of N/P ratio in the old site was probably due to by a larger quantities of living biomass than in the young site. Differences between standing and lying biomass indicated faster leaching of nitrogen in early stages of decomposition of lying biomass. In treatment with standing biomass prevailed photochemical degradation which caused less lignin and it helped to leaching of nitrogen from biomass. Generally the retranslocation of phosphorus initiated in later period of the growing season than nitrogen reabsorption.

The majority of nutrients were reabsorbed before senescence because the greatest losses were subsequently after dead of biomass in August, respectively in October. And then when standing biomass turned to lying biomass, which was in contact with soil, the nutrients losses from litter were very slow.

P 2.2.06

Nitrogen and carbon dynamics in the mycorrhizosphere of an organic forest soil

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1. Introduction

The rhizosphere is a hot-spot for biogeochemical cycles, as it shows enhanced microbial activity due to inputs of labile organic matter from rhizodeposits. *In situ* studies investigating the effects of roots and mycorrhizae on soil nitrogen (N) and carbon (C) cycling are scarce.

2. Objectives

Investigating the *in situ* gross N cycle transformations and apparent priming in a root/ectomycorrhizal exclusion experiment in an organic forest soil.

3. Materials & methods

The study was conducted in a drained organic forest soil (Histosol) at the Skogaryd research catchment, south-western Sweden. Exclosure of roots and roots plus mycrorrhiza was achieved by soil trenching, which was conducted six years prior to the experiment. We conducted *in situ* ^{15}N soil labelling using the 'virtual core approach' in order to quantify gross N transformation rates via a ^{15}N tracing model. At the same time we investigate potential rhizosphere priming by ^{13}C-glucose additions and tracing the ^{13}C into respired CO_2.

4. Results

The gross mineralization-ammonium (NH_4^+) immobilization turnover was enhanced by the presence of roots, probably due to enhanced inputs of labile carbon, stimulating microbial activity, which coincided with a positive priming effect. Autotrophic nitrification was only stimulated by presence of ECM, but not by presence of roots, which we could relate to changes in the abundance of nitrifying microorganism.

5. Conclusion

Overall we conclude that plants and their ectomycorrhizal symbionts actively control N and C cycling in forest soil.

P 2.2.07

Stimulation of soil organic nitrogen pool: the effect of plant and soil organic matter degrading enzymes

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1. Introduction

In boreal forest soil, a large part of total soil nitrogen (N) is in organic forms. Usually the mineral N concentrations are low and the ecosystem productivity is limited by the availability of N, which indicates restricted availability of organic N for plants and microbes. It is assumed that N is integrated to SOM via stabilization processes that form either chemically recalcitrant N, or protect N physically from microbial utilization. Decomposition of SOM is regulated by many processes that may preserve but also release N from SOM. These processes significantly affect soil C and N cycling.Therefore, the release of the chemically recalcitrant N from SOM and the formation of available forms of N for soil organisms are of crucial importance for ecosystem productivity in N limited boreal forest ecosystems.

2. Objectives

The objective of the study was to investigate the effect of SOM degrading oxidative enzymes laccase (L) and manganese peroxidase (MnP) and protein degrading enzymes (proteases, P) on soil N cycling with the presence or absence of a Scots pine seedling (*Pinus sylvestris* L.). Our hypothesis were 1) the addition of SOM and protein degrading enzymes increase SOM decomposition and the proportion of N forms available to the plant, 2) the presence of a plant stimulates SOM decomposition and N availability in the soil, 3) increased protein degradation in protease treatments (P) induces amine synthesis and amine concentration in the soil.

3. Materials & methods

Non-planted and planted (Scots pine) microcosms filled with homogenized humus from a boreal Scots pine forest were grown in greenhouse for eight months and both types of microcosms were subjected to three enzyme treatments: 1) no enzymes added (BSA protein as control C), 2) protease (P) enzyme added and 3) laccase (L) , manganese peroxidase (M) and protease (P) enzymes added.

The concentrations of NO_3^-, NH_4^+, amino acids, alkylamines, total N, recalcitrant N, degradable and proteinaceous N, plant biomass, enzyme activities and ectomycorrhizal fungal root tip numbers were quantified after the enzyme treatments.

4. Results

Statistically significant treatment effects were found in the largest N pools: total soil N, recalcitrant N, and lost N contents. Non-planted LMP treatment had lost more N than non-planted C and P treatments and the loss was statistically the same as in all planted treatments, irrespective the enzyme additions. Similar difference between treatments was observed in SOM content, which was decreased in all planted treatments and non-planted LMP treatment. The enzyme additions did not cause any decrease in total soil N content in the planted treatments but interestingly, the presence of plant had the same impact on total soil N content as non-planted LMP treatment.

When overall means of planted and non-planted treatments were compared, the total soil N content was significantly ($P<0.05$) lower in the planted treatment and more N was lost from the system if the plant was present.

Most N forms differed between planted and non-planted microcosms and sum of all alkylamines were found to be in a similar level as NO_3^- in soil.

5. Conclusion

Here we show that the total N pool in the organic layer of boreal forest soil can be artificially decreased if both organic matter oxidizing and protease enzymes are added. We show experimentally the influence of enzymes and plant on mobilization of recalcitrant N pools in the soil, a large N reservoir that often has been considered inactive. Our study brings new information on the potential mechanisms that may affect SOM degrading processes. As forest trees were shown to induce N and SOM loss in boreal forest humus, our results highlights the importance of including plant-induced SOM decomposition in global carbon models.

P 2.2.08

Barley genotype-specific variation in rhizodeposition derived-C impacts mineralization of native soil organic matter and recent organic material inputs in soil

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Rhizodeposition is an important source of substrate for microbial communities, supporting activities including soil organic matter (SOM) and nutrient cycling. Therefore, it is a potential trait of interest for crop plants, particularly in the context of variety selection for sustainable production systems. However, in sustainable agriculture, returns of organic materials to soil also have a major impact on C and N cycling. In this experiment, we assessed (i) variations in rhizodeposition derived-C among barley genotypes, (ii) the individual and combined effects of rhizodeposition derived-C and plant residue inputs to soil on native SOM mineralization, C-stabilization in soil and nutrient cycling, (iii) whether genotypes that vary in mineralization of native SOM also impact mineralization of recent organic soil amendments (i.e. plant residues) differently, and (iv) whether genotypes that stimulate high mineralization rates of organic soil amendments also directly benefit through nutrient uptake. We applied a continuous ^{13}C labelling approach to trace rhizodeposition and residue derived-C in surface soil CO_2 efflux, soil microbial biomass, soil solution (i.e. dissolved organic matter), and soil particle-size fractions (i.e. SOM pools), enabling us to fully assess processes of C-incorporation and C-loss in soil as a function of barley genotype and plant residue input. In addition, we used ^{15}N labelled ryegrass root residues to trace the flow of residue derived-N and its uptake by plants. Initial results reveal (i) genotype effects on total soil CO_2 efflux and its three component sources: rhizodeposition derived-C, residue derived-C and SOM derived-C, (ii) residue effects on total-C, rhizodeposition derived-C and SOM derived-C respired as CO_2, and (iii) differential plant uptake of residue released-N amongst genotypes. These results demonstrate genotype differences in impacting C-loss from soil as CO_2 efflux and in stimulating the mineralization of native SOM and newly incorporated organic materials in soil, revealing a potential for germplasm selection in barley to support sustainable production systems.

Key words: Rhizodeposition; C-stabilization, soil CO_2 fluxes; organic material inputs; plant N-uptake; $^{13}C/^{15}N$ labelling

P 2.2.09

Rhizodeposition and priming effect in switchgrass (*Panicum virgatum* L.) as revealed by ^{14}C pulse labelling and 3-source-partitioning approach

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During the conversion from annual to perennial herbaceous crops, the rhizosphere C flow represents the dominant portion of total C input to the soil system. Nevertheless, decomposition of preexistent SOC could be triggered by rhizodeposition from perennial herbaceous crops. The objectives of this research were: (1) to quantify, in soil with different ^{13}C signatures and N levels, switchgrass total C rhizodeposition, including C losses by rhizomicrobial respiration; (2) to reveal sources and mechanisms of priming effects on preexistent SOC ("old" and "recent") induced by switchgrass rhizodeposition. Switchgrass plants were grown in "old" C_3 soil (continuous wheat cropping) and "recent" C_3/C_4 soil (5 years of maize cropping), both labelled with ^{15}N (1% atom exc. $^{15}KNO_3$ equivalent to 100 kg N ha^{-1}). 60 days after sowing plants were pulse-labeled with $^{14}CO_2$ for 5 hours (186 kBq input per plant). The soil $^{14}CO_2$ efflux was monitored daily for 9 days after labelling and it was separated into root and rhizomicrobial respiration by a modeling approach to calculate rhizodeposition-to-root ratio. Rhizosphere and bulk soil, shoots and roots were collected at the end of experiment and analyzed for ^{14}C, ^{13}C and ^{15}N. Roots samples were analyzed for root biomass and root length density (RLD). ^{14}C rhizodeposition budget were used in combination with ^{13}C data in order to determine C sources of priming effect ("old", "recent" and rhizodeposits) in three compartments, namely CO_2, microbial biomass (MB) and dissolved organic C (DOC). ^{15}N data and soil enzymatic activities were used to assess the effect of N fertilization on the mechanisms of rhizosphere priming effect and to calculate switchgrass N use efficiency. Mixed model of repeated ANOVA showed a significant ($p < 0.05$) SOIL x TIME effect both on the rate and the cumulative $^{14}CO_2$ efflux. Root respiration (RR) and rhizomicrobial respiration (RMR) differed between the two soils. RR and RMR amounted respectively to 3.3% and 4.9% of total assimilated C in switchgrass cultivated in C_3 soil and to 2.5% and 4.2% in C_3/C_4 soil. Thereby, RMR accounted for 60% and 37% of total root-derived $^{14}CO_2$ efflux from C_3 and C_3/C_4 soil. Budget of rhizodeposited C (% of total rhizodeposition) showed a more active rhizosphere in C_3 soil, where 41% of total rhizodeposition was mineralized within 9 days from labelling, while it was 25% in C_3/C_4 soil. On average, 9.0% and 12.8% of rhizodeposited C was incorporated into microbial biomass and DOC and 44.7 % was found in soil. A rhizodeposition-to-root ratio of 0.95±0.09 and 0.53±0.06 was calculated for C_3 and C_3/C_4 soil and applied to root biomass, resulting respectively in a rhizodeposition rate of 5.6 and 3 µgC g_{soil}^{-1} day^{-1}. Overall, there was a significant positive correlation between rhizosphere-primed soil C and root biomass among all the treatments. Although there was no difference in total SOC concentration among treatments, the isotopic discrimination showed a greater decrease in C_3 carbon concentration with N addition. This indicates that addition of N coupled with a high C rhizodeposition might induce a strong negative priming effect on old C_3 carbon. With the aid of ^{13}C data for CO_2, MB and DOC, the magnitude, mechanisms and sources of switchgrass priming effect will be discussed. Particular attention will be paid on the implications of rhizosphere priming effects on SOM decomposition to understand whether microbial N mining or stoichiometric decomposition hypothesis do occur in switchgrass rhizosphere.

P 2.2.10

Bacterial communities in soils of a confined catchment area in central Mexico amended with bean residue

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Soil bacterial communities are defined by soil characteristics, climatical conditions and soil management. It remained to be investigated if these factors also control bacteria involved in the degradation of plant residues. In pre-Hispanic times Tenochtitlan, modern day Mexico City, was surrounded by lakes and agriculture took place in chinampas or 'floating gardens'. The lakes were drained later to avoid inundations of Mexico City. The former lake bed is highly saline and alkaline and on its fringes soils have been cultivated with maize, wheat or beans. The different ecosystems in this confined catchment area are well suited to study how differences in soil types, physico-chemical conditions and management histories affect microbial population and how these factors control the bacterial community structure when plant residue is applied. Soil from chinampas, the former lake bed and arable land was amended with bean residue (*Phaseolus vulgaris* L.) and C and N mineralization and changes in the bacterial community structure were monitored during an aerobic incubation of 56 days. The C and N mineralization, changes in the bacterial population structure and the factors that control these changes will be discussed.

P 2.2.11

The Critical Role of *Eisenia fetida* Earthworms' Microflora in Accelerating Waste Degradation by Secreting Hydrolyzing Enzymes

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Earthworms as one of the main soil invertebrates also known as 'ecosystem engineers' are involved in soil aeration through burrowing and feeding activities, mineralization and humus formation, thus improving soil fertility and quality by their final valuable product casts. Earthworms are involvement in soil fertility and quality depends on many factors, including the interactions between earthworms' activities such as microbiological characteristics of earthworm casts and microbes which secrete enzymes. These microbial enzymes accelerate reactions such as organic matter decomposition, nutrient cycling and pollutant degradation. Due to more available substrates in the earthworm casts, microbial populations and their activities in the earthworm casts are higher than the surrounding soil. In the present study, we detected and isolated *E. fetida* cast dominant microflora which secreted some hydrolytic enzymes under three diverse feed (litter leaves, cow dung and cellulosic carton) based on a factorial design. Results of screening did not show any Phytase producing bacteria. But two bacteria *Bacillus aerophilus* and *Bacillus safensis* which were able to produce both Cellulase and Xylanase, were purified and identified as dominant species. Accordingly, we have concluded that different diets are in favor of certain groups of bacteria in the earthworm casts. Various conditions and nutrient supplements lead to proliferation or stimulation of growth in microorganisms, affecting the decomposition rate.

P 2.2.12

Fresh and field aged biochars induce negative priming: a long term field study using $^{13}CO_2$ pulse labelling and soil physical fractionation

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Introduction

Soil organic carbon (SOC) can be stabilised through organo-mineral interactions and soil aggregation. Biochar has been shown to enhance these organo-mineral interactions and consequently form stable soil aggregates, particularly in a reactive clay-rich soils. This may in turn lower SOC mineralisation (i.e. negative priming). However, there is a paucity of information on the extent and mechanisms of priming effect under longer-term (>5 years) field conditions. Even less is understood how the re-application of biochar can affect the priming in a clay-rich soil. The impact of continuous labile carbon (C) inputs from plants (e.g. root litter and exudates) on organo-biochar-mineral interactions has also been largely neglected.

Objectives

- To determine the extent of biochar induced priming on an existing 9 year experimental site, including the effects of freshly applied, and field aged biochars in planted and unplanted Ferralsol;
- To trace recent C (native SOC and root-derived C) partitioning in SOM fractions separated from macro and microaggregates recovered from fresh and aged biochar amended pasture soils;
- To evaluate the impact of reapplication of biochar to existing aged biochar plots on the priming effect and recent C partitioning.

Methods

A field trial was originally established in subtropical C_3 pasture on a rhodic Ferralsol in 2006 (Slavich et al., 2013). *E. saligna* biochar (550°C) was applied at 10 t ha^{-1} in the top 100 mm of soil profile (equivalent to 1% w/w). In April 2014, a 12 month trial using the same biochar at the same rate was superimposed on the existing (8 year old) trial. Four treatments were: 1) unamended (0 t biochar ha^{-1}, "control"), 2) existing biochar plots (10 t biochar ha^{-1}, "9 year aged"), 3) biochar applied to the unamended soils (10 t biochar ha^{-1}, "1 year aged"), and 4) biochar re-applied to the existing biochar plots (20 t biochar ha^{-1}, "reapplied"). Six $^{13}CO_2$ pulse labelling campaigns were employed in three contrasting seasonal conditions (two labellings per season). During each campaign, root components were labelled with enriched $^{13}CO_2$ to create a large difference in the isotopic signature from ^{13}C-biochar and ^{13}C-soil. Autotrophic and heterotrophic soil respiration was separated to evaluate the biochar-root interactions, using novel in-field root respiration chambers. Three C sources (soil, biochar and root-C) were distinguished in the total soil CO_2 efflux using an isotope mixing model.

Soil was sampled at 0, 4, 8 and 12 months. A combination of aggregate size, density and particle size fractionation was employed. Initially, two aggregate sizes were separated by a dry sieving procedure: 1) macroaggregate (>250-2000 µm) and 2) microaggregates (<250 µm). For each aggregate size, four SOM fractions were further separated: 1) free particulate organic matter (f-POM, < 1.6 g cm^{-3}); 2) occluded POM (o-POM, > 1.6 g cm^{-3}, >53-250 µm) and 3) silt-bound OM (s-OM, >2-53 µm), and 4) clay-bound OM (c-OM, <2 µm). ^{13}C signals of bulk soil, each aggregate size and SOM fraction were determined.

Results

Both 1 and 9 year field aged biochar induced short-term positive priming, in both planted and unplanted soils, however, this reversed to negative priming after 16 days following pulse labelling. The reapplication of biochar showed a similar priming effect. The aging of biochar (1 year vs. 9 year) did not change the magnitude of the priming. The negative priming of SOC in the unplanted soils was greater than in the planted soils. We found biochar-C incorporated into the o-POM fractions of the bulk SOM by four months, and gradually increased by 8 months after application.

We also showed greater ^{13}C enrichment (^{13}C-root) in the freshly biochar-amened o-POM compared to the controls, following pulse labelling. Magnitude and relevance of this stabilisation of recent C will be presented.

Conclusion

We demonstrated biochar-induced negative priming in the presence of pasture over the longer-term. The assessment of the reapplication of biochar demonstrated additional negative priming. The comparison of ^{13}C partitioning in different aggregates and SOM fractions between freshly applied and aged biochar-amended soils will provide further knowledge on how biochar stabilises recent C over a longer term.

P 2.2.13

Biochar ease soil microbes in agricultural soils

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Use of biochar from pyrolysis of agricultural bio-wastes had been increasingly recommended for enhancing soil C sequestration and mitigation of greenhouse gas emission in soils. Yet, use of biochar in agriculture had been increasingly under field test globally while biochar for sustainable soil management had been recently facilitated under UNEP. However, a number of lab/pot studies suggested a potential priming effect by biochar on native organic matter decomposition, raising a confounding role of biochar to carbon sequestration when added to soil.

Using a meta-analysis protocol, this study analysed the changes in soil microbial biomass carbon and nitrogen as well as soil respiration with biochar addition in the studies reported by March 1, 2015.

Soil respiration quotient and metabolic quotient, and microbial quotient were used to assess changes in microbial efficiency of carbon use and microbial growth following biochar addition. The results showed soil microbial biomass was moderately but respiration slightly increased, in line with a moderate and slight reduction in respiration quotient and metabolic quotient in biochar added soils. Again, there was no correlation of changes in soil respiration to those in soil microbial biomass carbon.

Biochar addition slowed carbon turnover while promoted microbial growth in soil. This study affirmed a promising role by biochar in enhancing C sequestration and microbial health in agricultural soils.

P 2.2.14

Modelling ecosystem C and N dynamics - Influence of ectomycorrhizal decomposers on N availability in boreal forest ecosystems

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In terrestrial ecosystems plants growth is often limited by nitrogen (N). To increase the N uptake, plants form symbiotic association with ectomycorrhizal (EM) fungi. As a symbiotic response, plants provide EM with C and EM inturn degrades SOM to mobilise organic N and also acquires inorganic N. EM fungi have important role as 'primers' in soil C and N dynamic of terrestrial ecosystems. The term 'priming' here refers to the ability of EM to stimulate degradation of the SOM in order to obtain nutrients and translocate them to the plant, as a symbiotic response for the C it gets from the plants. It is difficult to test the importance and contribution of mycorrhizal traits such as the 'EM N priming' to SOM dynamics experimentally. Conceptual models provide a platform to study such processes. Currently there are a few model studies that show how nutrient supply and plant-EM associates alter C and N dynamics. We have developed an ecosystem model on C and N cycling and included EM priming as an important factor in the model and study how priming varies with N availability. We study how the plant- EM system responds to changes in N availability. Secondly we investigate how EM priming influences plant biomass on different N availability. We explore these scenarios by assuming that plants rely largely on EM to acquire N both in organic and inorganic forms.

The model includes 6 pools describing the annual C and N flows between i) plant biomass (C_P, N_P), ii), the two SOM pools - hydrolysable soil organic matter SOM_H (C_H, N_H) and oxidisable soil organic matter SOM_O (C_O, N_O), iii) the two microbial pools - saprotrophs (C_S, N_S) and ectomycorrhizal fungi EM (C_M, N_M) and iv) the inorganic N pool (N_I). The degradation by saprotrophs and EM is assumed to be enzyme driven. At first we tested the model by using parameter values found in literature for boreal forest conditions and found that the predictions, particularly with regard to N availability, are in agreement with the literature observations

We show that the plant - EM interaction has stronger impact on pool sizes at low N availability levels than at high availability levels. The organic N provided by mycorrhiza is an important source of N to plants at N limited conditions.. We concluded that the model can be used as a platform to test our understanding of the importance of EM as important nutrient drivers to plants at low N limited ecosystems.

P 2.2.15

Effects of Different Meadowfoam Meal Applications on Some Soil Biological Properties

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Meadowfoam Meal is produced after oil extraction of Meadowfoam. This meal is usually applied to soils as a carbon source. In this research, meal was added soils at the rates of 0%, 1%, 3% and changes of soil nitrogen and carbon productions were observed for incubation period of mixtures. Soil samples were collected and analysed periodically for two month. Ammonium contents rapidly increased until the second week then decreased below the initial concentration after the five weeks of the incubation. Nitrate concentration increased by time until the 4 th week and then reduced. Hydrolytic enzymes like as L-Aminopeptidase and β-Glucosidase increased by the rates of meal but, decreased by the incubation times. L- Aminopeptidase and β-Glucosidase enzymes were high during the first two weeks and low after the 2nd. week. Similarly, released CO2 were observed related with meal application reductions as ^{12}C.

P 2.2.16

Quality and biodegradability of dissolved organic matter originating from litter of spruce swamp forest vegetation dominants

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Quality of dissolved organic matter (DOM) originating from three plant dominants: Sphagnum girgensohnii (SG), Eriophorum vaginatum (EV) and Vaccinium myrtillus (VM) was studied. These plant species are dominants in spruce swamp forests (SSF) ecosystems. SSF belong to wetlands and they are lying between open peatlands and forests. Thus as wetlands they accumulate carbon in form of peat but at the same time they can be a source of DOM. It is unclear, how these plant dominants affect DOM quality and biodegradability within these ecosystems.

The aim of this work was to show if and what are the differences in quality and biodegradability of DOM originating from litter (shoots, roots, moss) of different plant species (SG, EV, VM).

Plant litter (VM and EV shoots and roots, SG whole plant) was incubated under constant temperature (15°C) and constant moisture under aerobic conditions for 6 months. DOM was extracted by shaking the litter with distilled water, then filtered through 0,2 um filter and then analyzed for C and N content on LiquiTOCII and for nutrient content onFIA (NH_4, NO_3, PO_4). Biodegradability was measured in the samples after their dilution to the same C concentration. Then pH was adjusted to 4,5, nutrients were added to get rid off nutrients limitation and samples were inoculated by inoculum prepared from SSF soil extracts. DOM was incubated in both aerobic and anaerobic conditions for 6 weeks. Biodegradability of DOM was measured as CO_2 production (CO_2 concentration in headspace of incubation vials) using gas chromatography.

The highest concentrations of DOC, TN, NH_4^+ and SRP were measured in DOM originating from EV leaves, the lowest concentrations were released from SG whole plant. NO_3^- concentration was the highest in DOM originating from VM roots. Value of DOM C/N ratio was increasing in order: EV leaves < EV roots < SG < VM leaves = VM roots. Value of DOM C/P ratio was increasing in order: EV leaves < VM leaves < EV roots < VM roots < SG . Biodegradability of DOM decreased in order EV leaves = VM leaves = VM roots > EV roots = SG.

Litter of studied plant species differed significantly in production and quality of DOM during their decomposition. Litter from EV leaves, VM leaves and VM roots seem to be important available carbon and nutrient sources for soil microorganisms in SSF, whereas EV roots and SG are more important source of organic matter, which is accumulating in soil.

P 2.2.17

Nutrients release during decomposition of cover crops biomass in brazilian semiarid

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Introduction - The decomposition of cover crops biomass increases the availability of nutrients for the main crop. In semi-arid regions, subjected to high temperatures and high ultraviolet radiation incidence, degradation of plant debris and soil organic matter is very fast. In irrigated crops, increasing the availability of water in the soil can further accelerate the rate of decomposition and release of nutrientes.

Objective - The objective of this study was to estimate N, P and K release rates during the decomposition of biomass of different species used as cover crop in the Brazilian semiarid.

Material and methods - Jack bean (*Canavalia ensiformis*), pigeon pea (*Cajanus cajan*) and sunn hemp (*Crotalaria juncea*) were grown for 90 days in a passion fruit irrigated orchard in the Brazilian semiarid. At the cut, samples of the biomass of each cover crop and also of a mixture of weeds were placed in litter bags and distributed over the soil surface. After 7, 15, 30, 60, 90, 120 and 150 days of delivery in the field, 12 bags of each type of cover crop were collected, the materials contained in the bags were cleaned, oven dried and weighed. Sub-aamples were collected to determine the concentrations of N, P and K. The amounts of the nutrients released by the decomposition of each species were estimated by the difference between the amounts contained in the initial biomass and the amounts contained in the biomass remaining at each sampling time. The nutrients release rates were estimated using the exponential mathematical model $Mt = Mi\ e^{-kT}$. The time required to release 50% of the nutrients (t50) and also the time required to release 95% of the nutrients (t95) of each species used as cover crops were calculated from the value of k (t50 = 0,693/k and t95 = 3/k, respectively).

Results - The time required to release 95% of the N present in the biomass of cover crops ranged between 20 and 30 days for jack bean, pigeon pea and weeds, but for sunn hemp were required 63 days. To release 50% of K present in the biomass of all species, only 2 to 4 days were required, and only 9 to 16 days were necessary to release 95% of the K content. A half of the phosphorus present in the biomass of legumes studied was released in 8 to 18 days after the start of the experiment. The time required to release 95% of the P present in the plant biomass ranged between 34 and 65 days.

Conclusion - The nutrient release of the biomass were very fast for all species of cover crops. Most of the P and N contained in the biomass of plants was released in the first 60 days of decomposition. With seven days of decomposing, almost all the K of all species had been released.

P 2.2.18

Living root systems affect earthworms production according to substrate properties

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The root systems and rhizosphaere microflora stimulate the decomposition of organic matter (Cheng 1990), and generally reduce the growth rate of earthworms in microcosm experiments. However, field observations demonstrates often the high abundance of earthworms under herbaceous plants. In this study we show, that the effect of root systems and rhizosphaere has different direction according to the substrate composition, structure and the plants location in the microcosm. We assume, that rhizosphere may compete for organic source, or on the contrary to be the food source for earthworms and increase the availability of nutrient for earthworms according to substrate conditions. Different mechanisms of interaction between soil fauna, rhizosphere and organic matter in soils or artificial substrate (Kocik, Truchan, Rozen 2007) may open the way for more complex technologies for land reclamation.

To evaluate the role of living roots in correspondance to the food source for endogeic earthworms, we chose goutweed *Aegopodium podagraria*, buckwheat *Fagopyrum esculentum* and endogeic species *Allolobophora chlorotica*, the «pink» morph. Substrate compounds were the loamy soil , leaf litter ang fresh horse manure. Substrates were waterlogged in the lower part of containers. In the experiences juvenile earthworms 50-100mg were maintained in 1L plastic containers with 3 variants of substrate, 2 types of plant location and without plants. Substrates were: leaf litter mixad with soil, manure mixed with soil 1:1 by volume, and manure burried under the soil ground. Plants were put directly in the containers with earthworms or in the smaller vessels with perforate bottom for earthworms and microorganism migration on the soil surface, to divide the direct effects of roots and microflora. We done three replication for each treatement. Earthworms growth rate were recorded each two weeks. We used arcsin-transformation of data and ANCOVA to compare the weekly growth of earthworms.

In all the treatements buckwheat rhizosphere in the containers with litter as food source inhibited the growth rate of earthworms. It was no significant difference between plant-less treatements and microcosms with plants in the additional vessels. However, buckwheat increased earthworm production in microcosms where the manure was burried and was toxic for *A. chlorotica*. In this case dung layer become decomposed and completely transformed by their burrowing activity. The presence of goutweed root systems reduces significantly the growth rate in the dung mixed with soil material. The higher production in soil-dung substrate was noted in the treatement with plants in additional pots. In the treatements with litter substrate goutweed stimulated earthworms growth.

Living root systems may affect earthworm production by different ways. Their effect is related to a main food source for earthworms, plant species and roots location in the substrate.

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P 2.2.19

Do sheep excreta cause a positive priming of peat-derived CO_2 and N_2O emissions?

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Introduction
Large areas of peatlands in Germany and the Netherlands are affected by drainage and high nitrogen deposition. Due to the large carbon release by aerobic decomposition of peat, drained peatlands contribute to around 5% of the total German greenhouse gas emissions (GHG). Thus, preserving or restoring the carbon sink function of natural and semi-natural peatlands is an important greenhouse gas mitigation strategy. Sheep grazing is a common extensive management activity on drained peatlands, in particular on nature protection areas. It aims at removing nutrients, preserving an open landscape, and preventing succession of forest vegetation. However, input of easily mineralisable material such as sheep excrements could enhance degradation of soil organic carbon, thereby increasing the effect of these ecosystems on national GHG budgets. Since sheep excreta contain active microbes, labile substances and a C/N ratio narrower than the peat, they have a strong potential for positive priming in peat soil.

Objectives
In this study, we investigated if sheep excreta increase emissions of CO_2, CH_4 and N_2O from peat soil and if sheep excreta induce a positive carbon and nitrogen priming in peat soil and trigger CO_2 and N_2O release from the peat.

Methods
We studied the influence of sheep excreta on GHG emissions from a degraded peat soil using stable isotope tracers to partition sources and determine possible priming effects. A microcosm experiment on the influence of sheep excreta on GHG emissions from a histic Gleysol with strongly degraded peat was designed. The ^{15}N and ^{13}C stable isotope tracer technique was used to partition sources of CO_2 and N_2O. Labeled sheep faeces and urine were obtained by feeding enriched material. After the removal of the upper 5 cm, undisturbed soil columns were treated with surface application of urine, faeces or mixtures of both in different label combinations to distinguish between direct effects and possible priming effects. Incubation was done under stable temperature and precipitation conditions in a microcosm system. Fluxes as well as ^{15}N and ^{13}C enrichment of N_2O and CO_2, respectively, and DOC and DON were measured for three weeks.

Results
Addition of sheep excreta increased emission of total CO_2 in proportion to the added carbon amounts. DOC contributed to total C export up to 25% of the gaseous C emissions. There was no CO_2 priming in the peat and no effect on CH_4 and N_2O was observed under the aerobic experimental conditions. The N_2O-N source shifted from peat to excreta, which indicates negative priming, but priming was not significant. DON export was up to four times higher than the gaseous nitrogen loss as N_2O.

Conclusions
The results indicate that sheep excreta do not significantly increase GHG emissions from degraded peat soils. Sheep excreta cover a small fraction of the grazed area and exert slightly negative carbon priming. Additionally, sheep also compact the soil by trampling. Overall, sheep grazing can be expected to slow down the degradation of drained peat soil. Considering the degraded peatland preserving benefits, sheep grazing on peatlands affected by drainage and high nitrogen deposition should be further promoted.

P 2.2.20

Ericoid plants affect soil nitrogen forms and total nitrogen pools in boreal pine forest

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1. Introduction

Boreal forest soil is regarded as nitrogen (N) limited despite the total N quantities in soil may be relatively high. In such soils, the N is mostly in organic forms and cannot be easily used by forest trees like Scots pine (*Pinus sylvestris* L.). In boreal pine forests, the forest floor is generally covered by mosses and ericoid shrubs species like common heather (*Calluna vulgaris*), blueberry (*Vaccinium myrtillus*) and lingonberry (*Vaccinium vitis-idaea*). While forest trees form ectomycorrhizal symbiosis with fungi, ericoid plants have ericoid fungal symbiosis. These forms of symbiosis differ in relation to the type of fungal-root association but also generally, there are different fungal species that form ericoid or ectomycorrhizal symbiosis.

Ericoid mycorrhizal fungi are known to grow well on nutrient-poor heathland soils and they produce enzymes that help them to access different forms of organic N, also from recalcitrant sources that are not available to most other organisms. Therefore, the interactions of ericoid and ectomycorrhizal plants in boreal forests are of particular interest, when the forest soil C and N cycling are studied.

2. Objectives

The aim of the study was to investigate how ericoid plants, which are common in boreal Scots pine forests affect soil N forms and total N pools. We hypothesize that ericoid plants transform organic N in soil into forms that are less available for Scots pine. We also hypothesize that changes in soil N forms can be estimated using enzyme activity measurement in soil solution.

3. Materials & Methods

Homogenized humus from boreal Scots pine forest: equal material in all microcosms. Soil was collected from Hyytiälä Forestry Field Station in southern Finland (61º 84´N, 24º26´E). Growth period 20 months.

The enzymes were recovered by filter centrifugation from microcosms (Heinonsalo et al. 2012). Enzyme activity measurements include fluorometric assays for acid phosphatase, N-acetylglucosaminidase, beta-glucosidase, beta-glucuronidase, beta-xylosidase, cellobiohydrolase, leucine amino peptidase (methods modified from Pritsch et al. 2011) and colorimetric assay for laccase.

Soil chemistry studies include measurements of total N, NH_4^+, NO_3^-, total organic carbon and total organic N (difference between total N and inorganic N), total amino acids. Moreover, we studied also total phenolic compounds and condensed tannins (as in Kanerva et al. 2008).

4. Results

Preliminary results will be shown in poster

5. Conclusion

The results will be discussed in poster in relation to boreal forest soil C and N cycling, with special focus on ericoid and ectomycorrhizal plant interactions.

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P 2.2.21

Nitrogen availability has a strong moderating effect on CO_2 emissions from soil caused by rhizosphere priming effects

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Labile carbon (C) compounds exuded by plant roots can significantly 'prime' soil organic matter (SOM) decomposition, resulting in increased emissions of CO_2 from soils. It is increasingly recognized that priming might be one of the quantitatively most important processes in the decomposition of SOM. Even so, the controlling factors, underlying molecular mechanisms and microorganisms involved in priming remains elusive. There are some indications that priming increases with increasing rates of labile C input, while input of labile C in combination with available N might have the opposite effect. A possible reason is that simultaneous input of C and N favors microbial 'cheaters' that do not decompose SOM, while input of only C 'prime' the decomposition of SOM by stimulating microbes that decomposes SOM in order to meet their N demand.

The objective of the experiment was to test this hypothesis and determine the effects of variations in C and N availability on the extent of priming and production of plant available nutrients. We also aimed at determining if priming mainly stimulates the oxidative decomposition of complex high molecular weight (HMW) SOM that release less complex polymers such as cellulose, starch and proteins with lower molecular weight (LMW), or alternatively, if priming stimulates the enzymatic decomposition of such LMW compounds directly. To test the hypothesis we designed a microcosm experiment where soil received daily additions of ^{13}C labelled glucose and inorganic N in varying concentrations during 15 days via an artificial root. Half of the microcosms received a mixture of proteins, cellulose and starch (henceforth LMW OM) in concentrations that increased the total SOM by 20% without altering the C:N ratio of the soil. Gas samples were taken every third day to quantify SOM respiration, glucose respiration and priming. At the end of the experiment, we also estimated gross N mineralization and ^{13}C retention in SOM and microbial biomass. The ability of the microorganisms to degrade C and N sources of varying complexity in the different treatments was tested using MT2 bioplates. The release of plant available inorganic N was tested by PRS probes installed in each treatment.

Initial results demonstrate that glucose additions induced priming at the two highest glucose addition rates in the treatment without LMW OM additions, with the strongest effect found in the treatment with the highest additions. In contrast, when glucose was added in combination with inorganic N we found positive priming at all three glucose addition rates. The highest priming was again found at the highest glucose addition rate, but the effect was an order of magnitude lower in this treatment compared to the treatment that did not receive inorganic N. In the treatments with soil pre-incubated with LMW OM, glucose addition resulted in strong negative priming at the two lowest glucose addition rates, and no priming at the highest. Addition of glucose in combination with inorganic N resulted in the opposite pattern, with high positive priming at all three glucose addition rates. The effect was most pronounced at the medium glucose addition rate and decreased at the highest. There was no consistent pattern that enabled us to conclude if priming mainly stimulates the oxidative decomposition of HMW SOM or the enzymatic decomposition of LMW SOM.

Taken together the results demonstrate that N availability strongly regulates the magnitude of priming that occurs in response to labile C input. At low input of labile C, N additions generally stimulated priming, while the opposite was true at high input of labile C. The strong moderating effect of N availability on priming needs to be accounted for in order to better understand and predict how soil CO_2 emissions will respond to increased belowground plant productivity at elevated atmospheric CO_2 concentration.

P 2.2.22

Can we link land use and management intensity to priming effect?

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The magnitude of priming effect has been shown to be dependent on the amount of labile energy sources and soil nutrient availability. As important controls for soil organic carbon (SOC) and nutrient availabilities, land use types and management intensity is thought to affect soil priming. In this study, we determined the impact of land use types (forest vs. grassland), forest management (deciduous vs. coniferous forest) and grassland management (fertilized vs. unfertilized grassland) on the magnitude of soil priming. Soil samples were taken from the topsoil horizons of 29 forest and 30 grassland sites in 3 German study regions (Shorfheide-Chorin, Hainich-Dün and Schwäbische Alb). To determine the intensity of priming we added 800µg glucose-C to 1 g of soil (δ13C label of glucose =100‰). We then incubated the samples with glucose addition and control samples in 12 ml glass vials at 20°C for 48 hours directly on the autosampler of gas chromatograph (GC-IRMS). Vials were flushed with CO_2-free synthetic air before incubation and after 24 hours to prevent the inhibitory effect of excess CO_2. Carbon dioxide concentration and ^{13}C concentration in the headspace of the bottles was measured every 2 hours. At the end of each incubation, potential soil extracellular enzyme activities involved in the C, N, S, P cycle (ß-glucosidase, N-acetyl-glucosaminidase, sulfatase and phosphatase) were determined in samples with and without glucose addition using a multiple enzyme assay with 4-Methylumbelliferone (MUF) associated substrates. Our results indicated that the main peak of CO_2 production occurred within the short incubation period. Carbon dioxide produced due to priming effect was observed to be higher in soils under grassland than in soils under forest. Additionally, we observed different patterns of microbial respiration and related δ13C signatures in soils under different land use types. Compared to grassland soils, a lag phase in CO_2 production was observed for soil samples from both deciduous and coniferous forest. From the analysis of potential enzyme activities, a significant increase in the samples with glucose addition was only observed for phosphatase in forest soils in all 3 study regions. No significant increase in ß-glucosidase, N-acetyl-glucosaminidase, sulfatase activities were observed following substrate addition. This provided the evidence that P limits microbial activities in soils under forest type across the study regions when energy is not the limiting factor. In contrast, P does not limit microbial activities in grasslands, indicating higher P availability. We concluded that land use affect the mineralization rate of labile C and belowground nutrient availabilities which subsequently determined microbial acquisition of nutrients and the intensity of priming effect.

P 2.2.23

The interaction between above- and belowground organic inputs may control soil carbon sequestration capacity

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Question:

Vegetation productivity can potentially compensate the increase on atmospheric CO_2 concentrations by the stimulation of photosynthesis. However, the capacity of ecosystems to offset the rise of CO_2 in the atmosphere will depend on nutrient availability and on vegetation-soil microbial interactions. Changes in vegetation productivity and carbon allocation patterns would alter the detritus inputs to the soil, which can potentially lead to changes on microbial activity and biogeochemical processes. Specifically, the extra supply of fresh organic matter both from above- and belowground detritus inputs (i.e.: litter and root exudates) into the soil may activate the microbial mineralization of the stable fraction of soil organic matter (i.e.: priming effect). These soil carbon losses can be especially sensitive to environmental changes such as temperature and moisture. The magnitude of above- and belowground inputs is ultimately controlled by C allocation patterns in response to atmospheric CO_2 and soil nutrient availability, however, their relative role and interactions controlling soil C sequestration capacity has not been specifically assessed before. We hypothesize that: 1) Above- and belowground vegetation interact controlling soil CO_2 emissions. 2) The activation of soil organic matter mineralization by labile organic substrates (i.e.: priming effect) depends on the amount and quality of the detritus inputs. 3) The higher availability of fresh detritus inputs enhances the soil respiration sensitivity to temperature.

Methods:

In order to elucidate these questions, different levels of litter addition (control, C; litter exclusion, NL; and double litter addition, DL) were implemented in trenched (root exclusion) and non-trenched plots (with roots) in a temperate deciduous forest. Changes in the soil respiration sensitivity to temperature and moisture will be detected by measuring CO_2 fluxes continuously at high temporal resolution with automatic chambers. The spatial and seasonal variability of soil CO_2 emissions according to different types and levels of organic matter inputs was also measured bi-weekly with portable chambers. The annual change in soil carbon and nitrogen stocks will provide information on the long-term changes in soil carbon sequestration in response to above- and belowground inputs.

Results:

Both roots and litter significantly enhanced soil CO_2 effluxes soon after the experiment implementation. Root inputs increased soil fluxes by ca. 1.1 µmol m^{-2} s^{-1}, while litter inputs did it by 0.9 and 1.8 µmol m^{-2} s^{-1} in the C and DL, respectively. A synergistic effect between roots and litter inputs on soil CO_2 emissions was observed, although was not statistically significant yet. That is, the activation of mineralization by one of the inputs (i.e.: litter or roots) was higher at higher levels of the other. The input from labile organic substrates from root exudates with low C:N ratios may have favoured microbial mineralization of recalcitrant components from litter, with also higher C:N ratios. Indeed, at plots with root inputs, the annual amount of C released by the soil due to litter inputs was much higher than the annual C input from litter (ca. 170 gr C m^{-2} $year^{-1}$). However, doubled amounts of litter inputs (DL) did not increase the soil CO_2 released in plots without root inputs. Moreover, temperature sensitivity of soil CO_2 fluxes was lower in plots with roots inputs, probably associated to the delayed photosynthates production, but increased at higher levels of litter inputs.

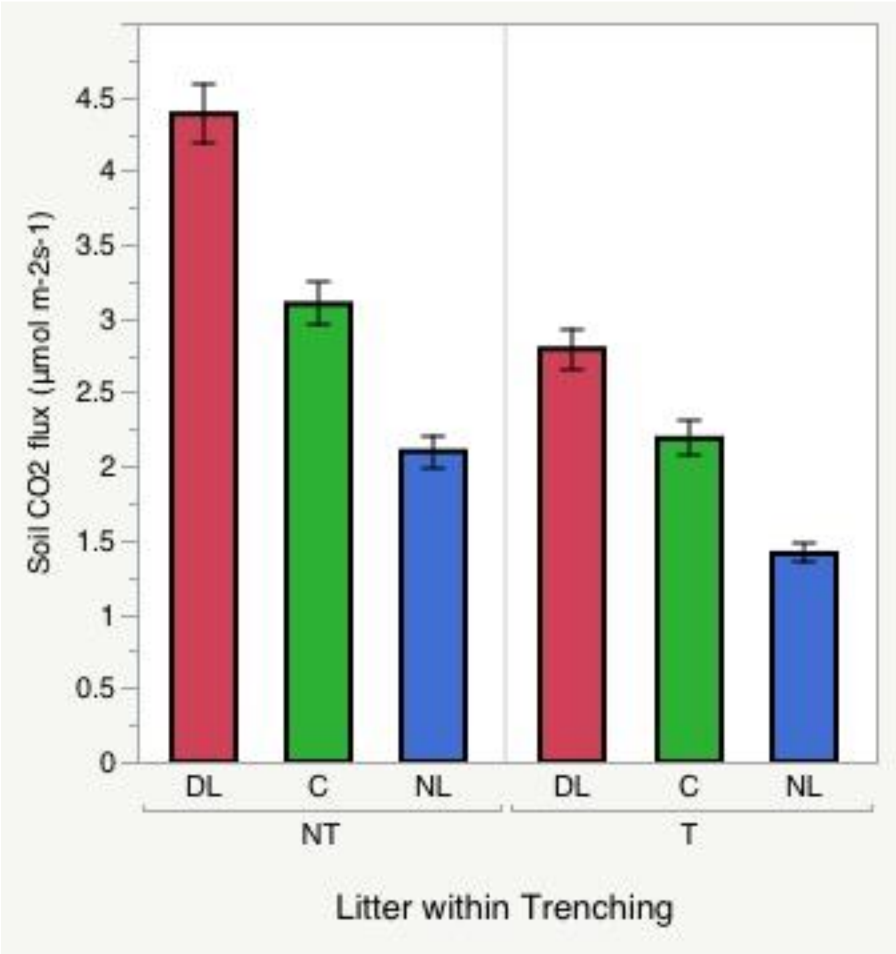
Conclusions:

Synergistic effects between above and belowground organic matter inputs on soil CO_2 emissions may have relevant implications for future predictions on the carbon sequestration capacity of soils under global change. Increases in atmospheric CO_2 concentrations enhance root exudation rates and belowground C allocation of vegetation. Preliminary results of this study point to higher soil carbon loses associated to the activation of microbial mineralization of recalcitrant organic matter by root inputs. On the other hand, the effect of litter inputs on soil carbon would depend ultimately on a balance between the amounts added, root inputs and soil nutritional status.

These results will be contrasted with the long term changes in C stocks and C:N ratios in the soil. The information could then be integrated into biogeochemical models in order to improve our understanding of the relations of soil carbon sequestration potential to altered productivity and allocation patterns.

Figure 1: Mean soil CO_2 fluxes in response to root and litter inputs. DL: Double litter, C: Control, NL: Litter exclusion. NT: Non-trenched plots with root inputs, T: Trenched plots without root inputs.

Figure 1



P 2.2.24

Do microbes destabilise old soil organic matter after fresh substrate addition?

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Introduction

Input of organic matter to soil may stimulate microbial activity and alter soil carbon storage by modifying the mineralization of native soil organic carbon (SOC). Assessing the age of SOC affected by the stimulated microbial activity is a major challenge as the destabilisation of old SOC would be much more damageable for the overall carbon budget than the mobilization of recent SOC.

Objectives

Here, we investigated the microbial populations sequentially activated after the addition of a labile substrate. We tested the hypothesis that glucose addition destabilizes old SOC by sequentially activating different microbial populations, the first ones feeding on recent labile SOC and the second ones on old recalcitrant SOC.

Materials & methods

We used soils from Congolese *Eucalyptus* plantations that were previously under savannah. As a consequence, their old and recent SOC exhibited different δ^{13}C. Soils were amended with glucose, in an amount sufficient to induce microbe growth, and incubated for one week. The δ^{13}C of respired CO_2 was recorded with a high temporal resolution (every 30 minutes) using a tuneable diode laser spectrometer (TDLS) to determine the relative contribution of CO_2 sources. The combination of two glucose treatments with different δ^{13}C signatures allowed partitioning the three sources of CO_2over time (recent C3 SOC, old C4 SOC and glucose). To relate changes of CO_2 sources with functional changes of microbial populations, we performed phospholipids fatty acids (PLFA) analyses and measured potential metabolic activities using Biolog EcoPlates after two and seven days of incubation.

Results

A peak of glucose mineralization occurred after 17 hours of incubation. After the peak of glucose consumption, over-mineralization of native SOC occurred for some days, first affecting the recent C3 SOC, and later the old C4 SOC. Before this peak, some decomposer populations with a strong feeding preference for recent SOC were triggered by glucose addition. They were likely responsible for glucose consumption but also for the subsequent enhanced mineralization of recent C3 SOC. They were then out-competed by slower communities preferentially utilising the old C4 SOC and displaying a high potential for degrading P- and N-containing substrates. As nitrogen enrichment of old soil organic matter is a general feature, we postulated that nitrogen exhaustion in the poor soil solution was responsible for the succession of microbial communities and the change of SOC pool utilisation.

Conclusion

Our results demonstrated that the input of labile substrate alters the microbial community composition, potential metabolic activities, and the SOC pools utilisation. They pointed out the necessity to assess the age of destabilised SOC when investigating the impact of priming on carbon storage in soil.

P 2.2.25

Plant-earthworm partnership to increase crop productivity in the tropics

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Tropical soils are often nutrient-depleted in their mineral form, which constrains crop growth. Therefore any process leading to the mineralization of N and P trapped into the soil organic matter need to be studied in order to develop sustainable agricultural tools in a near future. Priming effect is defined as a stimulation of the soil organic matter mineralization (SOM) by the amendment of fresh organic matter (FOM). This microbially-mediated process is not completely understood. In theory, organic amendments could stimulate nutrient recycling from the SOM stock, provided that they will be managed under the right conditions. Endogeic earthworms are ecosystem engineers known to influence the dynamics of SOM as they ingest high amount of soil and assimilate one part of the organic carbon in relation with microbial activity stimulation. During the gut transit, microorganisms are awaked and their activities are stimulated by the small molecules contained in the mucus and by the meeting with fresh residues. During a first laboratory study we observed that earthworms could increase the Priming Effect intensity resulted from a fresh residue amendment*. Priming effect stimulation could be linked to specific bacterial phylogenetic groups* and its intensity was dependent on the type of soil and the earthworm species. *Dichogaster saliens* is a small size earthworm species living at the root vicinity of *Bracharia sp.* We observed that this species was able to generate an important priming effect in his gut, and therefore could mineralize nutrients liberated close to the roots. In a second experiment rice plants cultivated in outdoor pots were inoculated with increasing number of *D. saliens* specimens. At the rice maturity, a positive relationship between the number of earthworms and the number of grains per panicle was measured. As plant-fungi partnership, earthworm can also be a good partner, providing nutrients to the plant when most of nutrients are in the organic matter pool.

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P 2.2.26

Compositions and properties of microbial residues formed by three single species fungi and mixed strains in cellulose-containing liquid media

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Large part of plant C fraction can be assimilated into microbial biomass during the decomposition of plant residue before incorporation into soil organic materials in the form of microbial residues after cell death. The non-living microbial residues are bound up with SOM (soil organic matter) pool and they can be related to SOM turnover. The soil microorganisms can serve as a significant impetus of SOM formation and their residues in soil are an important parent material for humus formation. Cellulose, as a main component of plant residues, is also essential to the formation of humus. To ascertain how the humus is formed, the method of shake-flask in liquid culture is adopted. The suspensions of *Trichoderma viride* (*Tv*), *Aspergillus niger* (*An*), *Penicillium* (*P*) and mixed strains (*Ms*) are inoculated into the cellulose culture fluid, ($NaNO_3$ 2.0 g L^{-1}, K_2HPO_4 1.0 g L^{-1}, KCl 0.5 g L^{-1}, $MgSO_4 \cdot 7H_2O$ 0.5 g L^{-1}, $FeSO_4$ 0.01 g L^{-1}, Sodium carboxymethyl cellulose 20 g L^{-1}) the dynamic studies about microbial residues are conducted at 15, 30 and 70 d. The elemental analysis and FTIR are applied to assess the residues respectively formed by three single species fungi and mixed strains isolated from the Luvic Phaeozem in cellulose-containing culture fluid to study the following matters: (1) the conversion rate of cellulose and its C-turnover between microbial residues and metabolic product; (2) the comparative analysis on the humification degree happened in residue comparing with cellulose; (3) the dynamic analysis the different microbial effects on characterizations of microbial residues.

The results show that all the inoculums examined can disturb the organic C distributions between microbial residue and metabolic product, simultaneously enhance the C amount of residue gradually. The *Ms* (34.97%) performs an advantage over the other mono-fungi treatments in term of cellulose conversion. The cellulose conversion rate mentioned above is used to indicate the utilized and transformed efficiency of organic C in the cellulose culture fluid, whose value is indirectly related to the degradation capacities of tested strains.

Compared with the cellulose sample (C/N 88.13, H/C 2.18 and O/C 1.31), the C/N, H/C and O/C ratios from all the microbial treatments are reduced to some extents. Furthermore, in the end, the C/N (12.48), H/C (2.06) and O/C (1.26) ratios of residue formed by mixed culture is greater than the other mono-culture treatments. Thus it can be seen the formation of microbial residue is a process that the N-containing materials and aromatic structures are accumulated at the cost of consuming O-containing functional groups. In specific, there are more condensed aromatic structures and less O-containing functional groups existing in the residues treated by both *Tv* and *An*, in this process the humification process is promoted, whereas the oxidized degradation to cellulose is performed by both *P* and *Ms*.

The decreased in ratio of 2926/1639 could be interpreted as the transformation of cellulose to highly humified substrate under the forces of *Tv* and *An*. *Ms* and *P* in the cellulose fluid could only generate some intermediate products of HS and fail to polymerize their structure levels to humus. Although we confirm SOM is mainly from the remains of dead microbial cells, the faintly discernible peak at 1721cm^{-1} told us the transition of microbial residue into humus need rather a long period.

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Key words：microbial residues，single species fungi， mixed strains，cellulose liquid media，humification

P 2.2.27

Effect of nutrients availability and long-term tillage on priming effect and soil C mineralization

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Introduction

Agricultural management practices including soil tillage exert strong control on soil organic matter (SOM) turnover and its interactions with global C cycle through different mechanisms. One control mechanism is the priming effect (PE) which consists in stimulating SOM mineralization with the addition of fresh, energetic plant material. In this study, we quantified C mineralization and PE in soils sampled in two contrasted long-term (40 years) tillage treatments which deeply modified soil properties (e.g. organic C concentration, microbial biomass, pH). We hypothesized that soil tillage might affect these processes through changes in C addition rates, nutrient availability, and long-term variations in SOM content and microbial communities.

Methods

We investigated the relationship between PE intensity, tillage and nutrients availability in soil samples taken in no till (NT) and full inversion tillage (FIT) in two layers (0-5 and 15-20 cm). Soils were incubated with or without addition of ^{13}C labeled cellulose and mineral nutrients. Potential C mineralization and primed C were measured during 262 days. Unlabeled soil microbial biomass C was determined at the end of the experiment to separate apparent and real priming effect.

Results

Basal cumulative C mineralization in the control soil ranged from 363 to1490 mg kg-1 35 soil at day 262. It was strongly correlated with soil organic carbon (SOC) concentration. Specific mineralization rates were 44.8 and 68.8 g kg-1 SOC in the 0-5 cm layer for the FIT and NT treatments, respectively and were strongly linked with the particulate organic matter content (r = 0.99***). These results suggest that SOC was more active in the upper layer of the NT treatment due to the high concentration of readily-decomposable, particulate organic matter. The cellulose was entirely metabolized after 60 days and its kinetics of mineralization was affected neither by tillage, depth nor nutrients. The percentage of cellulose C released as CO2 represented 55-61% of the added cellulose-C at day 262. A positive PE was found in all treatments and its kinetics was parallel to that of cellulose mineralization. The cumulative PE significantly varied with nutrients level but not tillage, ranging from 73 to 78 mg kg-1 under high nutrients level and from 116 to 136 mg kg-1 in low nutrients level. No significant differences were found in unlabeled microbial biomass C between control and amended soil, suggesting no apparent priming effect.

Conclusion

We conclude that the priming was mainly controlled by nutrient availability but not tillage, in spite of strong tillage-induced changes in SOC concentration and microbial biomass. Since PE is known to depend on C addition rate, tillage is expected to affect *in situ* PE through variations in the ratio of fresh carbon to nutrient concentration along the soil profile.

P 2.2.28

Priming responsible for soil carbon loss in a secondary young-growth forest and carbon sequestration in an old-growth forest

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Old-growth forests can substantially increase soil carbon sequestration and serve as carbon sinks. In contrast, a rapid soil carbon loss occurs in secondary young-growth forests. The mechanisms behind them remain unclear. To prove the mechanisms, we conducted an incubation experiment over 180 days using soils collected from a secondary successional series (grassland, young-growth forest and old-growth forest). All soils were pre-incubated at 20 °C for 7 days. Thereafter, water or ^{13}C-uniformly-labeled glucose (5.97 atom% ^{13}C) solution was added evenly dropwise to the soil surface using a pipette to obtain uniform distribution. Total glucose-C additions were equal to 2% of the SOC in each soil, which was comparable to microbial biomass-C. All incubations were conducted at 20 °C. CO_2 samples were trapped from each incubation bottle and analyzed for CO_2 and δ^{13}C. ^{13}C-PLFA was measured to represent dynamics of microbial composition. We find that stronger positive priming occurs in young-growth forest soil than in both grassland soil and old-growth forest soil. A significant negative net carbon balance was observed in the young-growth soil while a weak net carbon balance appears in both grassland soil and old-growth forest soil. ^{13}C-PLFA results demonstrated that fungi played important role in young-growth forest soil while common bacteria were more important in old-growth forest soil. This indicates that different microbial functional groups mediate decomposition processes in young-growth and old-growth forests, and leads to distinct priming effects. These findings provide new insights into the dynamics and stabilization of soil organic matter during successional processes that priming effects can serve as an important mechanism underlining soil carbon loss in secondary young forests and carbon sequestration in old forests.

IT 2.3

Spatially resolved quantification of organic matter in synthetic organo-mineral associations by NanoSIMS

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Soil structure is resulting from soil forming processes at the molecular scale, but has feedbacks on soil functions on macroscopic or even global scales. In this framework, soil organic matter (SOM) is of special importance as a gluing agent for soil structure, besides being a carbon sink.

Conventional bulk-scale analyses allows for quantification and for a characterisation of the chemical bonding types of OM. However, all information of the spatial distribution of OM on the relevant scale of few nano- to micrometres is lost during this kind of analyses. While nano-scale secondary ion mass-spectroscopy (NanoSIMS) delivers qualitative data on the spatial distribution of SOM at the nano-scale, receiving quantitative data from this method remains challenging due to matrix and charging effects. In order to overcome this problem, the aim of this study was to develop scaling factors between conventional bulk-scale methods and NanoSIMS.

For developing these factors, dissolved organic matter (DOM) was extracted from organic material, which was harvested from a podzol. Subsequently, model minerals, such as boehmite and illite, were loaded with defined amounts of this DOM by means of sorption experiments. After the end of the experiments the liquid and solid phases were divided by means of centrifugation and the solid phase was subjected to freeze drying. Carbon and nitrogen content of the solid and liquid phases were measured via C/N and TOC analyses, respectively. The measured data was fitted with Freundlich-type adsorption isotherms. Samples for NanoSIMS analyses were distributed onto silicon wafers as individual particles. The following elements were analysed: C, N, O, Si, S and Al. Spatially resolved analysis of the NanoSIMS data yielded a increased detection of SOM on the minerals in higher concentration steps.

Linear relationships with high correlation and low deviation were found when comparing the spatially resolved NanoSIMS data with the bulk scale methods. The developed scaling factors, therefore, allow for quantification of NanoSIMS data in simple sample systems. In contrast to the bulk-methods spatial resolution and heterogeneity of SOM distribution are preserved in this new approach.

O 2.3.01

Effect of drought and land use on SOM decomposition in long-term laboratory incubations

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Introduction

The short-term pulses of CO_2 emission by SOM decomposition are usually observed after rewetting of extremely dry soil. The pulse magnitude exceeds CO_2 emission from soil under optimal soil moisture by several times (Fierer and Schimel, 2002; Unger et al, 2010). CO_2 pulse contribution to the annual CO_2 efflux from soil to the atmosphere is still unclear. If drying-rewetting cycles intensify the decomposition of both labile and recalcitrant SOM pools, they could stimulate the greenhouse effect.

Objectives

This study was aimed to compare the decomposition rates of labile and recalcitrant SOM at drying-rewetting and optimal soil moisture in natural and agricultural ecosystems.

Materials & methods

SOM decomposition rates of labile and recalcitrant carbon pools in two soils, Luvic Phaeozem (Moscow Region, 54°50'N, 37°35'E; forest and grassland) and Haplic Chernozem (Voronezh Region, 51°41'N, 39°15'E; bare fallow, maize monoculture and crop rotation), were determined in the course of long-term (365 d) laboratory incubation experiment. Arable land was represented by NPK-fertilized plots and unfertilized controls.

Two series of 10g top soil samples: 1) air-dried and rewetted to 70% water holding capacity (WHC) and 2) field-moist 55% WHC and adjusted to 70% WHC were incubated in 120 ml vessels at 22°C. CO_2 emission during SOM decomposition was determined periodically by measuring CO_2 concentrations.

Cumulative CO_2 emission was fitted by double exponential decay equation (Larionova et al, 2007):

$$Y=1-A_1e^{-k1t}-(1-A_1)e^{-k2t} \quad (1)$$

where Y is the cumulative amount of C-CO_2 at time t expressed as a portion of organic C in soil; A_1 is a portion of labile pool; k_1 and k_2 are the rate constants for labile and stable pools of organic matter, respectively.

Results

The parameters of double exponential SOM decay (eq. 1) significantly differed in soils at drying-rewetting and optimal moisture. A_1 values amounted to 0.2-7.8% of total SOM, and the rate constant k_1 varied from $3.4´10^{-2}$ -$2.1´10^{-1}$ day^{-1}. The rate constants of recalcitrant pool k_2 varied from $3.2´10^{-5}$ to $2.9´10^{-4}$ day$^{-1.}$ ^{In} general, the size and turnover rates k_1 and k_2 were higher in Phaeozem than in Chernozem.

The size and decomposition rate constants of labile pool increased at the rewetting after extreme drought by the factor of 1.9-4.2. Maximal increase was found in forests while minimal was observed in unfertilized monoculture in Chernozem.

Mineralization of recalcitrant pool in both forests on Phaeozem and Chernozem was not affected by drying-rewetting events. By contrast, k_2 in grasslands and arable lands decreased by 1.2 - 2 times compare to optimally wet soil. This decrease was more pronounced in Chernozem than in Phaeozem. The lowering of recalcitrant SOM turnover resulted in a relatively short duration of soil respiration pulses after rewetting croplands and grasslands which are often exposed to natural drought events.

Conclusion

Our results evidence that drying-rewetting do not change or even decreases SOM decomposition in a long-term time span. Hence, extreme drought with subsequent rewetting does not intensify CO_2 efflux from soil into the atmosphere at the annual scale. Moreover, it could mitigate the greenhouse effect in grassland and arable land.

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O 2.3.02

Dynamics of organic compounds associated with non-cristalline minerals in andosols: a key for understanding long term SOM stabilization in any soils?

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Two important features characterize andosols: (1) mineral phases are dominated by short-range ordered aluminosilicates (SRO-AlSi) which (2) stabilize large amounts of organic matter (OM). SRO-AlSi are known to be imogolite (2-3 nm diameter tubes) and allophane (supposedly 3.5-5 nm diameter spheres). However, a recent study showed that the presence of OM would have an inhibitory effect on the formation of secondary mineral phases by blocking the crystal growth of SRO-AlSi at a proto-imogolite stage (Levard et al., 2012). SRO-AlSi mineral phases have a high ability to form bonds with organic compounds due their large specific surfaces (3D gel structure) and high reactivities. In a first order "bulk" approach, it is considered that these bonds strongly stabilize organic compounds as their mean age was found to be over 10 kyrs at some studied sites (Basile-Doelsch et al. 2005; Torn et al. 1997).

This study was focused on the soil horizon scale. We assessed whether: (1) SRO-AlSi are mineral phases that effectively store the largest amounts of OM, and (2) organic compounds are stabilized in the long-term by SRO-AlSi.

Two andosols from the island of Réunion were studied by two different approaches: an andosol from the Tamarins Forest at Maïdo (Basile-Doelsch et al 2005, 2007) for which the OM dynamics were monitored by ^{14}C analyses, and an andosol from the Saint Rose area for which the OM dynamics were monitored by ^{13}C analyses in a C3/C4 vegetation change chronosequence (C3 forest, 44 years of C4 sugarcane, 185 years of C4 sugarcane). For both horizons, we performed densimetric fractionation to separate OM according to the nature of the minerals associated with OM (Basile-Doelsch et al. 2007).

For both horizons, the results showed that the SRO-AlSi were the mineral phases that stabilized the largest amounts of OM. In contrast, both OM dynamics results were not expected. For soil from the Tamarins Forest at Maïdo, the $D^{14}C$ showed that the OM stabilized in the SRO-AlSi was younger than that stabilized by other mineral phases. For the cultivated-soil horizon from Saint Rose, the $^{13}C/^{12}C$ showed that the SRO-AlSi incorporated more recent C from sugarcane than the OM-pools associated with other mineral phases. We concluded that SRO-AlSi can effectively store large amounts of OM over long periods, but a part of the organic compounds associated with SRO-AlSi have a quite rapid turnover. These results led us to consider a new model involving two types of organo-mineral interaction: (1) OM stabilized by strong bonds to proto-imogolite, leading to slow OM turnover, and (2) OM retained within the porosity of the 3D structure formed by the proto-imogolite (similar to a gel structure), leading to faster OM turnover.

We conclude that the nano-scale mechanisms observed in Andosols represent a typical case, highlighting the role of silicate phases weathering in stabilizing soil OM (Levard et al. 2012). But such processes are not unique as they also occur in other soil types. In any soil, secondary nano-sized phases newly formed by the weathering of surface minerals may give rise to nano-sized organo-mineral complexes and stabilize organic compounds. We propose an alternative model of organo-mineral interactions that no longer considers soil minerals as stable surfaces but instead take nano-scale weathering mineral dynamics into account (Basile-Doelsch et al. 2015).

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O 2.3.03

Characteristics of organic carbon associated with soil density fractions of contrasting mineralogy

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Organic matter (OM) is a heterogeneous component of soils, with variable organic carbon (OC) composition and mineralisation behaviour. Organo-mineral association is vital for the protection of OC in soils that contributes to C sequestration. Therefore, the objective of this research was to evaluate the role of minerals on the quantitative and qualitative distribution of OC pools in contrasting soils.

Sequential density fractionation was applied to isolate free (<1.8 g cm^{-3}) and mineral bound OM (1.8 to >2.6 g cm^{-3}) pools from four soils (Ferralsol, Luvisol, Vertisol and Solonetz) with contrasting mineralogy. OM in the density fractions was characterised using X-ray diffraction (XRD), diffuse reflectance infrared Fourier transform spectroscopy (DRIFTS), X-ray photoelectron spectroscopy (XPS) and isotope-ratio mass spectroscopy (IRMS) in the original states, and after 6% NaOCl and 10% HF treatments. For chemical treatments, NaOCl resistant fraction was attributed as relatively stable OC (mostly mineral bound) and the HF soluble fractions denoted as only mineral bound OC.

The soils (Luvisol, Vertisol and Solonetz) with phyllosilicates dominated clay fraction had greater proportion of free OM (<1.8 g cm^{-3}) than the sesquioxides enriched Ferralsol. Free OM fractions had higher C(N) content, greater C:N ratio, lower $\delta^{13}C$ and were enriched in aliphatic C as compared to their corresponding mineral bound fractions. Higher oxidation with NaOCl and lower removal by HF confirmed their contribution to the labile pool. In the heavy density fractions (>1.8 g cm^{-3}), three discrete mineralogies were identified: sesquioxides dominated 1.8 to >2.6 g cm^{-3} (only in the Ferralsol), phyllosilicates 1.8-2.6 g cm^{-3}, quartz and feldspar dominated fractions >2.6 g cm^{-3} (in the other three soils). Sesquioxides dominated fractions contained higher amount of OC than the other two mineral fractions. OM in the oxide fractions was characterised with highest aromatic and oxidised C and amide N species. The increased C:N ratio of oxidation resistant OM and the highest amount of HF soluble C in the sesquioxide fractions indicate preferred preservation of C over N with metal oxides. OM associated with phyllosilicates was enriched with aromatic C, O-alkyl C and protonated amide N. The amount of oxidation resistant and HF soluble C(N) varied between phyllosilicates, with kaolinitic Luvisol had more oxidation resistant C than the smectite-rich Vertisol. Quartz and feldspar associated OM fractions contributed the lowest proportion of C(N) to the total C. The amount of oxidation resistant and HF soluble C and N associated with primary minerals were also lowest, and mostly O-alkyl and protonated amide N in nature. Our results show that sesquioxides have greater potential to preserve OC in soils than phyllosilicates and primary minerals, and phyllosilicates preferentially preserve N containing organic compounds in soils.

O 2.3.04

The coordination chemistry of iron in reduced natural organic matter from groundwater and sediment

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Introduction

Biogeochemical cycles of iron and carbon can be closely linked because of the high affinity of iron in either of its common oxidation states for many classes of organic compounds. Trivalent iron(III) cations, disordered precipitates of iron(III) oxyhydroxides, and bulk iron(III) oxide phases interact strongly with natural organic matter (OM) leading to flocculation and sorption processes that can reduce the rate of OM degradation. Soluble iron(II) cations can be complexed by OM and these interactions alter the transport and redox properties of iron in ways that are not yet fully established. Indeed, there are no published studies of the binding affinity of iron(II) for any OM type, no experimental evidence for the coordination chemisty of iron(II) by OM, and conflicting conclusions as to the effect of complexation on the rate of iron(II) oxidation.

Objectives

We are studying the interactions of iron(II) with a range of OM types to better understand iron(II) complexation mechanisms and the consequences for transport, bioavailability and redox reactions of iron in variable redox, subsurface environments.

Materials and Methods

We obtained reference humic acids (HA) from the International Humic Substances Society, including Suwannee River and Leonardite HA. We obtained two fractions of dissoved OM from groundwater pumped from a well at the DOE Field Site at Rifle, Colorado, using solid-phase extraction (SPE) columns that collected hydrophobic and transphilic components. These samples readily oxidized iron(II) and therefore a portion of these samples were reduced with by $H_2(g)$ with a palladium catalyst. We also extracted naturally reduced, mineral-associated OM from a section of a Rifle sediment core between 13 - 14 feet depth using 0.1 M sodium pyrophosphate ($Na_4P_2O_7$) at pH 10 in fully anaerobic conditions. The OM was acidified to pH 2 and $Na_4P_2O_7$ was removed from the acid soluble and insoluble fractions by SPE columns or dialysis, respectively. We performed extended X-ray absorption fine structure (EXAFS) spectroscopy at the Fe K-edge of iron(II) bound to OM or synthetic references. Linear combination fitting of the spectra from synthetic references was used to characterize the binding environment of iron(II) by OM. We used a colorimetric assay (2,2'-bipyridine) to quantify iron(II) concentrations.

Results

For all reduced dissolved OM samples studied, iron was present entirely or almost entirely as iron(II) that was mostly bound to carboxylic acid groups. However, we also observed a significant contribution from catechol-like molecules and from one or more unidentified functional groups. The rate of iron(II) oxidation by O_2 under circumneutral conditions was increased by complexation with citric acid relative to the rate in organic-free solution. However, reduced OM substantially reduced the rate of iron(II) oxidation, indicating that reduced organic moeties served as a temporary redox buffer. In constrast, iron present in sediment-associated OM that was extracted by $Na_4P_2O_7$ was predominantly in the oxidized, iron(III) state, despite the OM retaining a strong reducing capacity and iron(II) detectable by colorimetric assay. The EXAFS data are not consistent with iron(III) pyrophosphate clusters, suggesting that $Na_4P_2O_7$ treatment extracts nano- or microscale iron(III) crystallites.

Conclusion

Iron(II) complexation by all reduced dissolved OM showed similar patterns, with variable abundances of functional group type among the samples studied. Sediment-associated OM showed more complex iron speciation, so that direct observation of iron(II) complexation could not be obtained.

The oxidation state of iron(II) bound to reduced OM is strongly albeit temporarily stabilized by the redox state of the OM. Further work is required to understand the chemical and mineralogical forms of iron that is extracted by $Na_4P_2O_7$ from reduced sediments.

O 2.3.05

Changes in redox properties of humic acids upon sorption to Alumina

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Introduction

One prominent role of NOM in biogeochemical processes is its ability to act as electron shuttle, accelerating reaction rates and/or efficiency between a bulk electron donor and an acceptor. This is possible due to the reversibility of the redox reaction of quinone moieties in NOM. This shuttling effect has been studied in two major areas: transformation of redox active pollutants (1,2) and microbial respiration (3,4). Previous studies primarily compared effects in the presence or absence of NOM without addressing the redox properties (i.e., electron exchange capacities and redox state) of NOM nor its speciation (sorbed vs. dissolved).

Objectives

The interaction between humic acids and soil minerals may change properties and reactivity of organic matter. Specifically, we investigate whether changes in the redox properties of a humic acid (namely total electron exchange capacity (EEC) and redox state) occur upon sorption to redox inactive minerals.

Materials and methods

Pahokee Peat Humic Acid (PPHA) and Elliot Soil Humic Acid (ESHA) were used as received from IHSS and dissolved in 0.1M KCl. Aluminium oxide (Al_2O_3 90% standardized, Merck) was suspended in 0.01M KCl). Sorption of humic acids to alumina was studied at pH 7.0 in batch experiments at several HA/alumina ratios. Both the suspension (mineral+sorbed HA, plus dissolved HA) and the filtered fraction (0.45µm) were analyzed using mediated electrochemical techniques, and the electron donating and accepting capacities (EDC and EAC, respectively) were determined following established procedures (5,6).

Results

The two HAs studied showed different effects. For PPHA the EEC increased for whole suspensions (up to 46%), whereas the dissolved fraction of PPHA showed no significant differences compared to the stock PPHA. For ESHA we observed a decrease in the EEC both for the dissolved fraction and the whole suspension. EDC/EEC ratio, a measure of the redox state of the sample, showed no significant differences between samples and stock PPHA, whereas a significant increase was observed for whole suspensions compared to the dissolved fraction for ESHA.

Conclusions

These preliminary results suggest a change in the redox properties of sorbed PPHA, but not for the dissolved fraction. The sorbed fraction seems to present higher redox activity (higher EEC) than the stock PPHA. For ESHA fractionation and a decrease of redox activity upon sorption was found. Given the absence of redox transfer between the HA and the redox inert alumina oxide such changes may be due to conformational changes in the humic. In sorbed state, a higher (for PPHA) or smaller (for ESHA) amount of redox active groups would be exposed and detected by the electrochemical techniques here used.

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O 2.3.06

Biological soil crusts: insights into an initial phase of SOM formation and biogeochemical cycling

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Biological soil crusts, in short „biocrusts“, composed of green algae, cyanobacteria, heterotrophic bacteria, archae, fungi, and their metabolites gluing mineral particles together, can be considered as initial phase of soil organic matter (SOM) formation. Furthermore, the biocrusts very likely initiate the biogeochemical cycling of nutrient elements from inorganic into organic forms and vice versa. The talk will present recent results from various ongoing projects in which we study not only the organism communities but also the organic matter composition and the biogeochemical cycling, especially, of phosphorus (P). By comparing the pyrolysis-field ionization (Py-FI) mass spectra and the synchrotron-based carbon (C)- and nitrogen (N)-X-ray absorption near *K*-edge fine structure (XANES) spectra of the biocrusts with the corresponding spectra from the soil/sediment layers immediately beneath the crusts or from nearby non-colonized bare soil/sediment surfaces, we will deduce the contribution of the biocrusts to the SOM composition of sites in subarctic (e.g. glacier forefield, pedoclimatic gradient in Iceland) and temperate landscapes (e.g. coastal dunes, disturbed grassland and forest sites). Furthermore, the same spatial sampling approach was used to disclose how the biocrusts act in the biogeochemical P cycling. The P speciation was done by complementary classical wet-chemical, sequential P-fractionations and XANES at the P *L*- and *K*-edges. By comparison of XANES spectra recorded at µ-sites of special elemental enrichments with those from the bulk biocrust samples show, for instance, that a transfer of P from apatite to organically-bound P and Fe-bound P occurs already in a “young” biocrust but becomes a quantitatively more important phenomenon in rather mature biocrusts at pedogenetically further developed sites. Besides new insights into the molecular-chemical and organic-mineral composition of biocrusts the presentation will draw conclusions on the potential and limitations of the methods applied in conjunction.

O 2.3.07

Mineralogical control of soil organic carbon persistence at the multidecadal time scale

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One of the current challenges in understanding the long term persistence of organic carbon in soils is to assess how mineral surfaces, especially at small scale, can stabilize soil organic carbon (SOC). The question we address in this work is whether different mineral species stabilize different types of SOC.

Here we used the unique opportunity offered by long term bare fallows to study in situ C dynamics in several fine fractions of a silty loam soil. Indeed, with no vegetation i.e. no external input of fresh C, the plant-free soil of the Versailles 42 Plots (INRA, France) has been progressively enriched in persistent SOC during the 80 years of bare fallow (BF). To separate mineral phases of the clay size fraction we performed a size fractionation on samples taken from 4 different plots at 5 different dates (0, 10, 22, 52, and 79 years after the beginning of the BF) and analyzed the SOC in the different fractions thus obtained. First, the clay fraction (< 2 µm) was isolated by wet sieving and centrifugation in water. Then the clay fraction was further separated into 3 size fractions by centrifugation: fine clay (< 0.05 µm), intermediate clay (0.05 - 0.2 µm), and coarse clay (0.2 - 2 µm). X-ray diffraction was used to determine the mineralogy of the phases and we found that the coarse clay fraction on the one hand and fine and intermediate clay fractions on the other hand exhibited contrasted mineralogies. Fine and intermediate clay fractions contained almost exclusively smectite and mixed-layered illite/smectite minerals whereas coarse clays contained also discrete illite and kaolinite on top of smectite and illite/smectite. We carried out CHN elemental analysis to study the C and nitrogen dynamics with time in the different fractions. And synchrotron based spectroscopy and microscopy (NEXAFS bulk and STXM at the carbon K edge of 280 eV, CLS Saskatoon, Canada) was used to get information on the distribution and the chemical speciation of the SOC in fractions with contrasted mineralogies.

C contents appear to be stabilized after 50 years of bare fallows, even though the dynamics are different for the three clay fractions. Indeed, coarse and intermediate clays have the same final C content but coarse clays lose more C. Highest C losses and highest final C content happen in the fine clays. C:N ratios are really low (below 8) and are decreasing with time in all fractions, evidencing the presence of microbial SOC. NEXAFS STXM data shows that, in the fine and intermediate clay fractions, all mineral particles are associated with SOC. On the contrary, in the coarse clays, SOC displays more diversity, with time, more mineral particles not associated with SOC appear and the chemical signature is more diverse.

In conclusion, clay fractions showed different C dynamics. Fine clays contained more labile C and more stable C, compared to intermediate and coarse clays. SOC associated to clay fraction had a low C:N ratio that decreased with BF duration. However C:N ratio of coarse clays was higher, suggesting (i) a better protection of compounds enriched in N in finer fractions, or (ii) the protection of a higher amount of plant derived compounds in coarse clays. SOC protection by the mineral matrix was different in coarse clays compared to finer clays: some minerals in the coarse clay did not protect SOC and SOC protected in coarse clays displayed more diversity.

O 2.3.08

Organic matter distribution across particulate and mineral-associated fractions varies interactively with soil type and agricultural management

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The distribution of C and N across soil organic matter (SOM) fractions serves as an indicator for the nutrient-providing capacity of agricultural soils. Previous research has focused on the fractions deemed more labile or active, such as particulate organic matter (POM) or light fractions. However, there is increasing evidence that the mineral-associated organic matter (MAOM) fraction of agricultural soils may play a dynamic role in short-term fertility. MAOM stores the majority of soil organic N and may strongly influence ecosystem productivity, but how management influences MAOM quantity and chemistry remains uncertain. In this study, we examined how tillage and cover crop regimes affected the quality and quantity of C and N in SOM fractions, with a specific focus on the silt and clay-associated component. We further tested how soil mineralogy and texture influence the distribution of C and N across SOM fractions and its response to management.

We collected soils from an ongoing experiment replicated across four growing sites in north central and mid-Atlantic United States. Management treatments included chisel vs. ridge till and cover crop vs. fallow in winter. Combining both sonication and wet-sieving techniques, we fractionated bulk soils into four distinct components: free POM (fPOM), occluded POM (oPOM), a coarse silt fraction, and fine silt and clay organic matter (MAOM). We measured the weight of recovered fractions and measured the C and N content of each. We also determined the mineralogical composition of MAOM fractions with X-ray Diffraction (XRD) and organic matter chemistry with Pyrolysis-Gas Chromatography/Mass Spectrometry(py-GC/MS).

Our results reveal that management significantly influenced N and C distribution across SOM fractions, however the response was context-specific. Responses to management were not consistent between sites, possibly highlighting divergent processes underlying SOM transformation and transfer across pools. The C and N contents of oPOM were greater under less disruptive tillage compared to chisel plow, regardless of the soil type. This parallels the prevailing understanding that POM will respond quickly to changes in soil disturbance. Within the MAOM fraction, however, differences between sites emerged. Tillage influenced the C and N contents of the fine fraction in a sandy soil while cover crops appear to moderate the quantity of N in a silt-rich soil. We detected a negligible influence of management on MAOM C content in the silt-dominated soil, possibly reflecting a decoupling between C and N accrual in silt and clay fractions. In sum, cover crops and more conservative tillage approaches exert significant but variable influence on the distribution and potentially behavior of SOM.

O 2.3.09

Effects of mineral characteristics on the turnover of organic matter fractions sequentially separated from seven pedogenetically different topsoils under broadleaf forest

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1. Introduction

Mineral topsoils possess large organic carbon (OC) contents but there is only limited knowledge on the mechanisms controlling the preservation of organic matter (OM) against microbial decay.

2. Objectives

The objectives were to quantify the amounts of sequentially Na-pyrophosphate extractable OM and of the OM remaining in the extraction residue, to analyze the composition and turnover of these two fractions by FTIR spectroscopy and ^{14}C analysis, and to analyze the correlations between the amount, composition, and stability of these OM fractions and soil mineral characteristics.

3. Materials & methods

Samples were taken from the uppermost mineral topsoil horizon (0 to 5 cm) of seven sites under mature deciduous forest showing a wide range in mineral characteristics such as the concentration of clay size particles and polyvalent cations. At first, organic particles and the water-extractable OM were removed from the soil samples using electrostatic attraction, wet-sieving, and ultrasonication. Thereafter, Na-pyrophosphate extractable organic matter (OM(PY)), assumed to be indicative for OM bound via cation mediated interactions, and the OM remaining in the extraction residue (OM(ER), supposed to be indicative for OM occluded in mechanically highly stable micro-aggregates, were sequentially separated and quantified. The composition of OM(PY) and OM(ER) were analyzed by FTIR and their stability by ^{14}C measurements.

4. Results

The OC remaining in the extraction residues accounted for 38 to 59% of the bulk soil OC (SOC) which was larger as compared with OM(PY) that accounted for 1.6 to 7.5% of the SOC. The FTIR analyses revealed a lower relative proportion of C=O groups in OM(ER) compared to OM(PY). Correlation analyses suggest an increase in the stability of OM(PY) with the soil pH and contents of Na-pyrophosphate soluble Fe, Al, and Mg and an increase in the stability of OM(ER) with the soil pH and the contents of clay and oxalate-soluble Fe and Al. The $\Delta^{14}C$ signatures (53 to 188‰) indicated mean residence times (MRT) less than 100 years for most of the OM(PY) and OM(ER) fractions.

5. Conclusions

The negative correlations between $\Delta^{14}C_{PY}$ signatures and contents of Na-pyrophosphate soluble Fe, Al, and Mg as well as with soil pH suggest that the turnover of OM(PY) is influenced by cation mediated interactions between organic molecules such as cross-linking. The stability of OM(ER) increases with mineral compounds such as clay-sized particles and oxalate extractable Al and Fe that were shown to be involved in the formation of highly stable micro-aggregates. Therefore, we suppose an occlusion in highly stable micro-aggregates to be important for the turnover of OM(ER) that seem to be more relevant than cation mediated interactions because of the generally lower $\Delta^{14}C$ values and distinctly higher amounts of OM(ER) compared to OM(PY). The $\Delta^{14}C$ values of OM(ER) and OM(PY) suggest the presence of OM that had recently entered the soil that might be derived from methodological uncertainties and/or the fast cycling compartment of the mineral-associated OM.

O 2.3.10

Organo-mineral interactions promote greater soil organic carbon storage under aspen in semi-arid montane forests from Utah

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Question: Forest species influence soil organic carbon (SOC) storage through litter input and microclimate, which in interaction with soil texture and mineralogy may lead to differences in SOC stabilization and chemistry. The decline of quacking aspen (*Populus tremuloides*) and expansion of conifers in the western United States due to natural succession, management practices and climate change could affect SOC dynamics. The objectives of this study were to: (i) assess the effects of overstory composition on SOC storage and stability across the aspen-conifer ecotone, and (ii) characterize the chemical composition of SOC with Fourier transform infrared spectroscopy.

Methods: We sampled mineral soil (0-15 cm) across the natural gradient of aspen and mixed conifers stands (*Abies lasiocarpa* and *Pseudotsuga menziesii*) in semi-arid montane forests from Utah. SOC was divided into light fraction (LF), mineral-associated SOC in the silt and clay fraction (MoM), and a dense subfraction > 53 µm (SMoM) using wet sieving and electrostatic attraction. SOC decomposability and solubility was derived from long term laboratory incubations and hot water extractions. Mineral matrix samples were obtained by removal of organic matter with NaOCl (6%) at room temperature. We applied Fourier transform infrared spectroscopy to analyze the chemistry of organic matter (OM) (i.e., bulk soil spectra - mineral matrix spectra), LF, and MoM.

Results: Vegetation cover did not affect SOC storage (47.0 ± 16.5 Mg C ha^{-1}), SOC decomposability (cumulative CO_2-C release of 93.2 ± 65.4 g C g^{-1} C), or SOC solubility (9.8 ± 7.2 mg C g^{-1} C), but MoM content increased with presence of aspen [pure aspen (31.2 ± 15.1 Mg C ha^{-1}) > mixed (25.7 ± 8.8 Mg C ha^{-1}) > conifer (22.8 ± 9.0 Mg C ha^{-1})]. Silt+clay (%) had a positive effect on MoM content ($r = 0.64$, $p < 0.0001$), and was negatively correlated to decomposable SOC per gram of C ($r = -0.48$, $p = 0.001$) or soluble SOC ($r = -0.59$, $p < 0.0001$), indicating that organo-mineral complexes reduced biological availability of SOC. Differences in chemistry among vegetation classes were patent in the LF, with greater proportion of polysaccharides and C-O groups (e.g., esters, phenols, carboxylate) for aspen and mixed LF and greater proportion of aliphatic C for mixed and conifer LF. The same patterns remained in MoM, although the effect of vegetation was statistically significant only for aliphatic C.

Conclusions: Our results suggest that aspen dominance favors SOC storage as MoM, although the influence of vegetation may be surpassed by texture in sites with relatively high content of silt and clay (i.e., > 70 %). Management efforts towards the conservation and regeneration of aspen may promote long-term C sequestration in sites with silt + clay content around 40 - 70 %. Greater storage of MoM under aspen may be caused by chemical protection of relatively simple molecules resulting from litter breakdown, fine root turnover, or rhizodeposition, rather than the preservation of recalcitrant compounds (i.e., aliphatic C).

O 2.3.11

Promoted soil bioactivity with carbon stabilization under long term rice cultivation: Lessons from a salt marsh derived rice soil chronosequence

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Introduction: Soil organic carbon (SOC) is a critical soil quality indicator for plant production and multiple ecosystem services, and carbon sequestration with enhanced stable carbon storage has been widely accepted as a prestige ecosystem property. Yet, there has been a knowledge gap on carbon stability versus bioactivity for ecosystem functioning with organic carbon accumulation and stabilization in field soils.

Objectives: In this paper, we assess the changes in microbial activity versus C stability of rice soil along a chronosequence of rice cultivation over centuries from East China.

Methods: Topsoil samples were collected of a series of paddy soils under rice cultivation of 0, 50, 100, 300 and 700 years. Soil basic properties, aggregate size fractions and carbon pools and fractions were analyzed, as well as chemical recalcitrance of bulk organic matter were characterized and carbon sequestration potential assessed with exotic carbon amendment incubation. Microbial biomass, community structure and enzyme activities were assessed using extraction, molecular assays and biochemical assays as well as basal soil respiration measurement respectively. We used mean weight diameter (MWD) for addressing soil aggregation, normalized enzyme activity for microbial bioactivity and carbon gain from exotic input for soil C sequestration functioning. In addition, we employed a response ratio to infer the changes in all analyzed parameters with rice cultivation length.

Results: While the stable or recalcitrant carbon pools were in line with SOC accumulation (Fig. 1), basal soil respiration and both bacterial and fungal diversity were almost constant in the rice paddies under different lengths of rice cultivation. However, bacterial abundance and normalized enzyme activity were positively but sharply correlated to SOC accumulation (Fig. 2,3), indicating an enhanced bioactivity with carbon stabilization in the rice soils over centuries of rice cultivation. This could be linked to a prominent enhancement of particulate organic carbon pool, which was shown in a function of MWD (Fig. 4). Soil basal respiration, microbial biomass as well as soil basic properties showed an insignificant or slight response to prolonged rice cultivation. In contrast, both labile and stable carbon pools and enzyme activity exerted steady positively logarithmic response and bacterial abundance (Fig.5), bacterial to fugal ratio and microbial C use efficiency showed sharply linear response to prolonged rice cultivation over centuries(Table 1).

Table 1 Microbial parameters and carbon sequestration potential of the paddy soil chronosequence

Soil	MBC (mg kg^{-1})	NEA	SR (mgCO_2-C g^{-1})	CS (g kg^{-1})	BtA (copies×10^{9} g^{-1})	FA (copies×10^{7} g^{-1})
P0	63.41±42.88 c	0.11±0.001e	0.98±0.10c	1.38±0.17c	0.40±0.01d	0.88±0.03d

P50	495.41±33.35 a	0.16±0.004d	2.50±0.16b	2.14±0.22b	5.34±0.58c	2.31±0.18a
P100	532.44±28.49 a	0.19±0.003c	2.97±0.01a	2.78±0.06a	9.95±0.72b	1.66±0.02c
P300	481.78±21.69 a	0.24±0.006b	2.98±0.17a	2.72±0.19a	12.78±2.53b	2.05±0.10b
P700	450.41±12.95 b	0.30±0.005a	2.94±0.08a	2.86±0.15a	18.25±1.34a	1.61±0.13c

Note: MBC, microbial biomass carbon; NEA: normalized enzyme activity; SR: Soil respiration; CS: carbon sequestration potential with exotic carbon amendment incubation. BtA: bacterial abundance; FA: fungal abundance

Conclusion: This study finds that carbon sequestration and stabilization could provide high bioactivity for ecosystem functioning where particulate organic carbon pool be preserved due to physical protection with enhanced soil aggregation in agricultural soils.

Key words: carbon stabilization, bioactivity, microbial abundance, ecosystem functioning, soil chronosequence, rice paddy, rice cultivation

Fig.1 SOM accumulation in a negative correlated to LOC/SOC ratio

Fig. 2 Correlation of bacterial gene copy number to SOC in the studied rice soils.

Fig. 3. Normalized enzyme activity index (b) versus bacterial gene copy numbers of the studied rice soils.

Fig. 4 Correlation of POC (particular organic carbon) to soil organic carbon (a) and to mean weight diameter of microaggregates (MWD, b) of the chronosequence soils.

Fig. 5 Soil respiration portion to SOC against bacterial gene copy numbers of the studied rice soils.

Refereces:

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P 2.3.01

Clay mineral protects organic matter as macromolecular structures under the possible harshest environmental conditions

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Introduction

Soil microbial biomass represents the most active and dynamic fraction of the living SOM pool. As a primary source of SOC, it is therefore expected to play a critical role in the carbon biogeochemical cycle. Ubiquitous and abundant in soils, clay minerals are important natural adsorbents of SOM and serve as natural modulators of the rate and extent of soil-atmospheric carbon fluxes. Although such effects have been noted, the spatial distribution of OM on clay surfaces and the factors controlling it remain poorly understood.

Objectives

In attempting to address these knowledge gaps, NMR spectroscopy and allied analytical techniques were employed to provide molecular-level information on which organic structures preferentially associate with clay minerals, which may be accessible to decomposers, and which are physically protected from degradation.

Material and methods

In this contribution, a mixed heterotrophic soil biome was prepared from an Irish field soil and the resulting biomass adsorbed to montmorillonite clay mineral before undergoing degradation or acid hydrolysis. Hydrolysis is critical to the process of chemical weathering and soil formation. Acid hydrolysis is a chemical degradation approach frequently used to depolymerize OM into monomers suitable for chemical analysis thereby enabling investigation of stabilization of labile OM by clays.

Results

Surface and interlayer interactions of soil microbial biomass with montmorillonite have been confirmed by SEM and XRD, respectively, and elemental X-ray analysis of SEM images shows spatial co-variations of microbial-derived OM with Fe, Al and Si, suggesting important roles of these mineral components in clay-microbial interactions. There is also good evidence to suggest that aliphatic components preferentially adsorb to the mineral and remain dominant after degradation and acid hydrolysis. Although not as abundant as aliphatic components, proteins/peptides and carbohydrates are also strongly adsorbed and are protected as macromolecular structures.

Conclusions

Microbial-derived OM interacts with the external and inner surfaces of montmorillonite, through, for example, hydrogen bonding, and remains protected under acid attack, the possible harshest condition such complex will experience in the environment.

P 2.3.02

Ecological assessment of Chernozems using soil organic matter indexes

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After consolidation of two approaches of assessment using both the humus degree and the dates of physical fractionation, the **nondegradated** soils are presented by native Chernozems with very high humus degree (>7.5), balanced carbon cycle, which confirmed by ratio $C_{unstable}/C_{stable}$≈1.0 and balanced ratio of two basic organic matter fractions (C_{LF}/C_{Clay} ≈1.0) (Table).

Weakly degradated soils were presented by ploughing noneroded and water deposited Chernozems with high humus level (5.5-7.5). The C_{LF}/C_{Clay} ratio in noneroded soils varied from 0.4 to 0.5. The water deposited soils were characterized by the ratio C_{LF}/C_{Clay} of 0.4. In noneroded soils, due to intensification of deaggregation, including the breakdown of stable microaggregates, the portion of $C_{unstable}$ increased and the $C_{unstable}/C_{stable}$ ratio achieved 1.5. In water deposited soils, due to minimum C_{Clay} amount, the portion of $C_{unstable}$ decreased, and the $C_{unstable}/C_{stable}$ ratio declined - 1,2.

Weakly eroded soils were attributed to **middle degradated** Chernozems with humus level of 3.5-5.5 and characterized by abrupt depletion of C_{LF}, which attended by the decline of the C_{LF}/C_{Clay} ratio till 0.3. Furthermore, the $C_{unstable}/C_{stable}$ ratio of these soils increased under the further soil deaggregation and achieved ~2.0.

Heavily degradated Chernozems were characterized by a low humus level which was from 2.5 to 3.5. The C_{LF}/C_{Clay} ratio varied from 0.3 to 0.4. The $C_{unstable}/C_{stable}$ ratio was ≥2.0.

Chernozems with **intolerable ecological level** weren't revealed.

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Figure 1

The level of ecological welfare	Humus,% of soil	C_{LF}/C_{Clay}	$C_{unstable}/C_{stable}$	Landscape site
nondegradated	**>7.5**	**1.0**	**1.0**	
Sptreletskay steppe, Chernozem typical	7.9	1.0	1.1	noneroded
Ostrovtsovskay steppe, Chernozem typical	10.8	1.2	1.1	the same
Poperechenskay steppe, Chernozem leached	12.7	1.1	1.1	the same
weakly degradated	**5.5-7.5**	**0.4-0.5**	**1.0-1.5**	
Kursky region, Chernozem typical	5.5	0.4	1.5	noneroded
the same	5.5	0.5	1.5	the same
the same	5.7	0.4	1.0	deposited
the same	5.8	0.4	1.2	the same
middle degradated	**3.5-5.5**	**0.3-0.4**	**1.5-2.0**	
Kursky region, Chernozem typical	3.6	0.3	1.9	weakly eroded
the same	3.8	0.3	2.0	the same
the same	4.2	0.3	1.8	the same
the same	5.2	0.4	1.5	eroded-deposited
heavily degradated	**2.5-3.5**	**0.3-0.4**	**2.0-2.5**	
Bad Laushtadt, Chernozem gaplic	2.7	0.4	2.0	noneroded
intolerable ecological level	**< 2.5**	-		

P 2.3.03

Soil organic carbon and aggregate-associated organic carbon fractions affected by long-term fertilization in an intensively managed upland soil of northern China

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More and more results revealed that agricultural soil could to be an important sink for atmospheric CO_2 by increasing soil organic carbon (SOC) through best managements, and then alleviated the greenhouse effect. However, the mechanisms of SOC accumulation and protection in upland soils under temperate continental climate have not been well documented. In this study, we measured 0-20, 20-40 and 40-60 cm SOC and total nitrogen (TN) stocks and wet-sieved More and more results revealed that agricultural soil could to be an important sink for atmospheric CO_2 by increasing soil organic carbon (SOC) through best managements, and then alleviated the greenhouse effect. However, the mechanisms of SOC accumulation and protection in upland soils under temperate continental climate have not been well documented. In this study, we measured 0-20, 20-40 and 40-60 cm SOC and total nitrogen (TN) stocks and wet-sieved soil aggregates, as well as separated five soil C fractions, based on a long-term fertilization filed experiment established in 2006. Results indicated that, compared to initial, long-term fertilization could increase the SOC and TN stocks at 0-20 cm soil depths, especially the balanced N treatments, but no significantly differences at 20-40 and 40-60 cm soil depths ($P > 0.05$). The balanced N and conventional N treatments could significantly increase the proportion of 250-2000 μm aggregate and associated C ($P < 0.05$), whereas no significantly differences between optimized N and control treatments. There are significantly relationships between the proportion of macroaggregates (> 250 μm) and SOC concentrations, especially in straw returned and organic fertilizer applied. The aggregate associated-C contents in this kind of upland soil were fit for the concept of aggregate hierarchy, and organic matter was the mainly binding agents in soil aggregates formation. C concentrations were mainly in iPOM_m and s+c_f that accounted for 32.8 - 41.4% and 36.2 - 41.2% of the total SOC, respectively. Furthermore, the contributions of increased SOC from "slow pools" (iPOM_m & s+c_f) were 83.9 - 84.4% and 47 - 69.8% in the balanced N and chemical N (optimized and conventional N) treatments, respectively. These findings suggested that improving soil fertility and stabling SOC sequestered from atmospheric CO_2 simultaneously could be achieved by balanced N management (organic with inorganic fertilizer).

Figure 1

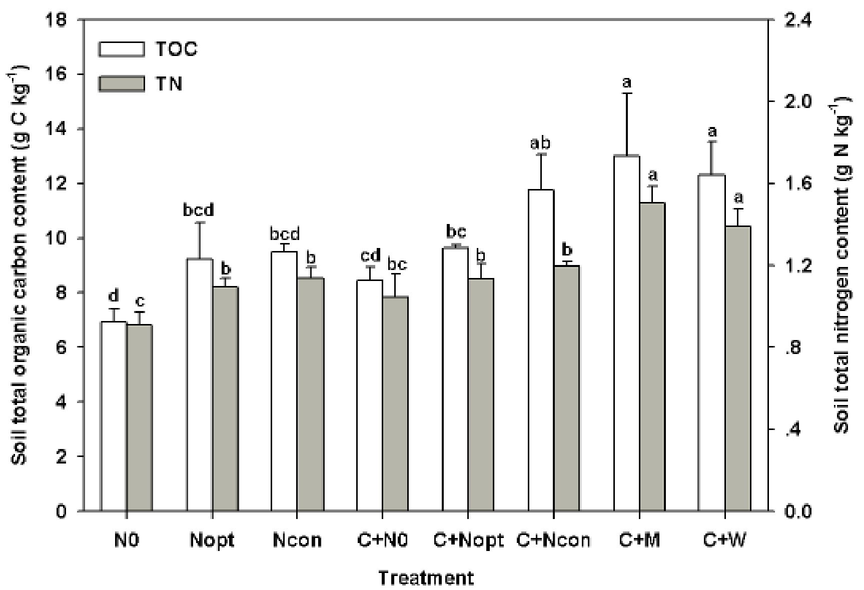
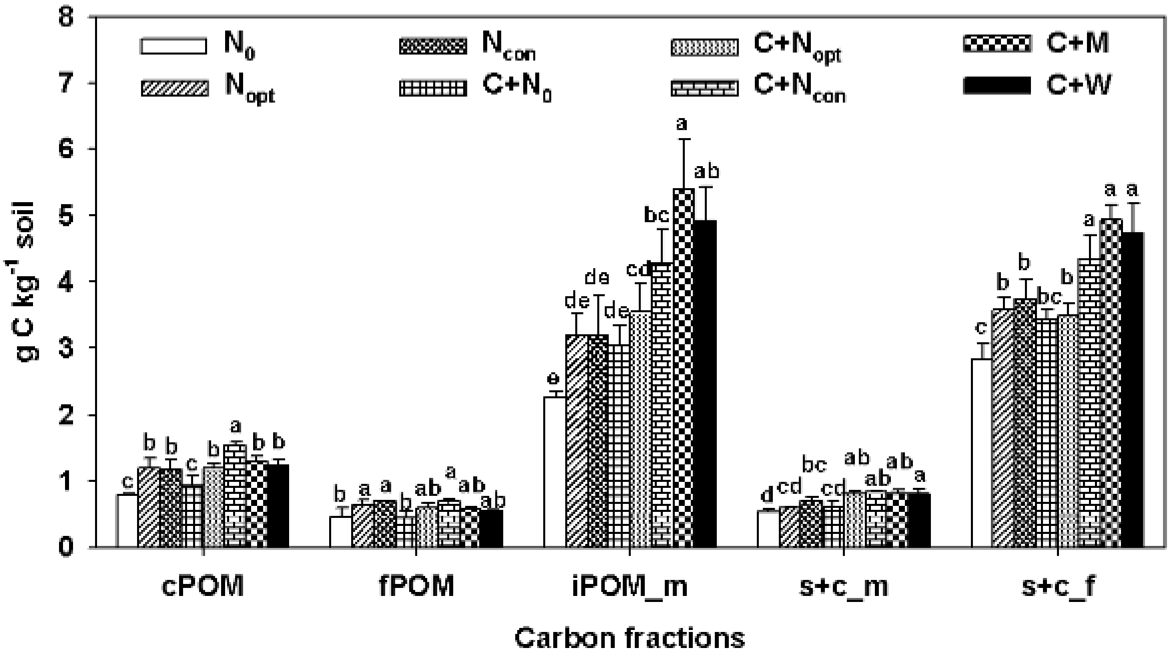


Figure 2



N0
Nopt
Ncon
C+N0
C+Nopt
C+Ncon
C+M
C+W
g C kg-1 soil
8
7
6
5
4
3
2
1
0
cPOM
fPOM
iPOM_m
s+c_m
s+c_f
Carbon fractions

P 2.3.04

Influence of Soil Mineralogy and Geochemical Properties on Soil Organic Carbon Fractions in Soils of Contrasted Mineralogy

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Methods

The aim of this study was to assess the relation between soil organic carbon (SOC) fractions of different protection mechanisms (unprotected, physically, chemically and biochemically protected) and the soil mineralogy. For that, SOC fractionation (figure 1; Six *et al*., 2002 methodology) was performed in soils of contrasted mineralogy (granitic vs margas or acid vs basic soils).

Figure 1. Scheme of the SOC fractions. POM = Particulate organic matter, LF = light fraction, H = hydrolysable organic carbon, NH = non hydrolysable organic carbon, d = organic carbon in the <53µm fraction, µ = organic carbon in the 53-250 µm fraction, iPOM = internal particulate organic matter. Scheme modified from Six et al. (2002)

Results

There was a negative correlation between SOC fractions associated to silt and clay (H-µSilt + µClay and H-dSilt + dClay) and some geo-chemical properties related to acid soils (high in quartz, the existence of limestone, low pH, low CEC and low in carbonates) (**table 1**). The opposite was found for other SOC fractions non-associated to silt and clay (e.g. iPOM).

Table 1. Pearson-moment correlations between some soil physico-chemical properties and SOC fractions. CEC = cation exchange capacity, iPOM = internal particulate organic matter, H-µSil + µClay = organic carbon associated to silt and clay in the microaggregate, H-dSilt + dClay = organic carbon associated to silt and clay in the <53µm fraction.

Conclusions

We found strong correlations between some soil mineralogy and geochemical properties and SOC fractions. This information helps us to know more about the mechanisms involving SOC sequestration and to propose new mechanisms.

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Figure 1

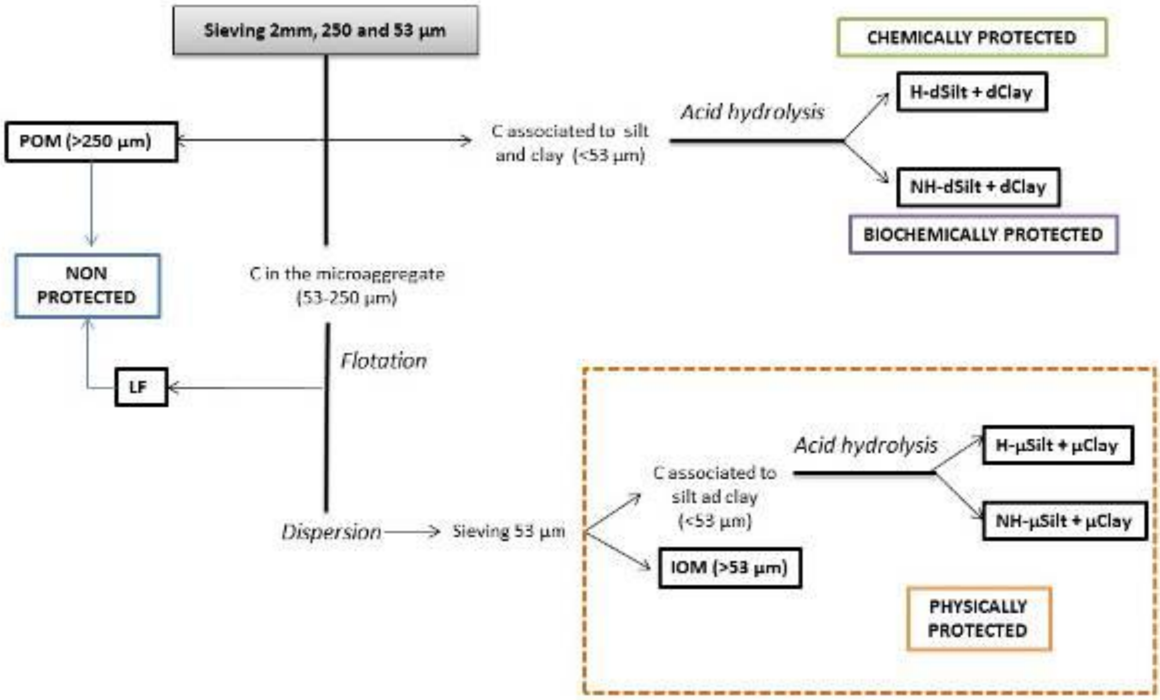

Figure 2

Variables	pH	Quartz	Limestone	CEC	Carbo-nates	iPOM	H-µSilt + µClay	H-dSilt + dClay
pH		-0,861	0,771	0,577	0,783	-0,808	0,820	0,879
Quartz	-0,861		-0,754	-0,490	-0,771	0,633	-0,765	-0,816
Limestone	0,771	-0,754		0,130	0,965	-0,524	0,812	0,783
CEC	0,577	-0,490	0,130		0,141	-0,753	0,497	0,524
Carbonates	0,783	-0,771	0,965	0,141		-0,519	0,804	0,777
iPOM	-0,808	0,633	-0,524	-0,753	-0,519		-0,744	-0,777
H-µSilt + µClay	0,820	-0,765	0,812	0,497	0,804	-0,744		0,918
H-dSilt + dClay	0,879	-0,816	0,783	0,524	0,777	0,777	0,918	

P 2.3.05

Mechanisms controlling soil organic carbon composition pertaining to microbial decomposition of biochemically contrasting organic residues: Evidence from midDRIFTS peak area analysis

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Introduction and objective:

Although it has been shown that biochemically contrasting organic residues determine the accumulation potential of soil organic carbon (SOC) in tropical sandy soils, the underlying mechanisms leading to SOC accumulation remain, however, uncertain. This became particularly evident from our previous work in a sandy soil in which organic residues contrasting in biochemical quality brought about similar SOC quantity. Hence, it could be expected that different mechanisms were responsible for this outcome.

Objective:

In this paper, we evaluated the potential of diffuse reflectance Fourier transform midinfrared spectroscopy (midDRIFTS)-based peak as proxies of SOC composition to prove that biochemical quality of organic residues is a determinant of SOC composition in a tropical sandy soil treated with biochemically contrasting organic residues for 13 years. We further hypothesized that these organic residue driven differences of SOC composition - as characterized by midDRIFTS peak areas representing predominant functional groups of SOC- were a result of distinct mechanisms pertaining to short-term microbial decomposition as regulated by organic residue quality. The final goal of this study was to propose a conceptual model that relates organic residue quality to SOC composition as mediated through the derived mechanisms.

Materials and methods:

We relied on a field experiment in Northeast Thailand where organic residues of contrasting biochemical quality (g kg^{-1}) (rice straw (RS, 5 nitrogen (N), 29 lignin (L), 7 polyphenols (PP), 507 cellulose (CL)), groundnut stover (GN, 23 N, 68 L, 13 PP, 178 CL), dipterocarp (DP, 6 N, 176 L, 65 PP, 306 CL) and tamarind (TM, 14 N, 88 L, 32 PP, 143 CL) were applied yearly since the experiment started in 1995. At the end of year 13 (2008), samples of the bulk soil (0-15 cm) were obtained to evaluate the long-term effect of residue inputs on SOC composition. In addition, short-term microbial decomposition of the same residues in litter bags was assessed at intervals during a 26 week period to relate the biochemical quality of decomposing residues to SOC composition in bulk soils.

Results:

All samples were subjected to midDRIFTS peak area analysis to categorize the abundance ("low" versus "high") of the most prominent labile and stable organic functional groups. The spectral information was used to examine four mechanisms (i.e., physico-chemical protection, C loss, regulatory N effect and SOC stabilization) that are responsible for SOC composition. A conceptual model for residue decomposition was formulated based on an established approach to classifying residues according to their N, L and PP contents, which we extended by adding the CL content and modifying the threshold levels of these four biochemical properties.

Conclusion:

Combining mechanistic evaluation of SOC composition together with the conceptual model of decomposition controlled by organic residue quality provided deeper insights into the microbially mediated regulation of SOC stabilization and composition. We conclude that this approach will have important implications for soil organic matter management aimed at supplying N and sequestering C in sandy soils.

P 2.3.06

Solubilisation of organic matter following addition of different bases to soils with contrasting mineralogy

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Dissolved organic matter (DOM) is an important substrate for many soil biological processes including denitrification and respiration. Recent research suggests that organic matter is solubilised primarily as a result of abiotic processes. Three soils of contrasting mineralogy (sedimentary, allophanic and ultic) were used to examine how the quantity and quality of DOM changes when soil pH is raised by the addition of lime ($Ca(OH)_2$) or by the generation of NH_4OH (via the hydrolysis of urea applied in fertilizer or livestock urine). The addition of KOH (a chemical analogue of NH_4OH) consistently produced higher soil pH values than the corresponding rate of $Ca(OH)_2$. Concomitantly, dissolved organic carbon (DOC) increased with increases in base addition rate, with the response to KOH being much larger than that to $Ca(OH)_2$. At the highest rate of KOH, between 4 and 13% of total soil C was solubilised compared with 0.7 to 2.5% at the equivalent rate of $Ca(OH)_2$. The proportion of carbohydrate-C (hexose- and pentose-C) in the DOM did not show consistent effects of base addition rate or base type and was generally similar for the three soils (35% of DOC, on average). Dissolved phenol-C increased in all three soils as the base addition rate increased. Only monomeric phenols were solubilised in the $Ca(OH)_2$-treated soils whereas increasing amounts of polymeric phenols were solubilised as the rate of KOH was increased. Although the quantity of extracted DOM differed considerably between treatments, its bioavailability (45% on average) was remarkably similar across treatments and soil types. There was a reasonably good correspondence between carbohydrate-C (considered the most labile component of DOC) and bioavailable C in both $Ca(OH)_2$ and KOH treated soils. Based on our KOH treatment data, we infer that pH increases resulting from urea hydrolysis could make stable organic matter assessible to microbes by liberating it from the protective influence of soil minerals.

P 2.3.07

Stabilization of microbial cells and their residues in soils by co-precipitation with Fe and Al oxyhydroxides

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Introduction and Objectives. Soil organic matter (SOM) has a complex chemical structure which is still unknown in detail. Recent studies have shown a much higher contribution of microbial residues in particular of cell envelope fragments to SOM than previously considered. This material, however, is readily degradable and thus needs to be stabilized in soil. Here, we hypothesize that the interaction with mineral and metal oxides provides a relevant stabilization mechanism. In particular, incrustation of organic material by oxyhydroxides or co-precipitation of biotic molecular aggregates and cell envelope material with oxyhydroxides may play an important role.

Material and Methods. We analyzed the turnover of ^{14}C-labeled typical Gram-negative bacterial cells (*Escherichia coli*) alone or co-precipitated with Fe or Al oxyhydroxides. A similar experiment was performed with ^{14}C-labeled particulate cell envelope fragments. In order to investigate the effect of environmental conditions (oxic and O_2 depleted) on the ^{14}C mineralization, incubation experiments were performed under different water contents and supply of carbon substrates.

Results and Discussion. Co-precipitation with Fe and Al decreased the mineralization of intact cells and cell envelope fragments by a factor of 2 to 4, indicating strong protection of biomass and its fragments. Surprisingly, the mineralization of intact cells was higher than that of cell envelope fragments indicating that these fragments are more resistant to biodegradation than bulk cells, which may result in selective enrichment of cell envelope materials in soils.

***Conclusion*.** The present results show that the incrustation of Fe and Al oxyhydroxides into microbial residues, in particular cell envelope fragments, is a relevant stabilization mechanism for microbial residues and for macromolecular aggregates in SOM.

P 2.3.08

Carbon stability in Pyrenean subalpine grassland soils: effect of biochemical quality, physical protection and mineralogical constraints

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Introduction. The stability of soil organic matter (SOM) depends on its physical protection, its biochemical quality (*q*), and mineralogical features such as the presence of iron or aluminum oxyhydroxydes: all these constraints stabilize organic matter, but the relative relevance of each is discussed. Many studies focus in a single factor (e.g., iron forms, physical protection, biochemical recalcitrance) and do not pay attention to the rest. This may give distorted views about the net of constraints that results in the stabilization of SOM.

Objectives. To gather insight about the relative relevance of the several factors that affect SOM stability. Here we study a wide variety of constraints: obtainin g a panoramic view of the SOM stabilization process is one of our goals. This research continues our previous work (Rovira et al. 2010), by introducing an in-depth look to the specific targets of each constraint.

Materials and methods. The SOM from four grassland soils in the Pyrennees was studied for its physical protection (ultrasonic dispersion, size fractionation), *q* (acid hydrolysis, carbohydrates, phenolics, unhydrolyzable OM), and the combination of both (acid hydrolysis applied to the size fractions). Free forms of Fe and Al were extracted with dithionite-citrate-bicarbonate (Fe_D and Al_D). Soil horizons were incubated under optimal conditions to obtain the C lost after 33 days (Cresp33: mg of C g total C^{-1}) and the basal respiration rate (BR_R: mg C g C^{-1} day^{-1}). Microbial C (MC_{UC}: uncorrected microbial C) was obtained by fumigation-extraction at the end of the incubation. The microbial activity rate (MA_R: mg C g microbial C^{-1} day^{-1}) was obtained by combining these measures.

Results. The soluble + microbial C is the best estimator for the active C pool. The stability of SOM is related to its distribution among the size fractions: the higher the proportion in the organomineral complexes (< 20 µm), the more stable is SOM (Fig. 1). The *q* of the whole SOM barely affects its turnover, but the *q* of the most available SOM fractions is a good predictor of SOM stability, provided the appropriate indicator of *q* is used (not shown in this abstract). The physical availability (size fractionation) affect the size of the microbial C pool, but it has little effect on MA_R. We observed little effects of Al_D, but Fe_D strongly (and negatively) relates to Cresp33, BR_R and also MA_R. Free iron does not affect the size of the microbial C pool; its main role seems as a direct modulator of the microbial activity (Fig. 2).

Conclusion. For a good prediction of SOM stability from the complex net of constraints that determine it, it is necessary to take into account the hierarchy between them (e.g., *q* is much less relevant than physical protection), but also the specific target of each of these constraints (either the size of the microbial pool, its specific activity, or both). The relevance of biochemical quality (*q*) for SOM stabilization, lower than other constraints (physical protection or free iron forms), could be underestimated, owing to an unappropriated choice of the indicators.

Figure captions

Fig 1. Relationships between the proportion of total C in each size fraction, and indicators of SOM stability (Cresp33). Significance of correlations: †: in the limit of signification, $p < 0.100$; *: $p < 0.050$; ** $p < 0.010$; *** $p < 0.001$.

Fig 2. Relationships between free iron forms (extracted with dithionite-citrate-bicarbonate mixture) and indicators of SOM stability (Cresp33 and BR_R), microbial C (MC) and the specific microbial activity rate (MA_R). Significance of correlations as in figure 1.

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Figure 1

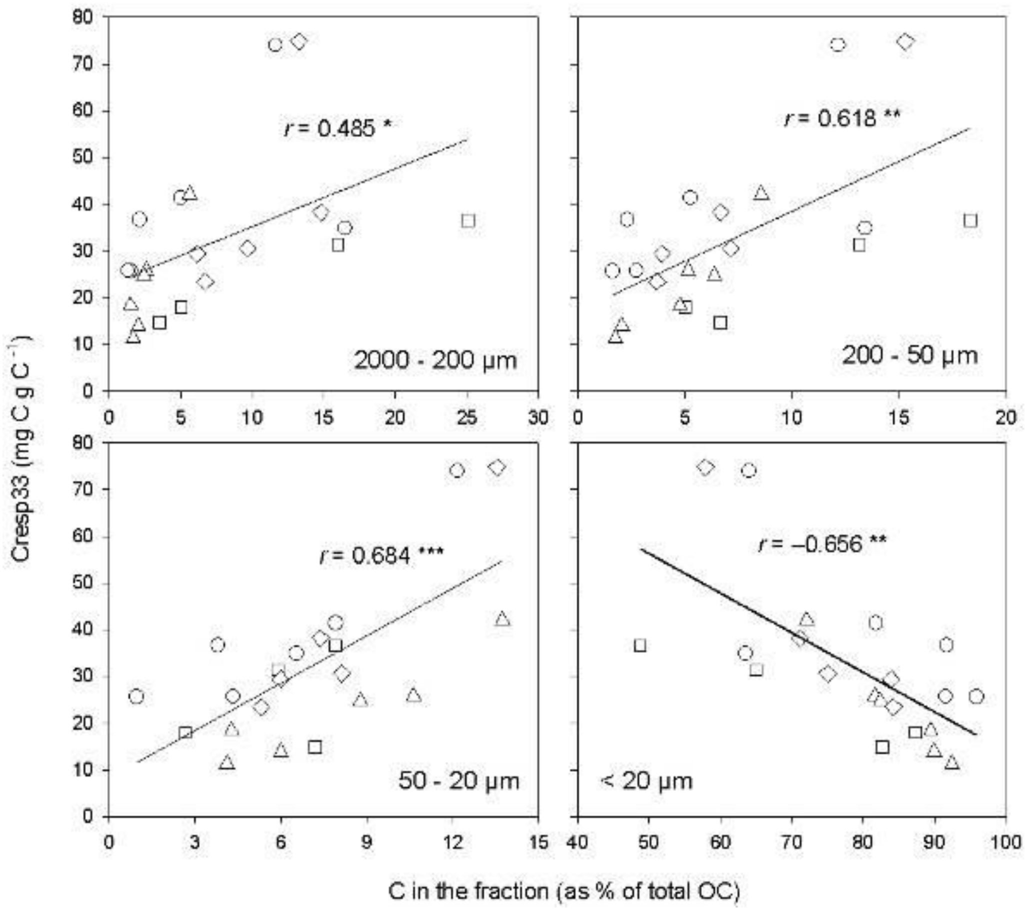
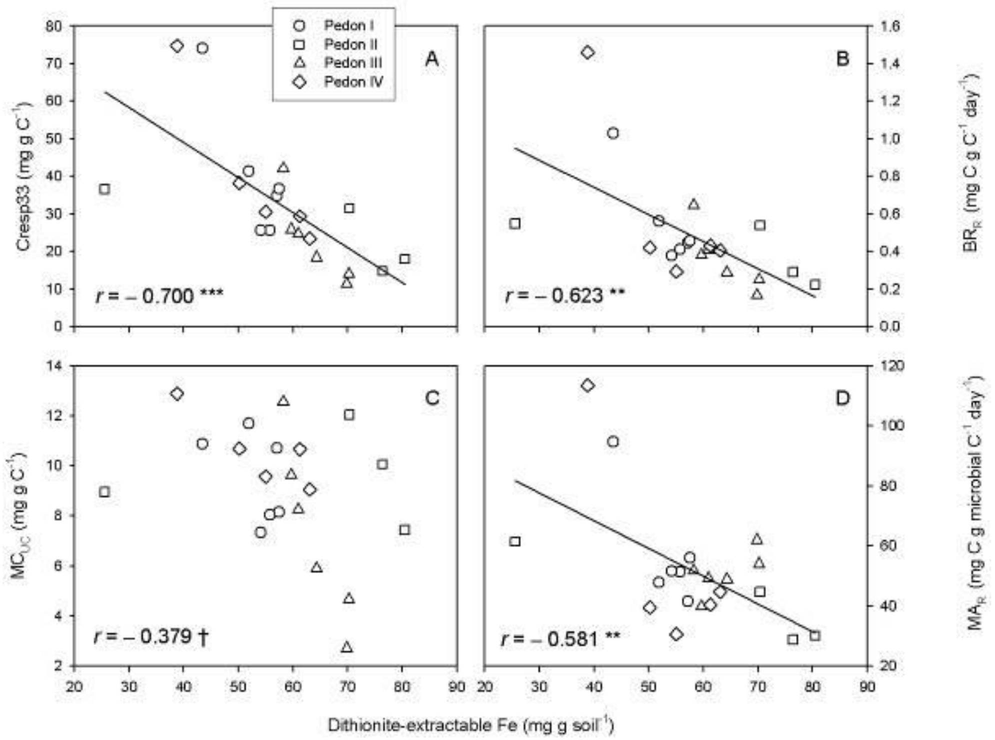


Figure 2



P 2.3.09

Decomposition of organic matter and sequestration in fine-sized fractions modified by the clay mineral composition

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The interaction between minerals, organic matter (OM) and microorganisms is a key to the turnover of OM in soils. In particular, clay minerals, iron oxides and charcoal are considered as important constituents affecting the sequestration of carbon (C) and nitrogen (N). The overall objective of our study was to evaluate the role of specific surfaces provided by different minerals and charcoal in the complex interplay between minerals, OM and microorganisms. Artificial mixtures of minerals and OM incubated with a microbial inoculum from a natural soil were utilised to produce so called "artificial soils". The defined composition of the artificial soil systems allows a direct relation of the structural development and the sequestration of C and N to the presence of the specific components. Here, we incubated pre-produced artificial soils (developed over 842 days with two additions of sterile manure) and a natural soil (Ap, Luvisol) with ^{13}C and ^{15}N labelled plant litter over 63 days to follow the OM turnover and the formation of organo-mineral associations regarding different compositions (montmorillonite (MT), illite (IL), montmorillonite + charcoal (MT+CH), illite + ferrihydrite (IL+FH)). The microbial biomass, salt extractable organic C, the isotopic C and N composition in the bulk soil and the soil fractions obtained by a combined density and particle size fractionation were determined. By comparison of the artificial soils with the natural soil, we were able to show that the produced soil-like systems have OM dynamics comparable to the natural soil incubated in a laboratory experiment. We found out that the decomposition of the added plant litter was affected by the type of clay mineral that formed the artificial soils, as the soil MT exhibited a slower mineralisation compared to IL, which was in line with a lower microbial biomass. Although a high specific surface area (SSA) provides a high sequestration capacity for C and N, smaller amounts were sequestered in the MT soil with a higher SSA compared to the soil IL. It was assumed that a more intensive decomposition is associated with a higher microbial biomass leading to higher amounts of microbial products sequestered in the clay-sized fraction. The effect of the clay minerals seemed to become evident only in developed artificial soil systems after several OM additions.

Reference:

Cordula Vogel, Katja Heister, Franz Buegger, Irina Tanuwidjaja, Stephan Haug, Michael Schloter and Ingrid Kögel-Knabner (2015): Clay mineral composition modifies decomposition and sequestration of organic carbon and nitrogen in fine soil fractions, Biology and Fertility of Soils, DOI: 10.1007/s00374-014-0987-7

P 2.3.10

Increasing the soil organic matter by adding compost or vermicompost stabilized with clay and/or biochar.

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Compost and vermicompost are both amendments used to increase soil organic matter. However, these amendments are easily degraded by soil microorganisms leading to carbon emissions and to a rapid decrease of organic matter and thus soil quality. In soil, organo-mineral associations are well-known to sequester and protect organic matter from mineralization. Indeed, clays have a specific surface area and can form associations with organic matter. Biochar, a carbon rich product of pyrolysis of biomass plant, is also recognized as a substrate able to sequester carbon due to its capacity to adsorb labile compounds. In this paper we investigate the effect of the addition of a 2:1 clay and/ or biochar on carbon emissions during composting and vermicomposting and after the application of these mixtures to a cambisol soil. We added in different proportions clay (25% or 50%) and biochar (10%) to pre-composted green-wastes and followed the carbon mineralization of these mixtures before and after their application to a cambisol soil. The most efficient treatment in terms of improving soil organic matter stabilization was the addition to soil of vermicompost mixed with 25% of clay followed by the compost mixed with 50% of clay. In this treatment, the carbon emissions were decreased up to 44% compared to a compost without additives. These findings suggest that the presence of earthworms enhanced the contact between clay and organic matter up to a certain clay/organic matter ratio and thus increased the organo-mineral associations during vermicomposting leading to carbon protection. This strategy could be used to enhance the stability of organic matter and increase soil carbon sequestration.

Keywords: vermicompost, compost, clay, biochar, organo-mineral associations

P 2.3.11

Differential Potential of Different Tree Species to improve Soil Organic Matter and Chemical Properties

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Soil salinity is a serious environmental issue which is reducing crop yields and causing environmental degradation particularly in arid to semi-arid regions of the word. There exists a great diversity among plant species for their salt tolerance and the salt-affected soils can be rehabilitated by growing different salt tolerant tree species. The positive effects of trees on soil organic matter content and other chemical properties of soil were investigated by growing five tree species viz. *Albizzia lebbeck, Sesbania sesban, Psidium guajava, Jatropha curcas* and *Grewia asiatica,* in a salt affected field. Plant growth data, leaf ionic composition and soil properties including organic matter content were recorded after every six month for a period of two years. Plant growth data showed that at the end of the second year, maximum plant height and stem circumference was produced by *Sesbania sesban* followed by *Albizzia lebbeck,* whereas minimum value of plant height was found in case of *Psidium guajava* and *Jatropha curcas*. Stem circumference was found minimum in the case of *Grewia asiatica* followed by *Psidium guajava.* Regarding ionic composition of leaves, it was observed that leaf Na^+ and Cl^-concentrations were higher in the older leaves, whereas, the concentration of K^+ was higher in younger leaves of all the tree species. The growing plants have remedial effect on soil chemical properties like pH_s, EC_e and SAR. Among these parameters maximum reduction was found in case of SAR. The organic matter content was increased with time by all the tree species. The improvement in all these soil properties was more for upper (0-15 cm) soil layer as compared to lower (15-30 cm) soil layer.

P 2.3.12

Shining a light on stabilisation of recent carbon in a long-term biochar field experiment: nanoscale revelations

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Introduction

The incorporation of biochar in soil can trigger either positive or negative priming effects. However, the mechanisms controlling this priming effect are still poorly understood in agricultural systems over longer timescales (>5 years). This knowledge is essential to assess the role of biochar in stabilisation of native soil organic carbon (SOC) and root-derived C (recent C). In a previous field study established in 2006 (Slavich et al, 2013), a rapid increase in the total soil C stock was detected on a Ferralsol within a subtropical C_3 pasture system up to 36 months following the incorporation of an *E. saligna* biochar (550°C). It was suggested that this biochar stabilised recent C, which contributed to the increased total soil C content. Examination of surface functional properties of the biochar from this site may provide insights into the mechanisms leading to this stabilisation.

Objectives

- To investigate the nanoscale organo-biochar-mineral interactions, including the development of native organic C functional groups on biochar surfaces, within pores and between organo-mineral interfaces in the presence of pasture at this 9 year old biochar experimental site;
- To improve the understanding of stabilisation of recent C via organo-mineral interactions using spatial mapping of mineral phases localised on different regions of aged biochars.

Methods

A 12 month study was superimposed on the original trial in which *E. saligna* biochar (550°C) was applied to a Ferralsol at 10 t ha^{-1} in the top 100 mm of soil profile (equivalent to 1% w/w) 8 years prior to the current experiment. Within the original plots, four treatments were created: 1) unamended (0 t biochar ha^{-1}, “control”), 2) original biochar plots (10 t biochar ha^{-1}, “9 year aged”), 3) biochar applied to the unamended soils (10 t biochar ha^{-1}, “1 year aged”), and 4) biochar re-applied to the original biochar plots (20 t biochar ha^{-1}, “reapplied”). We designed an in-field soil and soil plus root respiration chamber and applied i*n situ* ^{13}C pulse labelling, which allowed us to assess priming effects in unplanted and planted systems. Fresh, 1 and 9 year aged biochars were recovered from soil by washing (distilled water) and hand picking. We harnessed synchrotron-based near edge X-ray absorbance fine structure (NEXAFS) spectroscopy (Australian Synchrotron, Melbourne, Australia) to characterise the bulk C functional groups in fresh, 1 and 9 year aged biochars, biochar and soil mixtures and unamended soil. Fourier transform infrared spectroscopy (FTIR) was used to quantify the chemical complexity of aromatic carbon in the biochars. High-resolution transmission electron microscopy (Joel ARM and Titan TEM, Brazil) was used to examine the aging process of biochar over time (at 0, 1 and 9 years) in the nanoscale crystallites on biochar surfaces, within pores and between organo-mineral interfaces.

Results

NEXAFS results indicated a great level of similarity in the bulk C functional groups between 1 and 9 year aged biochars, despite an increase in carboxylic C=O of aged biochars compared to the fresh biochar. This may imply a rapid *in-situ* development of functional groups and consequent stabilisation of native and plant-released C in soil after the application of biochar in this highly reactive clay-rich Ferralsol. The bulk C functional groups of planted and unplanted biochar-amended soils were also profiled.

FTIR showed little change in aromatic C=O and C=C, while C-H, C-O and O-H (H-bonded) functional groups increased as biochar aged. Based on TEM, both Fe^{2+} and Fe^{3+} spectra were observed on the aged biochar surfaces, which indicate a redox reaction between the Fe in the soil and the labile component of the biochar. Nanoscale spatial resolved maps of specific carbon-oxygen groups obtained via TEM will be presented at the conference.

Conclusion

In our project, we qualitatively and quantitatively examined the *in-situ* nanoscale interactions between a high temperature hardwood biochar (550°C) and a Fe-rich Ferralsol in a longer-term field experiment. We suggest that the changes in bulk C functional groups of aged biochars may result from the complex redox and organo-mineral interactions between biochar, soil and root leading to stabilisation of recent C.

P 2.3.13

Nanoscale characterization of carbon-mineral interfaces in soil microaggregates

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Understanding the processes regulating soil organic carbon (SOC) stabilization in soil is essential for accurate prediction of SOC cycling and turnover in response to changing environmental variables. Surface adsorption and other interactions between SOC and soil minerals contribute to long-term SOC stabilization, but the spatial and chemical complexity of SOC-mineral interactions is not well described. Direct visualization and chemical characterization of SOC-mineral interfaces in soil with combined imaging and spectroscopy (i.e., spectromicroscopy) may improve understanding of interaction mechanisms, but the spatial resolution of current spectromicroscopy methods is incommensurate with the high spatial heterogeneity of soil. High-resolution Scanning Transmission Electron Microscopy with Electron Energy Loss Spectroscopy (STEM-EELS), a technique recently applied to soil, may allow for analysis that describes SOC-mineral interfaces at the necessary scale. In order to prevent sample damage and eliminate use of C-based resins, we developed a method of thin-section preparation and STEM-EELS imaging under cryogenic conditions. Using cryogenic Focused Ion Beam milling, we prepared samples with regions thin enough for STEM-EELS analysis, and collected carbon EELS data for a relatively homogenous region. We found that aliphatic carbon was spatially associated with aluminum oxide mineral surfaces in a 350 kyr-old volcanic soil. Further development of this approach and continued analysis of soils from model ecosystems with mineral control on SOC stabilization may serve to visually and chemically confirm mechanisms of hypothesized SOC-mineral interactions, or generate new hypotheses that can be tested using incubation techniques. Understanding the SOC-mineral interface may provide critical information for predicting mineral protection of SOC in soil.

P 2.3.14

The effects on soil carbon according to type of organic matter in upland soil

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The effects on soil carbon according to type of organic matter in upland soil

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Organic matter is a substance that contains carbon. When applied to soil, it can improve the physical and chemical properties of soil and supply nutrients to plants. Also, it is decomposed in soil due to microbe activity, or absorbed and utilized by crops. The remaining differential to materials is accumulated in the soil and increases the level of organic matter in soil. Given that the humidity and temperature are appropriate, and there are energy sources favorable for microbe activity, the decomposition rate is higher, thus resulting in the increase of the nutrient availability of crops. Therefore, we analyzed the types of carbon content according to time while cultivating beans in soil with 4 different kinds of organic matter applied.

We placed upland soil in pots of 50*50 cm^2 in this experiment. The upland soil was mixed with 4 different organic matter, rice straw compost(RC), hairy vetch(HV) and livestock compost(LC), and oil cake compost(OC) to be precise. They were 2% of the total weight of soil in cultivating area(depth of 10cm). We transplanted beans after two weeks of organic matter application. We sampled once a month and analyzed total carbon content(TC), humic acid carbon(HC), fulvic acid carbon(FC), and humin acid carbon(HnC).

Total carbon content(TC) was higher in organic matter application than in control(non organic matter). Among the other organic matters, it was especially high in LC application with 11.38 g kg^{-1}. HV(8.88 g kg^{-1}), OC(8.92 g kg^{-1}), and RC(8.24 g kg^{-1}) did similar. According to soil carbon form, HnC had the highest total carbon contrast of 63.1%, HC had 36.9%, and FC had 18.6%. This pattern was the same in both control and organic matter application. Every type of carbon was the highest in LC application. TC levels were temporarily high in June, which was after organic matter application, and decreased. It was higher than any other organic matter application in LC. HC increased in May and June which was when the organic matter was applied, slightly decreased in July, and were the highest in LC with TC. FC slowly increased after organic matter application until March and slowly decreased afterwards. It was highest in LC, and similar in HV, OC, and RC, which shows that it had the smallest difference of content between kinds of organic matter. HnC inclined to decrease slowly as time passed after organic matter application, but rapidly increased in July and June. Also,it was the highest in LC, and similar in HV, OC, and RC. Therefore, it was concluded that LC, which had a high level of humin acid carbon that is difficult to decompose, was the best for accumulating carbon in soil.

Key word : soil carbon, organic matter, livestock compost

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P 2.3.15

Factors affecting the organic carbon stabilisation capacity and saturation deficit of New Zealand soils

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Introduction

The C saturation concept assumes that each soil has a maximum SOC storage capacity, which is primarily determined by the characteristics of the fine mineral fraction (i.e. <20 µm clay + fine silt). Although fine mineral particles, especially clays, play a key role in stabilizing SOM, the relationship between SOM and texture is often not strong. Our recent research has shown that mineral surface area is a much better predictor of soil C stabilisation capacity than the mass proportion of the fine fraction. The maximum C loading rate (mg C m^{-2}) for both Allophanic and non-Allophanic soils was best described by a log/log relationship between specific surface area and the SOC content of the fine fraction. A multi-variate regression that included extractable Al and soil pH along with surface area provided the "best fit" model for predicting the SOC stabilisation capacity. However, further research is needed to verify and better understand the role that physico-chemical factors play in soil C stabilisation in agricultural soils.

Objectives

The objectives of this study were two-fold: 1) to investigate additional soil and environmental factors that may explain variability in the predicted soil C stabilisation capacity and saturation deficits of soils in New Zealand National Soils Database (NSD) and 2) to analyse an independent set of samples from sedimentary soils to more closely examine the role of the fine mineral fraction, including clay content, in soil C storage.

Materials & Methods

For the first part of this study, we expanded our analysis of the previously published results (Beare et al 2014) to investigate the influence of soil classification and climate factors (rain-fall, temperature etc) on the stabilisation capacity and saturation deficit of soils in the NSD. In the secondary part of this study, we collected and analysed a total of 58 soils (0-15 cm depth) representing Inceptisols, Alfisols and Entisols under different forms of land use (Dairy, Sheep/beef, arable cropping, vegetable cropping). The concentration of C (and N) in whole soils and particle size fractions (<5, 5-20, 20-50, >50 µm) was determined by Dumas combustion. Iron and Al in the fractions (and whole soil) were extracted using 0.1 *M* sodium pyrophosphate and analysed on a inductively coupled plasma-optical emission spectrometer.

Results

The total SOC concentrations in the NSD soils ranged from 0.65 to 138 mg C g^{-1}. As reported previously, mineral surface area was much more closely correlated with the SOC content of the fine fraction than was the mass proportion of the fine fraction. Furthermore, there was strong evidence that nearly all soils had a saturation deficit greater than zero. Further analysis of the data confirmed that median saturation deficit for both Allophanic and non-Allophanic soils was 12 mg C g^{-1} at 0-15 cm depth, however the deficit for 15-30 cm depths was somewhat higher than originally estimated. Although there were some differences in the saturation deficit of major soil classes, there was no obvious mineralogical or climatic explanation for these differences.

The independent set of sedimentary soils had a wide range of textures and SOM; the mass proportion of clay (<5 µm) ranged from 10 to 60 g 100 g^{-1} and soil C from 16 to 45 g kg^{-1}. Irrespective of soil classification or land uses, the majority of the soil C (57 to 66%) was stored in the clay fraction. However, as noted in previous studies, there was no correlation (R^2 = 0.02; P>0.05) between the C concentration in whole soil and clay content. The C concentration in the clay fraction (range = 35 to 135 g kg^{-1} clay) decreased as the mass proportion of clay increased. A similar trend was observed for the fine (5-20 µm) silt fraction. Because of this inverse relationship, there was little change in amount of stable C (defined as C in the <20 µm fraction) as the mass proportion of fine (<20 µm) particles increased. Mineral surface area was a dominate factor affecting the C content of the fine fraction.

Differences in extractable aluminium explained part of the variability in C concentration in the fine fractions; however, we were unable to identify any other specific physico-chemical factors that would account for the relatively low C concentrations observed in the <5 and 5-20 µm fractions of fine-textured soils.

Conclusions

Reanalysis of previously published data from New Zealand soils suggests that the soil C saturation deficits of subsurface soils (15-30 cm) may have been underestimated. Analysis of additional soils supports the conclusion that most are under-saturated and have potential to store additional stable C, however, the reasons of these wide spread saturation deficits remain unclear.

P 2.3.16

The influence of different disturbance degree of mountain meadow soil organic matter and acidity

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Question:

The geographical position and direction of Jiangxi Wugong Mountain has important status in the East China vegetation regionalization. The degradation of meadow area caused by that the extension of the scale of tourism and tourists run length range.

Methods:

This study selects Wugong Mountain as the typical area, aiming at the problem of subtropical mountain meadow ecosystem of extreme vulnerability, sensitivity and serious disturbance, where is in the main peak elevation of 1900 meters (visitors to focus on Jinding scenic area), set to one of 4 kinds of processing according to the influence of disturbance degree on vegetation coverage (no disturbance, vegetation coverage of 90% to 100%; slight disturbance, vegetation coverage of 60% to 90%; medium disturbance ,vegetation coverage of 30% to 60%; severe disturbance (vegetation coverage was 0%-30%). Using soil nutrient systematic approach (ASI), carried out in different soil depth (0-20cm and 20-40cm) with different disturbance degrees to study the characteristics of nutrient elements in soil volume.

Results and Conclusions:

The results showed that:

(1) the soil of Wugong mountain meadow is strong acid or extremely strong acidic, the lower and the upper soil acidity gradually increases with the increase of disturbance degree, the content of commutativity acid in the range of 1.8-1.8 coml/L, shows the distribution trend of similar to active acid; the content of organic matter is rich, the content range of soil organic matter by different treatment from 2.71% - 2.71%, and the soil content of upper is higher than the lower.

(2) The different degree of disturbance has significant effects on soil active acid content, the value of significant is less than 0.01, when the value of significant is 0.85, the different degree of disturbance has a certain degree of influence on soil exchangeable acid content; however, it has no obvious effects on organic matter content; When the value of significant is 0.006, different soil depth has significant effects on organic matter content, has certain influence on soil exchangeable acid, no influence on the active acid of soil.

(3) It appears certain negative correlation to the elevation of acid soil activity and organic matter content, and the correlation coefficient is -0.114. While at the 0.01 level, soil exchangeable acid and organic matter content has significant correlation, the correlation coefficient is 0.666, the linear equation between them is: $y = 0.343 + 1.477x$ ($R^2 = 0.444$).

Key words: Disturbance; Meadows; Organic matter; Acidity

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P 2.3.17

Interlayer fillings in clay minerals from surface horizons of Albeluvisols from the Carpathian Foothills, Poland

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The main aim of the present study was to determine composition of material occurring in interlayers of clay minerals in surface horizons of Albeluvisols from the Carpathian Foothills in Poland using X-ray diffraction (XRD), Fourier Transform Infrared Spectroscopy (FTIR and FTIR-ATR), and chemical analyses. Eight, representative soil profiles (four forest soils and four crop soils) formed entirely from loess and showing occurrence of fragipan were selected to the detailed study. The obtained results show that in the surface A horizons of the studied Albeluvisols 2:1 clay minerals are present. The clay minerals do not fully collapse to 10 Å after heating at 330^{o}C and 550^{o}C and do not expand after glycerol solvation. Comparison of XRD patterns, FTIR spectra, and content of C, N, H, and S in the clay fraction before and after removal of organic matter using hydrogen peroxide indicates that most likely mainly organic matter is present within the interlayers of clays from the soil horizons. However, after this treatment the full collapse of swelling clay minerals was still not observed what most likely is connected with occurrence of organic matter, which is resistant to oxidation by hydrogen peroxide or is related to presence of some amounts of Al-hydroxy, Fe-hydroxy, and/or Mg-hydroxy polymers within the interlayers. Comparison of FTIR spectra obtained for natural clay fraction and after K saturation of the clays indicates replacement of some part of the organic material for K ions. This could indicate that the easily exchangeable part of organic material occurring in the interlayers of the clay minerals are ammonium cations.

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P 2.3.18

Characteristics of Ash Influencing Humic Substances in Bottom Ash amended Soil

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Coal ash is produced at rate of 12-20% by weight of the original coal when coal is burned to produce steam for electricity generation. Korea consumes approximately 42 million tons of coal annually to generate electricity, and generates around 6 million tons of coal ash annually. However, only 60% of the coal ash by-products are recycled, while 40% are buried at the power plant site. In particular, most of bottom ash was landfilled, and then properly recycling methodology should be developed. Bottom ash is well known as soil amendment and high organic matter (ca. 0.3-15%) containing material. However, the function of organic matter containing in coal bottom ash as it applied in soil as an amendment was not studied well. In this study, in order to evaluate the properties of ash containing organic matter when it applied in soil as amendment, the chemical characteristics of humic substances in the coal bottom ash mixed soils were compared with the pure soil. We collected two types of soil from the landfill cover simulator which is bottom mixed soil (BA35% + soil 65%) and only soil (100%) treatment in the 5th year after installation. The soil organic matter was fractionized with humic, fulvic acid and humin by using the sequential extraction method. The chemical structure of humic substances was characterized by ^{13}C NMR spectroscopy. Bottom ash mixed soil has 5 times higher total organic C content than the pure soil. In addition, humic substance C content was also higher in the bottom ash mixed soil with the similar composition ratio with total organic C content. However, there was no significant difference of chemical composition of humic substances between the bottom ash mixed soil and the pure soil. Aromatic group of humic acid and fulvic acid was most dominant with around 30% of TOC, and then followed by O-alkyl (22.2-28.4%), Alkyl (13.2-20.1%), and carboxyl OC groups (9.2-19.4%). Conclusively, the mineralogical effect of BA might be a main factor on accumulating SOM in BA mixed soil layer.

Key words: Bottom ash, Humic substance, ^{13}C NMR

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P 2.3.19

Effect of long-term fertilization on organic carbon in calcium-bound and iron/aluminum-bound organo-mineral complexes in purple paddy soil

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Question: Soil organc carbon (SOC) sequestration is related to chemical stabilization and protection through binding to minerals by calcium(Ca), iron (Fe) and aluminum (Al) ions (Zhou et al. 2009; Kleber et al. 2007). Application of inorganic and organic fertilizers in maintaining and increasing levels of SOC in paddy soils has been well documented (Tan et al. 2014; Brar et al. 2013). However, few studies focus on the effect of fertilization on organic carbon in calcium-bound (Ca-OC) and iron/aluminum-bound (Fe/Al-OC) organo-mineral complexes.

Method: A 22-year field experiment in purple paddy soil under rice-wheat system was used to address the effect of long-term different fertilization on Ca-OC and Fe/Al-OC. The organo-mineral complexes were obtained by density fractionation, e.g., heavy fraction (HF), and Ca-OC and Fe/Al-OC were separated using the sequential extraction method of Na_2SO_4 and $NaOH+Na_4P_2O_7$ mixture (Lu 2000).

Results: Organic carbon in heavy fraction (HF-OC), Ca-OC and Fe/Al-OC ranged from 9.4-14.1 g kg^{-1}, 0.25-0.32 g kg^{-1} and 2.78-5.14 g kg^{-1}, accounting for 75.6-85.5%, 1.7-2.3% and 22.3-34.7% of total SOC respectively. Long-term fertilization significant increased HF-OC (20.1-49.9%) and Fe/Al-OC (28.6-84.9%) than no fertilization, and balanced fertilization of chemical NPK or together with inorganic fertilizer showed greater increase than unbalanced fertilizer. There were significantly positive and linear relationships between total SOC content and HF-OC, Ca-OC and Fe/Al-OC contents.

Conclusions: Therefore, chemical binding to minerals by Fe and Al was potential mechanism for SOC sequestration, by which fertilization, especially combined application inorganic and organic fertilizers improved SOC in purple paddy soil and probably in other type paddy soils.

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Figure legends

Fig. 1 Effects of long-term fertilization on organic carbon in heavy fraction (HF-OC), calcium-bound (Ca-OC) and iron/aluminum-bound organic carbon (Fe/Al-OC). CK, no fertilization (treatment for check); N, application of chemical N fertilizer; NP, application of chemical N and P fertilizer; NK, application of chemical N and K fertilizer; PK, application of chemical P and K fertilizer; NPK, application of chemical NPK fertilizer; S, only straw return; NPKS, combined application of chemical NPK fertilizer with straw return; hNPKS, high application of chemical NPK fertilizer (150%) but equal amount of straw return; NPKM, combined application of chemical NPK fertilizer with pen manure. Different letters above bars indicate significant difference between treatments at $p < 0.05$ level.

Fig. 2 Relationships between total SOC and organic carbon in heavy fraction (HF-OC), calcium-bound (Ca-OC) or iron/aluminum-bound organic carbon (Fe/Al-OC). Error bars denote standard deviations.

Figure 1

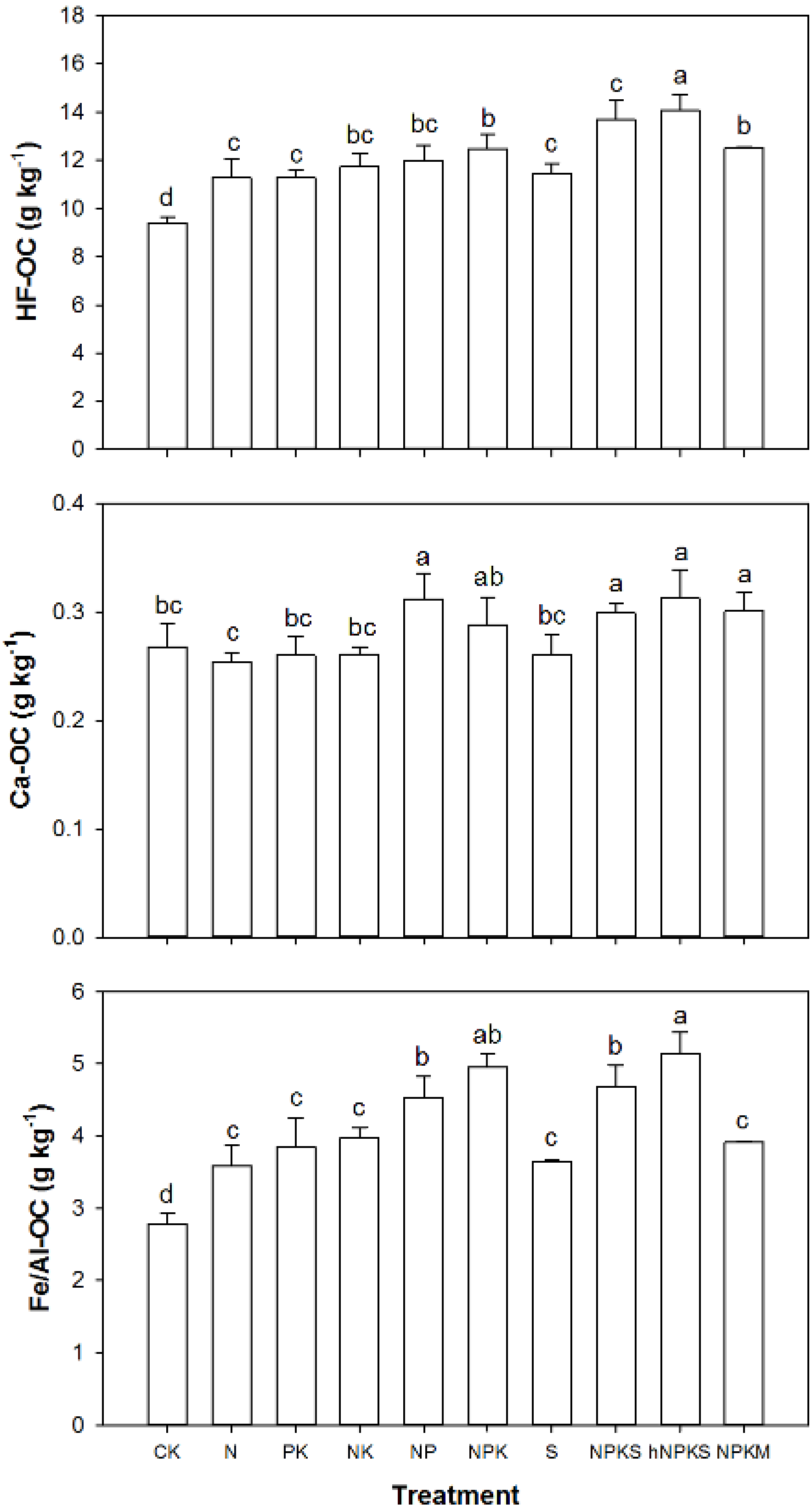
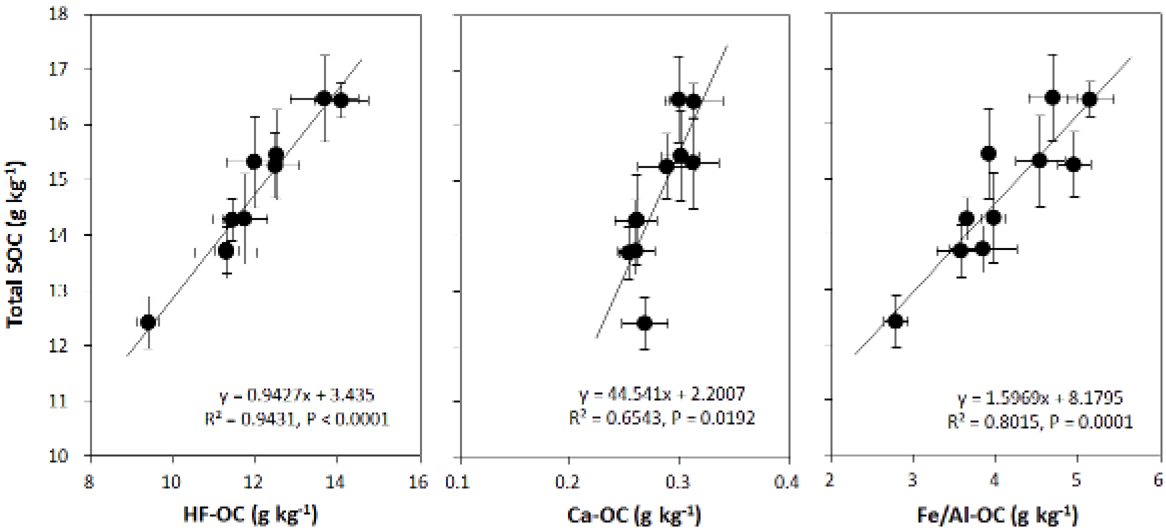


Figure 2



Total SOC (g kg-1)
18
17
16
15
14
13
12
11
10
y = 0.9427x + 3.435
R² = 0.9431, P < 0.0001
8
10
12
14
16
HF-OC (g kg-1)
y = 44.541x + 2.2007
R² = 0.6543, P = 0.0192
0.1
0.2
0.3
0.4
Ca-OC (g kg-1)
y = 1.5969x + 8.1795
R² = 0.8015, P = 0.0001
2
3
4
5
6
Fe/Al-OC (g kg-1)

P 2.3.20

Iron and Cooper Retention into Humic Substances (HS) from a Wheat Straw-Based Compost and Compost-Amended Soils: A Visual Study of the Interaction and Incorporation by Electron Microscopy

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The resulting humified organic matter produced by composting is used as a suitable amendment for agricultural, degraded or metal polluted soils. In order to promote the compost stabilization some inorganic materials such as allophane and metallic oxides have been used elsewhere. In this study we characterized humic substances (HS) extracted from a wheat straw residue co-composted with Fe_2O_3 (WSFe). Also, we analyzed HS extracted from Cu-polluted soil after compost amended (6/months). Both HS were characterized under SEM and TEM microscopy. WSFe was characterized at two different pHs (4 and 8). All samples were analyzed by Energy Dispersive X-ray spectroscopy (EDS) in order to evaluate the element distribution in HS matrix. In addition, FTIR spectroscopy to study the presence of different functional groups was carried out. At pH 4, SEM analysis indicated that globular structures of WSFe prevailed, some of them aggregating within a large network. Conversely, at pH 8, long tubular and dendritic shaped of HS structures prevailed. TEM images at scales of 1 to 200 nm showed iron nanoparticles (~20 nm) incorporated into the WSFe matrix and also forming nano- to micro-size aggregates. In the EDS microprobe analysis, different elements as Fe were observed in the composition of the analyzed samples. In soils, HS showed a similar behavior than WSFe as consequence of pH and the presence of metals. The main functional groups of HS suggest the formation of stable complexes with some metals such as Cu, Fe and Zn even at nano-scales according to our TEM micrographs. We conclude that metals and pH have an important role in controlling the morphology of HS and their stabilization. Moreover, HS extracted from compost (WSFe) are indicating that similar mechanisms of the stabilization of HS in soils may be present in HS from soil-less systems as compost.

P 2.3.21

Impact of land use on the stabilisation and storage of soil organic matter in an Andisol of Southern Chile

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Mitigation of CO_2 emissions by soil carbon subsequent imply a fully knowledge and understanding of the process and mechanisms involved in soil organic matter (SOM) stabilisation. On the other hand, volcanic soils are extremely important in terms of C storage, as they occur only in 0.8% of the global land area, but they can store more than fivefold the amount of soil C than non-volcanic soils. In Chile there are more than 5.1 million hectares of volcanic soils under agriculture generally developed under native forest of *Nothofagus* spp. before clearance and burning during the 19th century. The temperate rainforest of southern Chile show low temperatures (4.5°C) and high precipitation (5,000-7,000 mm), where the woody vegetation and litter-input produce a slow decomposition rates. In contrast, prairies growing in similar soil, show a rapid decomposition than forest soils. We hypothesized that the distribution of SOM in different C pools strongly depends on litter-quality in connection with Al complexes formation affecting the rates of decomposition. Here, we determine the distribution of SOM in physical fraction of an allophanic soil under different land-uses. We select Liquiñe soil under *Nothofagus* spp. forest (39 ° 38 'S, 72 ° 05' W) and adjacent area with natural prairie dominated by native species (eg. *Agristis spp, Cynosurus echinatus, Taraxacum officinale*). Soil samples of forest were taken by core cylinder (5 x 8.2 cm) per horizon A1, A2 and C at 0-10 cm10-90 cm and > 90 cm, respectively. For the prairie we sampled for A, B1 and B2 horizons at 0-20, 20-80 and > 80 cm, respectively. All soils were analysed for the bulk density, pH, element C and Al extracted by pyrophosphate amongst others determinations. We also use density fractionation to separate free particulate organic matter (fPOM, -3), occluded particulate organic matter (oPOM, 1.6-2.0 g cm^{-3}) and mineral associated organic matter (MF, > 2.0 g cm^{-3}). The results indicate that most variations in the C levels were explained by the complexation between Al and humic substances. We found a significant correlation between Al and SOC in both, prairie (R^2=0.74) and forest soil (R^2=0.90). A significant amount of C in the organo-mineral complexes was found in the top soils in both sites (57% - 63%) and < 24% in the subsoil. SOM isolated in oPOM had high concentration of C in the forest topsoil 10% compared with 1% in prairie soils. Physically protected organic matter (oPOM) was more important in forest probably due to litter quality, because both sites presented similar textures.

P 2.3.22

Effect of mineralogy on the turnover rates of SOM of different Hungarian soils

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Soil texture is among the abiotic factors that influences the soil organic matter (SOM) decomposition. The biological stability of SOM is controlled by the chemical structure of the SOM and various protection mechanisms offered by the soil matrix and soil minerals. Fractionation of soil according to particle size (clay, silt, and sand-size fractions) yields organo-mineral fractions with distinctly different properties in terms of SOM turnover. However, clay minerals are generally considered an important stabilizer as fine textured soils generally contain more microbial biomass, and have a lower rate of biomass turnover and organic matter decomposition than coarse textured soils, several recent studies have shown contradicting trends.

The aim of this study is to evaluate soil mineralological effect on the turnover of SOM by identifying and quantifying phyllosilicates and quantifying their surface properties (CEC, specific surface area).

All of our samples are derived from C3 forests and croplands from different sites of Hungary. C4 maize residues are added to the soils in order to get natural 13C enrichment as tracer for the young carbon. Bulk samples of the soils from 0 to 20 cm depth are collected. The samples are dried at 40°C, passed through a 2 mm mesh sieve, homogenized and analysed for pH, cation exchange capacity. The amount of total C and N in the soils and maize leaves is analysed using NDIR-chemiluminescent analyzer (Tekmar Dohrman Apollo 9000N). Particle size distribution is determined by laser diffraction method (Fritsch Analysette MicroTec 22 plus). The mineralological composition of the samples is determined by X-ray diffraction (Philips PW 1730 X-ray diffractometer).

The samples are preincubated in the dark for 4 months at about 15 °C. Moist soil equivalent to 500 g dry soil mixed with 2 g maize leaves is kept in air tight glass chambers for 183 days at 20°C. The leaves had previously been dried at 60 °C, were cut into pieces and sieved through a 2 mm mesh. The evolved CO2 is trapped by 10 mL 2 M NaOH, which is exchanged on day 1, 3, 5, 7, 10, 14, 21, 28 and subsequently every 31 days.

The fractional abundance of 13C of the soils, the plant material and the evolved CO2 was measured with isotope ratio mass spectrometer (Thermo Scientific Delta V IRMS).

Our work studies the link between phyllosilicate mineralogy and soil C dynamic by reporting a quantified phyllosilicate data in connection with SOM turnover and stabilization.

P 2.3.23

Effects of waste products amendment on improve the degraded soils condition and increase the content of soil organic matter

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1. INTRODUCTION

The land degradation is one of the fundamental and sustained problems in the world. To counteract of soil degradation processes are taken many remedial actions consisting in: improving the physico-chemical properties of soil, restoring the level of soil humus and restoration of plant cover. In order to reclamation of degraded soils can be used the organic substances from wastes as a soil additives. These activities affect also the recycling and management of large amount of waste substances. The waste products can be a source of soil organic matter, carbon and other biogenic elements. In addition, this organic substances have the ability to absorb/adsorb and immobilization of soil pollutants.

2. OBJECTIVES

The main aim of the pot experiment was to identify the effects of waste products amendment on improve the degraded soils condition, increase the content of soil organic matter and biogenic elements. An additional purpose was to support the phytoremediation process of contaminated soil with trace metals by used of five organic additives.

3. MATERIAL AND METHODS

3.1 Soil material characteristics

Soil samples from two different degraded areas were used in the experiment. The first sample was obtained from an area affected by a zinc smelter. Soil samples from this area are characterized by a high concentration of heavy metals, with a low pH and a low sorption capacity. This soil is poor in biogenic elements and organic substances. The second degraded area is the Bełchatów Brown Coal Mine. The soil samples from this area has a lower fertility due to human activities carried out in the area and does not have a proper soil profile. Such soil has a high pH and low moisture content, it has low biogenic element and organic material content. The soil also has lower levels of heavy metals than the soil from the zinc smelter area.

3.2 Characteristics of organic soil additives

Organic substances from waste were used in the pot experiment in order to supply organic matter and biogenic elements to the soil. In the experiment were used of five organic additives such as the sewage sludge from the food industry, first compost from the biodegradable fraction of municipal waste, second compost from sewage sludge from household wastewater treatment plant, coal slurry and lake chalk. The soil additives were characterized by a high nutrient content, low concentration of heavy metals and PAHs.

3.3 The pot experiment

The pot experiment was carried out under controlled conditions in a phytotron chamber over a period of one year and with uses two species of plant. After the experiment the following parameters were measured for the soil subsamples: humic acids by Stevenson method, soil organic matter by an incandescent loss, TN by modified Kjeldahl method, TOC by Tiurin method, TC (after the dry combustion) and DOC in the pore water (after filtered) with using Multi N/C Analitykjena, TP (after the mineralization process) with using inductively coupled plasma atomic emission spectrometry (ICP-OES; Thermo apparatus).

4. RESULTS AND CONCLUSION

In course of the one year pot experiment the influence of organic soil additives on improve the soils condition was examined. The influence of biowaste on the increase the content of soil organic matter, humic acid and biogenic elements in degraded soils was significant. The results obtained lead to the following conclusions: application of sewage sludge, municipal compost, coal slurry and lake chalk improved the condition of degraded soil and lead to increased production of plant biomass, apart from waste substances organic material was also introduced into the soil due to its content of biogenic elements that improve water capacity of the soil and provide heavy metal sorption, when the release of nutrients (especially N) from sewage sludge into the soil occurs too quickly it may pose a potential threat of contamination of surface and ground waters with biogenic elements, lake chalk was the most successful organic waste product in terms of growth and development promotion in the case of Scots pine.

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P 2.3.24

Effects of Organic Amendments on Mining Polluted Soils, Metal Availability, Compartmentalization and Stabilization with OM Form Composts

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Organic amendments as compost are considered an important biotechnology in remediation of metal-polluted soils because decrease the bioavailability of metal and metalloids through various processes that include immobilization, reduction, and rhizosphere modification.The organic matter (OM) incorporated by amendment do not remove metals from soil, but transform them into less soluble or insoluble forms (Macnair et al., 2000; Mench et al., 2003) through the mechanisms of adsorption, complexation or co-precipitation (Kumpiene et al., 2008). In order to promote metal immobilization in mining polluted soils, incubation studies were conducted. Wheat straw co-composted with inorganic bulking agents (metallic oxides and clay materials) were applied to metal polluted soils and its effects on metal availability were studied. For this, soils from Puchuncaví valley (Alfisol, Maitenes soils series) were contaminated with Arsenic (As) and Copper (Cu) at two different doses (As: 0-25 ppm; Cu: 0-500 ppm). Soil samples were mixed with compost at a rate of 50 g C kg-1 soil and were placed in jars incubated in darkness at 24 °C for 90 days. Copper and As compartmentalization were carried out. The Cu and As fractions in soils were measured using selective extraction procedure. Both elements were separated in the following fractions: easily exchangeable (E), bound to carbonates (CA), bound to Fe and Al oxides (Ox) and organically bound (OM). The extraction was conducted using 1 g soil (incubation with compost) at 21°C.

Results indicated that compost addition reduced the easily exchangeable fraction and increased organic bound of Cu. Copper in treatments with no compost addition were associated with easily exchangeable fraction, accounting for over ~40% of total Cu. On the other hand, As showed a similar behavior than Cu in the studied fractions. However, another kind of analyses should be carried out as complementary information. Our results suggest that wheat straw based-compost co-composted by bulking agents has an important effect on metal retention.

We concluded that composts here studied have the potential to affect the behavior of Cu-As in mining polluted soils by altering their availability, being an interesting way of mining polluted soil remediation.

P 2.3.25

Using position-specific ^{13}C and ^{14}C labeling and ^{13}C-PLFA analysis to assess microbial transformations of free versus sorbed Alanine

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Question

Sorption of charged or partially charged low molecular weight organic substances (LMWOS) to soil mineral surfaces delays microbial uptake and therefore mineralization of LMWOS to CO_2, as well as all other biochemical transformations. We used position-specific labeling, a tool of isotope applications novel to soil sciences, to compare the transformation mechanisms of sorbed and non-sorbed alanine in soil. Alanine as an amino acid links C- and N-cycles in soil and therefore is a model substance for the pool of LMWOS.

Methods

To assess transformations of sorbed alanine, we added position-specific and uniformly ^{13}C and ^{14}C labeled alanine tracer to soil that had previously been sterilized by γ-radiation. All non-sorbed alanine was removed by shaking with millipore water. The labeled soil was added to non-sterilized soil from the same site and incubated. Soil labeled with the same tracers without previous sorption was prepared and incubated as well. We captured the respired CO_2 and determined its ^{14}C-activity at increasing time intervals. The incorporation of ^{14}C into microbial biomass was determined by chloroform fumigation extraction (CFE), and utilization of individual C positions by distinct microbial groups was evaluated by ^{13}C-phospholipid fatty acid analysis (PLFA).

Results

A dual peak in the respired CO_2 revealed the presence of two sorption mechanisms. Microbial uptake and transformation of the sorbed alanine was 3 times slower compared to non-sorbed alanine. To compare the fate of individual C atoms independent of their concentration and pool size in soil, we applied the divergence index (DI). The DI reveals the convergent or divergent behavior of C from individual molecule positions during microbial utilization. Alanine C-1 position was mainly oxidized to CO_2, while its C-2 and C-3 were preferentially incorporated in microbial biomass and PLFA. This indicates that sorption by the COOH group does not protect this group from preferential oxidation. Microbial metabolism was determinative for the preferential oxidation of individual molecule positions.

Conclusion

The use of position-specific labeling revealed mechanisms and kinetics of microbial utilization of sorbed and non-sorbed alanine, as well as interactions between microbial groups, soils and LMWOS. None of these findings could have been achieved without the use of position-specific tracers, therefore this method will improve our understanding of stabilization processes and soil C fluxes.

P 2.3.26

Influence of natural organic matter on the sorption of ciprofloxacin on titanium dioxide (TiO_2)-nanoparticles

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Engineered nanoparticles and antibiotics in wastewater are of growing interest in terms of their environmental impact. Sorption of antibiotics to nanoparticles might modify their bioavailability, persistence, mobility and effects in wastewater and in the environment. Organic matter (OM) may also interact with nanoparticles and antibiotics, which could influence their interactions.

In the present study, a series of batch experiments are presented to study the sorption of ciprofloxacine (CIP) on titanium dioxide nanoparticles (TiO_2-NPs) and the influence of natural organic matter (NOM) on these interactions. Experiments were performed with buffer solutions (ionic strength adjusted to 0.001 M by NaCl addition) containing radio-labelled CIP and Suwannee River NOM at concentration of 500 µg L^{-1} and 50 mg L^{-1}, respectively, at varying pH and concentrations of TiO_2-NPs. The radioactivity of the solutions was measured by scintillation after filtering the batches with polyvinylidene fluoride (PVDF) membrane filters (pore size of 100 nm).

The mean hydrodynamic diameter (D_h) of TiO_2-NPs in the buffer solution was measured at 143.3 nm ±2.76 nm (n=3) at pH 8 and a TiO_2-concentration of 5 mg L^{-1}. At this pH, no significant sorption of NOM to TiO_2-NPs was observed above the method variability with a relative standard deviation of 2.7 % up to 64 hours. At 72 h only a small amount of NOM of 8.9 % ±0.6 % was sorbed. The low sorption of NOM on TiO_2-NPs surfaces could be explained by the fact that at pH 8, which represents the value occurring frequently in wastewater, TiO_2-NPs and NOM are both negatively charged.

At pH 8 and a TiO_2-NP concentration of 5 mg L^{-1} the sorption of CIP was below the method variability of 10 % indicating that the sorbent concentration must exceed a critical value to be effective. At this pH, CIP is present in the zwitter ionic form. This explains the low affinity of CIP to sorb on TiO_2-NP. However, the higher variability at pH 8 compared to that at pH 3, where both compounds are present in their cationic form, indicated already some interactions.

At pH 8 and a TiO_2-NP concentration of 500 mg L^{-1} a significant sorption of CIP on TiO_2-NPs of 51.9 % was observed. The sorption equilibrium was reached after 64 hours. Sorption isotherms with and without NOM were described well, assuming the Freundlich model with a determination coefficient (R^2) of 0.990 and 0.982, respectively. The Freundlich sorption coefficients (K_F) in the presence of NOM of 2,167 L^n•mg•mg^{-n}•kg^{-1} was about 10 times lower than in the absence of NOM.

Our results demonstrate that the sorption capacity of TiO_2-NPs for CIP is low at wastewater relevant TiO_2-NPs concentrations. At higher TiO_2-concentrations this sorption capacity becomes important. This sorption is decreased by competitive sorption of CIP to NOM. NOM itself did not significantly interact with TiO_2-NPs. One can conclude that in wastewater the sorption of CIP to TiO_2-NPs is negligible whereas the fraction of NOM

P 2.3.27

SOM mineralisation and the role of micro-scale heterogeneity

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Soil respiration represents the second largest CO_2 flux from terrestrial ecosystems to the atmosphere, and a small rise in average temperature could increase it very significantly. Unfortunately, the extent of this effect cannot be quantified reliably, and the outcomes of experiments designed to study soil respiration remain notoriously unpredictable. In this context, the mathematical simulations described in this article suggest that assumptions of linearity and presumed irrelevance of micro-scale heterogeneity, commonly made in quantitative models of microbial growth in subsurface environments and used in carbon stock models, are not at all warranted. Results indicate that microbial growth is non-linear and, at given average nutrient concentrations, strongly dependent on the microscale distribution of both nutrients and microbes. These observations have far-reaching consequences, in terms of both experiments and theory. They indicate that traditional, macroscopic soil measurements are inadequate to predict microbial responses, in particular to rising temperature conditions, and that an explicit account is required of microscale heterogeneity. Furthermore, models should evolve beyond traditional, but overly simplistic, assumptions of linearity of microbial responses to bulk nutrient concentrations. The development of a new generation of models along these lines, and in particular incorporating upscaled information about microscale processes, will undoubtedly be challenging, but appears to be key to understanding the extent to which soil carbon mineralization could further accelerate climate change.

P 2.3.28

CO_2 and N_2O emission in soil amended with organic and mineral enrichments under hypoxic conditions

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INTRODUCTION

Conservation of soil organic matter is widely recognized as a strategy used to improve soil quality and reduce carbon emissions to the atmosphere. Organic fertilizers provide plant nutrients and improve soil properties, but enhance CO_2 evolution due to stimulation of soil microorganisms. Clay minerals generally reduce decomposition rates due to lower accessibility organic matter and increased adsorption of metabolites onto surfaces. Liming is used in acid agricultural soils, as it increases pH up to values where the availability of nutrients is higher. The net effect of these practices on CO_2 and N_2O emission remains unclear. From an environmental perspective, a very important is the $N_2O:(N_2+N_2O)$ ratio. Under hypoxic conditions, the $N_2O:(N_2+N_2O)$ ratio reflects the N_2O reductase enzyme activity; the lower the ratio, means the higher N_2O reductase activity. The main aim of this study was to determine the effect of clay and lime application in manure fertilized soil on CO_2 production (reflecting mineralization of OM in soil) and N_2O reductase activity, that is to say, the ability of soil to prevent of N_2O emission to the atmosphere.

OBJECTIVES

The experimental field was located in the south-east of Poland (near Lublin city) on sandy soil (Haplic Luvisol) characterized by C_{org} 0.47% and pH in KCl of 4.46. Three experimental treatments were selected for the study:

- manure (M)

- manure and clay (M+CL)

- manure, clay and lime (M+CL+Ca)

Enrichments were added at rates of 4, 25 and 0.56 kg per m^2 (cattle manure, clay and post flotation lime, respectively).

The experimental plots were covered with the grass (*Dactylis glomerata*).

MATERIALS AND METHODS

Soil samples were collected three years after application of amendments, from the depth of 0-25 cm. Soil was weighted into glass flasks, flooded with deionized water (1:1, w/w) and incubated at 20°C with or without addition of acetylene (10% C_2H_2, v/v) in triplicate. The use of C_2H_2, an inhibitor of the last stage of the denitrification (reduction of N_2O to N_2) allowed calculation the $N_2O:(N_2+N_2O)$ ratio. Incubation under flooded conditions simulate an intensive rainfall resulting in soil hypoxia. After 1, 2, 3, and 7 days of incubation, the concentration of CO_2, N_2O and O_2 in the headspace was determined by gas chromatography. Soil pH, NO_3^- and NH_4^+ content were measured at the start and the end of the incubation.

RESULTS

CO_2 production started faster and initially was higher in the M treatment, but final cumulative CO_2 (94.6 mg C kg^{-1}) did not differ from that in the M+CL and M+CL+Ca (88.4 and 80.2 mg C kg^{-1}, respectively). In turn, both clay and lime significantly affected the denitrification activity. When incubated without C_2H_2, maximum N_2O (on day 3) was about 5 times lower in the M than in M+CL and M+CL+Ca treatments (1.36, 8.69 and 6.39 mg N kg^{-1}, respectively). Then N_2O decreased (up to by 28% in the M+CL+Ca). In the presence of C_2H_2, N_2O at the end of the incubation was higher in M+CL and M+CL+Ca soil than in the M (by 90 and 40%, respectively). Calculated $N_2O:(N_2O+N_2)$ ratios were nearly four times higher in both M+CL and M+CL+Ca treatments, as compared to the M (0.44 vs. 0.13). The N_2O reductase activity increased with the increasing pH.

CONCLUSION

The addition of clay and lime to manure-fertilized sandy soil slightly reduced emission of CO_2, but significantly enhanced production of N_2O. Moreover, calculation of the N_2O:(N_2O+N_2) ratio indicates that N_2O reductase activity was less efficient in the soil additionally amended with clay and lime.

IT 2.4

Contribution of soil pores to “hot spot” functioning

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A substantial portion of soil biogeochemical processes occur in a hot spot/hot moment fashion; that is, there are highly temporally and spatially variable micro-sites within a soil profile that at a given point in time are responsible for the majority of the profile’s biogeochemical activity. It is generally assumed that occurrence of a hot spot requires an optimal combination of current and antecedent water and air conditions, availability of C and N substrates, and presence of relevant microorganisms. While this is conceptually understood, experimental quantifications of the local conditions necessary for an occurrence and functioning of a hot spot are still lacking. A main reason is the technical challenge of obtaining information on hot spot occurrence and activity from intact soil samples with a sufficiently high level of spatial resolution.

Recently the development of tools for micro-scale soil analyses, including X-ray computed micro-tomography (µCT), enabled effective quantitative analyses of at least two of the major factors of hot-spot formation, that is, (i) presence and characteristics of soil pores and (ii) presence of particulate organic matter (POM). Pores are the avenues enabling air and water fluxes and accessibility of microorganisms and their enzymes to C sources. Freshly added plant material and POM are typically the nuclei of hot spot formation.

By combining X-ray µ-CT measurements (at 6-13 µm resolutions) with designed microcosm and intact soil sample experiments we found that the effect of pores on the fate of plant material in hot spots is significant and multifaceted. Due to the scanning resolutions used in our studies we specifically focused on the pores 10-100 µm in diameter. As a working definition of a hot spot we used an elevated level of CO_2 emission from the sample.

The results indicated that, first of all, the influence of characteristics of 10-100 µm pores on CO_2 emission was only observed when fresh plant material or POM were present and was typically associated with hot spots. That influence was minor to non-existing in an absence of plant materials. Even though it might seem that this finding downplays the importance of pore characteristics in C related soil processes, let us not forget that a very substantial portion of CO_2 emission from soil can be produced by hot spots.

Based on our results it appears that what matters the most in determining how active a hot-spot produced by presence of plant residues or POM will be depends on whether POM/plant residues are connected to the atmosphere by pores >30 µm. In presence of atmosphere connections, we observed a substantial decomposition of the plant material with sizeable reductions in its volume on µCT images, e.g. up to 80-90% of the added plant leaf volume was lost. In absence of atmosphere connections, POM volumes on µCT images remained largely intact while plant leaves lost smaller portions of their volumes, e.g., 50-60%. Despite smaller reductions in the plant leaf volumes, the hot-spot activity, as assessed by CO_2 emission, was actually substantially greater in the cases of absence than in the cases of presence of large connected pores.

We hypothesize that the likely reason for the observed results is priming, that is, an enhanced decomposition of the native soil organic material due to fresh organic inputs. It appears that soil pore characteristics are of great importance to the magnitude of this process. In presence of small pores there is a substantial amount of diffusion of the fresh organic decomposition products from plant residues into the adjacent soil. While there, the decomposition products likely have a greater potential to induce native organic matter decomposition. In presence of prevailing large pores more of the plant decomposition takes place *in situ* and more complete leaf decomposition ensures. The results of testing the proposed hypotheses using ^{13}C enriched plant material experiments will be reported.

Overall, at least in the relatively coarse textured/low C Alfisols of this study, creation of a hot spot requires not only presence of a plant residue/POM source but also an optimal combination of pore characteristics. The optimal pore characteristics are such that will not only enable decomposition of the source material but also will enable enhanced diffusion of the decomposition products into the adjacent soil matrix.

O 2.4.01

Differential responses of soil organic matter and root derived respiration to irrigation in an undisturbed grassland

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Conversion of dry-land farming to intensive dairy farming is expanding rapidly in New-Zealand. Irrigation and addition of nitrogen fertiliser increases productivity but very little is known about the impact of the major land-use change on soil carbon dynamics.

Partitioning of soil respiration (R_S) into respiration derived from the soil organic matter (SOM) and from the roots (noted R_{SOM} and R_R, respectively) is necessary to understand the interactive effects of changing climate and land use on soil carbon stocks. However, the methodology is technically problematic. A major difficulty is that R_{SOM} needs to be measured in intact ecosystems, in the presence of roots, because of the potential influence of the roots and rhizosphere and of the soil structure on R_{SOM}. Although variations in R_S, and to a lesser extent R_R and R_{SOM}, have often been correlated with changes in soil temperature and water content, some studies suggest that different drivers regulate R_{SOM} and R_R.

We studied the effects of irrigation and addition of nitrogen fertiliser on R_{SOM}, R_R and R_S in a pure C3 grassland. We used a natural abundance stable carbon isotope approach to partition R_S into its components R_R and R_{SOM}.

Neither R_S nor its components were affected significantly by addition of nitrogen fertiliser, but R_R and R_S were higher for the irrigated treatment than for the non-irrigated treatment (P = 0.02 and 0.01 for R_R and R_S, respectively). SOM-derived respiration was not different between the irrigated and the non-irrigated treatments (P = 0.17). Soil respiration was correlated with R_R (R^2 > 0.6), but not with R_{SOM}. We conclude that differences in R_S were regulated dominantly by changes in R_R. In contrast with the responses of R_S and R_R, variations in R_{SOM} were not correlated with soil temperature and water content. We attribute some of the variation in R_{SOM} to soil characteristics, principally total carbon and nitrogen and hot water extractable carbon.

Our findings contrast with the general consensus that variations in R_{SOM} are correlated with soil temperature and water content. We attribute this to the techniques used in many studies that involve significant disturbance. We argue that, in this grassland ecosystem, soil structure and physical protection are the main influences that regulate SOM decomposition, with environmental factors less important.

O 2.4.02

From the dead plant to the aggregate - organic matter transfer at micro-scale litter-soil interfaces

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1. Introduction

The complexity of soils extends from the ecosystem-scale to individual micro-aggregates, where nano-scale interactions between microbiota, organic matter (OM) and mineral particles are thought to control the long-term fate of soil carbon and nitrogen. It is known that such biogeochemical processes show disproportionally high reaction rates within nano- to micro-meter sized isolated zones ('hot spots') in comparison to surrounding areas. However, the majority of soil research is conducted on large bulk (> 1 g) samples, which are often significantly altered prior to analysis and destructively analysed. Thus it has previously been impossible to study elemental flows (e.g. C and N) between plants, microbes and soil in complex environments at the necessary spatial resolution within an intact soil system. By using nano-scale secondary ion mass spectrometry (NanoSIMS) in concert with other imaging techniques (e.g. scanning electron microscopy (SEM)), classic analytical analyses (isotopic and elemental analysis) and biochemical methods (NMR spectroscopy, GC-MS) it is possible to exhibit a more complete picture of soil processes at the micro-scale.

2. Objectives

Our main aim was to study how OM from decaying plant materials is incorporated in the surrounding bulk soil. For the present study we had two main hypotheses. First, fresh OM gets directly incorporated into soil micro-aggregates and in parallel new organo-mineral associations are formed. And second, saprotrophic fungi play an important role as vectors for OM from the decaying plant material into the mineral soil.

3. Materials & methods

We incubated above- and belowground litter for 84 days in small containers (diameter of 10 mm) filled with an artificial soil mixture which contained mainly quartz derived sand and silt and additionally Goethite and Illite in the clay fraction. We incubated leaves/needles and roots of European beech and Norway spruce. The samples were incubated in field moist organic layer material derived from a beech and spruce forest, respectively. In parallel the litter decay was analysed using litter bags. For in-situ analyses the samples were chemically fixed, embedded in epoxy resin and sections analysed using SEM and NanoSIMS. The litter decay was analysed after 14, 28, 42 and 84 days by ^{13}C-CPMAS-NMR and cutin and suberin biomarkers were analysed by GC-MS after saponification of the plant materials.

4. Results and conclusions

Both NMR and GC-MS data revealed a clear decay of both, above- and belowground litter. Especially the ratio between alkyl C and O/N-alkyl C increased in all incubated litter materials, indicating a clear alteration of the incubated plant material. Although the plant structures showed no visible evidence of decay after 14 days of incubation under the reflectance light microscope, by using NanoSIMS we were able to show fresh OM patches at mineral interfaces surrounding the incubated plant materials. After 42 days of incubation the whole artificial soil matrix was penetrated by fungal hyphae which were growing from the infested plant cells into the surrounding soil matrix. At the same time there was a tremendous increase in OM within soil micro-aggregates but also at larger mineral surfaces, indicating the new formation of organo-mineral associations. The incorporation of fresh OM extended over millimetres into the surrounding soil material, mediated by the growing fungal hyphae. Thus in a carbon free soil material we were able to show the direct incorporation of fresh OM into soil micro-aggregates within a very short period of time and also proved fungi as an important OM vector from dead plant material into the mineral soil. This work shows that litter surfaces are not just hot spots for microbial activity but also for the new formation of organo-mineral associations and organic rich micro-aggregates.

O 2.4.04

Linking enzymes stoichiometry to resource and microbial biomass stoichiometry along the litter-soil continuum: a case study from leaf litter decomposition of bioenergy crops

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Leaf litter degradation is a very interesting case study for examining litter stoichiometric control over microbial-mediated C,N and P cycling processes in the litter-soil continuum. Few studies have examined how microbial communities on decomposing leaf litter of bioenergy crops change in relation to litter stoichiometry (C:nutrient ratios) and how the stoichiometry of underlying soil (i.e. stoichiometry of soil, microbial biomass and enzymes) respond to changes in leaf litter input. We hypothesized that leaf litter C:nutrients ratios of different bioenergy crops may cause changes in microbial biomass and enzymes stoichiometry, thus leading to feedbacks in SOM storage and soil nutrient cycling. We investigated for one perennial herbaceous crop (miscanthus) and three woody SRC crops (black locust, poplar and willow), through an aboveground litter manipulation experiment, two key aspects related to the litter-soil continuum: (1) the temporal effects of leaf litter input and litter exclusion on stoichiometry of soil, microbial biomass, enzymes and extractable nutrients; (2) the role of litter stoichiometry in shaping different stoichiometric responses of litter microbial community during the different stages of leaf litter decomposition. Total and dissolved soil C:N, fungal biomass C, microbial biomass C:N:P, dsDNA, ten enzymatic activities (acid and alkaline phosphatase, phosphodiesterase, pyrophosphate phosphodiesterase, β-glucosidase, cellobiosidase, xilanase, chitinase, leucine aminopepditase and esterase) and extractable nutrients (NO_3, NH_4 and PO_4) were examined both in soil and in litter at 1, 3, 5,7,9,12 months after autumnal litterfall. Therefore, cellulose, hemicellulose and lignin contents were determined in litter samples. Woody leaf litters showed higher *k* decay rates than miscanthus (poplar > black locust > salix > miscanthus). Litter input resulted in an increase with similar ranking among the crops of SOC, dsDNA, MBC, alkaline phosphatase and leucine aminopepditase. Due to the annual litter input, the stoichiometry of soil enzyme, soil, and litter C:N significantly correlated with their correspondent C:P stoichiometry components. In particular, under woody crops we observed significant correlations of C:N and C:P soil enzyme stoichiometry with corresponding leaf litter C:nutrients ratios. As regards to litter decomposition, nonmetric multidimensional scaling showed how litter decomposition rates were explained by litter chemistry (C fractions, C:N and C:P) at initial 5 months after litterfall (68-80% of the variance), and by microbial biomass and enzyme activities at the remaining 7 months (56%). Indeed, during late stages of litter decomposition, the labile woody litters, compared to miscanthus litter, showed higher MB to litter mass and higher mass loss per unit of cumulative enzyme activity. MB stoichiometry did not show significant correlations with enzymes activities across litter types and temporal changes in litter decay. However, microbial communities in the decomposing litters were differently N- and P-limited among litter types. N or P availability seems to alter the trajectory of nutrient (N:P) acquistion. We found a negative relationship between litter C:N and enzyme efficiency in litter decomposition for P acquiring enzymes or between litter C:P and leucine aminopepditase. Among woody litters, our results proved that microbes tend to allocate C and nutrients toward the production of extracellular enzymes to mine for the nutrient that is more limiting. During the conference particular attention will be paid on the implications that these results could have on the understanding of soil C and nutrient cycling processes in bioenergy cropping systems.

O 2.4.05

Effects of protozoan grazing on carbon flow and enzyme activities in rhizosphere and detritusphere

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The differences in complexity and accessibility of plant provided carbon (C) sources for the soil food web result in two major decomposition pathways based on 1) root and shoot litter, and 2) rhizodeposits (especially exudates). The amount and quality of substrates entering the soil mainly controls microbial processes in the rhizosphere and detritusphere. Furthermore, soil fauna has important functions in regulating microbial activity and enzymatic substrate utilization.

A triple-labeling (^{13}C, ^{14}C and ^{15}N) experiment was conducted focusing on the identification of C resources (rhizodeposited C by ^{14}C and root litter by ^{13}C) that fuel microbial-protozoan interactions in two soil hotspots: rhizosphere and detritusphere.

Soil was taken from an arable field planted with maize, autoclaved and re-inoculated with a microbial community extracted from the same soil. The following treatments were established: 1) no addition of plant C, 2) addition of sterilized ^{13}C /^{15}N labeled maize root litter, representing detritusphere 3) $^{14}CO_2$ pulse labeling of growing maize plants, representing rhizosphere.

To determine the effects of faunal grazing on nutrients (by ^{15}N) release each treatment was setup with and without amoeba. Enzyme kinetics was implemented as indicator for microbial activity and ^{13}C flux to the microbial pool was determined by ^{13}C-PLFA analysis. We analyzed ^{14}C, ^{13}C and ^{15}N in the microbial biomass, soil, plant, root and CO_2. Additionally, microbial biomass was assigned by dsDNA extraction.

Between 65-89% of soil released $^{14}CO_2$ was respired by roots and microorganisms in the first 3 h after the $^{14}CO_2$ pulse. First results show an increase of ^{14}C allocation in the soil due to protozoan grazing. Enzyme activities increased in the rhizosphere (maize planted treatment) compared to litter-treated and control soil independent of the presence of protozoa. The dsDNA-derived microbial biomass C decreased by protozoan grazing. Further results on ^{13}C and ^{15}N are going to provide deeper insight following the microbial loop.

Figure 1

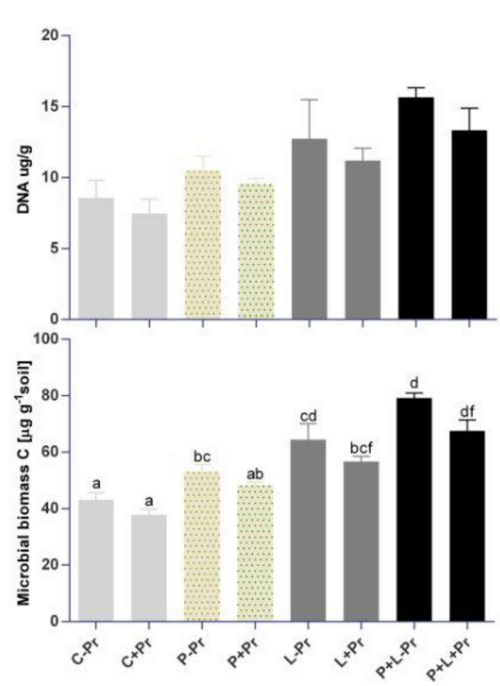
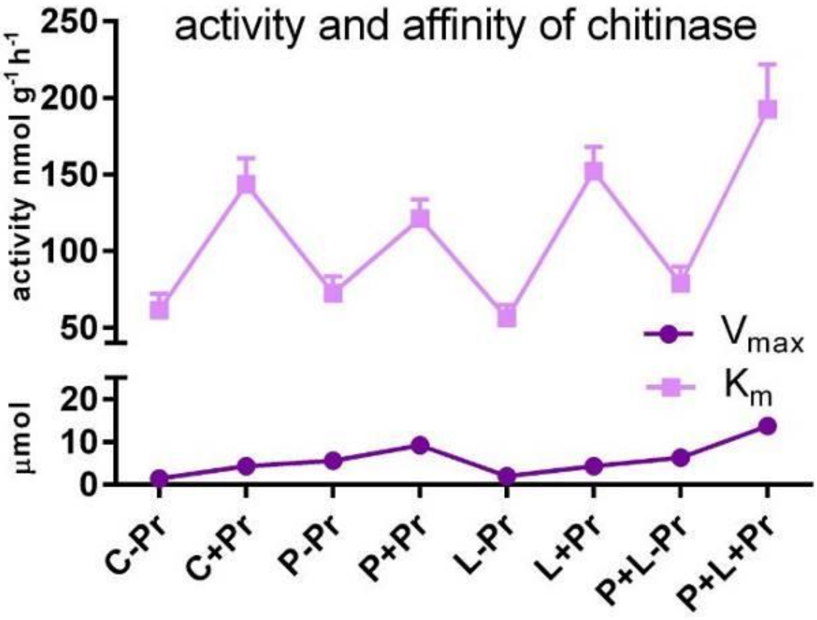


Figure 2



activity and affinity of chitinase
activity nmol g-1 h-1
250
200
150
100
50
µmol
20
10
0
Vmax
Km
C-Pr
C+Pr
P-Pr
P+Pr
L-Pr
L+Pr
P+L-Pr
P+L+Pr

O 2.4.06

Spatial Isolation of Soil Organic Carbon in Different Soil Pore Size Domains

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The protection of organic carbon in soils is in part, a combination of physical occlusion within isolated pores and separation from decomposing microbes. Pore network connectivity controls microbial access to deposits of soil C. As soil water content varies, and pore networks become increasingly saturated, isolated soluble compounds may diffuse to locations accessible to microorganisms. Therefore, the quality of the SOC in pore waters held with different tensions is a key characteristic needed to differentiate physical and chemical SOC protection mechanisms. This protected carbon may contribute to net greenhouse gas fluxes if it is microbially decomposable.

We studied intact soil cores collected from the Disney Wilderness Preserve, FL. These soils are dominated by sandy textures, and depending local topographic position, show moderate to high levels of SOM accumulation at the surface. Samples of soil pore water held at two different water tensions (15, 500 mb) were collected from three continuous-depth soil cores (0-30, 30-60, and 60-90 cm), from three transect locations (dry, intermittently wet, and wet). We used Fourier Transform-Ion Cyclotron Resonance Mass Spectrometry (FTICR-MS) to develop highly resolved profiles of the C compounds in each pore-size fraction. The more tightly held pore waters (500 mb) had significantly more condensed hydrocarbons and tannins compared to the loosely held water (15 mb), which had more lipids. These differences were consistent for all transect positions and soil depths. These pore waters were then used as growth substrates for cultivation of selected bacteria (*Streptomyces cellulosae*, *Cellvibrio japonicus*) and fungi (*Trichoderma reesei*), and then the growth media again analyzed by FTICR-MS to allow us to make inferences about key metabolic transformations in each pore size. For all organisms, significantly more CO_2 was respired from the higher-tension pore waters with the more complex C compounds. However, closer inspection of the carbon profiles suggests that there are more diverse metabolic transformations in the macropore samples. Although fine pore associated-C may be more chemically complex than C in larger pores, these C compounds are highly decomposable; the C in coarser pores may be more rapidly metabolizable, and therefore may quickly form stable biological intermediates. By resolving the balance between these chemical reactions and transport processes, we may better understand the nature of “protected” carbon in soils.

P 2.4.01

Evaluation of Soil Organic Carbon Content and Humification Degree in Coffee Crop Area Under Cover Crops and Weed Control Methods

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Soil organic matter (SOM) plays an important role in determining soil quality and contributes to crop productivity, acting as a microbial energy source, promoting biological diversity. Total soil organic carbon (SOC) and humification degree are considered of crucial importance to evaluate soil quality, and qualitative and quantitative changes related to different soil management systems. Laser-Induced Fluorescence Spectroscopy (LIFS) is a rapid, non-destructive, sensible and selective technique with good applicability for SOM characterization by assessing humification degree (HFIL) in bulk soil samples. This study assessed the effects of long-term weed control and cover crops between coffee tree rows on SOM quality in a very clayey (80 dag kg-1 of clay) Typic Haplorthox (Dystroferric Red Latosol) from the State of Paraná, southern Brazil. Seven weed control and cover crop treatments were assessed: (i) hand weeding - HAWE; (ii) portable mechanical mower - PMOW; (iii) pre + post-emergence herbicides - HERB; (iv) horse peanut cover crop (Arachis hypogeae) - GMAY; (v) dwarf mucuna cover crop (Mucuna deeringiana) - GMMA; (vi) no-weed control between coffee row - SCAP; and (vii) no weed control check - CONT. Coffee trees were pruned and he pruning residues were mowed and left on the soil surface to allow biological incorporation. Soil samples were collected in March, 2014, at the center of the inter-rows between coffee trees at four depths: 0-10 cm, 10-20 cm, 20-30 cm, and 30-40 cm. SOM quality assessment included total soil organic carbon (SOC) content and organic matter Humification degree (HFIL) measured using Laser-Induced Fluorescence Spectroscopy (LIFS). C content was up to 26% higher for SCAP and CONT samples compared to the other treatments, indicating the influence of plant material accumulation in the top 10cm of soil. Higher HFIL (up to 47% higher) in deeper soil layers, indicates the presence of less humified/labile structures in the top 10 cm of soil, and condensed/recalcitrant organic matter structures at depth, regardless of cover crop and weed control method used. We observed a highest negative impact on weed growth in the GMMA cover crop treatment (decrease of 90.8% in weed density). This result may be attributable to the chemical composition of the species, suggesting the occurrence of an allelopathic phenomenon. Nevertheless, considering that the study is taking place at a long-term agricultural research experiment, and given the SOM dynamic nature, continuous monitoring is advisable.

P 2.4.02

Sensitivity of soil organic matter in anthropogenically disturbed organic soils

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Drained peatlands are hotspots of carbon dioxide (CO_2) emissions from agriculture. However, the variability of CO_2 emissions increases with disturbance, and little is known on the soil properties causing differences between seemingly similar sites. Furthermore the driving factors for carbon cycling are well studied for both genuine peat and mineral soil, but there is a lack of information concerning soils at the boundary between organic and mineral soils. Examples for such soils are both soils naturally relatively high in soil organic matter (SOM) such as Humic Gleysols and former peat soils with a relative low SOM content due to intensive mineralization or mixing with underlying or applied mineral soil.

The study aims to identify drivers for the sensitivity of soil organic matter and therefore for respiration rates of anthropogenically disturbed organic soils, especially those near the boundary to mineral soils. Furthermore, we would like to answer the question whether there are any critical thresholds of soil organic carbon (SOC) concentrations beyond which the carbon-specific respiration rates change.

The German agricultural soil inventory samples all agricultural soils in Germany in an 8x8 km² grid following standardized protocols. From this data and sample base, we selected 120 different soil samples from more than 80 sites. As reference sites, six anthropogenically undisturbed peatlands were sampled as well. We chose samples from the soil inventory a) 7.2 % SOC and b) representing the whole range of basic soil properties: SOC (7.2 to 56 %), total nitrogen (0.2 to 1 %), C-N-ratio (10 to 80 %) bulk density (0.06 to 1.14 g/cm³), pH (2.5 to 7.4), sand (0 to 95 %) and clay (2 to 70 %) content (only determined for samples with less than 19 % SOC) as well as the botanical origin of the peat (if determinable). Additionally, iron oxides will be determined for all samples. All samples were sieved (2 mm) and incubated at standardized water content and in three replicates using the Heinemeyer device (Heinemeyer, 1989) CO_2 production is measured for basal respiration and substrate induced respiration (SIR) with glucose addition.

P 2.4.03

Effect of ^{15}N loadings on soil carbon dynamics along soil profile in moist acidic tundra during 2 years of exposure to repeated freeze-thaw cycles

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Introduction In oligotrophic environments such as Arctic tundra and boreal forest understories, nitrogen (N) availability is one of the most important limiting factors associated with soil carbon (C) dynamics. Particularly, an increase in N can facilitate soil C sequestration due not only to enhancing litter input through plant growth but also to reducing fungal growth and microbial enzyme activities involved in recalcitrant soil C. As the effect of N inputs on soil C storage varies depending on vegetation and soil types, soil C quality and the extent of N limitation, it is still controversial whether the effect of N inputs is negative, positive or neutral to soil C sequestration. Considering the increase in N deposition due to anthropogenic activities and a considerable amount of deeper soil C stocks in Arctic tundra understories, it is practically important to understand and quantify the time-course effect of repeated permafrost thaw in response to N inputs on deeper soil C stocks and dynamics.

Objectives We hypothesized that repeated freeze-thaw patterns would determine soil moisture conditions and the depth of permafrost table and cause a difference in vertical transport of N inputs from the surface to the permafrost table in tundra soils, thus affecting extensively soil C pools and dynamics. Therefore, we tested this hypothesis and interpreted the time-course effect of N loadings to moist acidic tundra in Alaska on temporal and spatial changes in soil C pools and dynamics under repeated freeze-thaw cycles by interpreting the results obtained from the *in situ* soil retrieval core incubation and by calculating the portion of the N derived from loadings in each soil C pool by ^{15}N-isotope dilution.

Materials & Methods The study site was located in a tundra region, Alaska (64° 51′ N, 163° 42′ W), where soil pH was 4.5 and sphagnum moss, tussock, and shrub such as blueberry were dominant. To investigate C dynamics along a soil profile in response to N inputs, we installed 2 sets of retrievable stainless cores (7.2 cm in diameter and 45 cm deep) at spatially different three locations in July 2010 and immediately applied ^{15}N-urea (5 atom %) at a rate of 330.8 g N m^{-2} $year^{-1}$ to each core. After a year from the first N application, one set of soil core samples (T1) were retrieved and the other set (T2) received the second N application in July 2011. The remaining set (T2) was retrieved after a year from its second application (July 2012). Each soil core sample was dissected in 5cm intervals, and each dissected soil sample was analyzed for total C, total N, inorganic N (NH_4^+-N and NO_3^--N) and dissolved organic C, and the corresponding ^{15}N atom % of total N and inorganic N was assessed by ^{15}N-isotope dilution. The activity of phenol oxidase, a representative enzyme involved in the degradation of recalcitrant C stocks and phenolic compounds, was determined.

Results The recovery of applied ^{15}N in the entire soil profile was 86.0±2.9 % for T1 and 67.8±0.4 % for T2 set, and decreased gradually with soil depth. Most of ^{15}N recovered in the soil profiles was distributed in the upper half (25 cm) of the soil profile, and the magnitude was greater for T2 (83.4±4.0 %) than for T1 (75.7±0.6 %). Most of the N inputs to the surface of the retrieval soil cores remained as NH_4^+-N forms within the upper half of the profile, indicating that N transport and nitrification were negligible below 25 cm for at least 2 years in these moist acidic tundra soils. While the total amount of soil C was not affected by N inputs, dissolved organic C (DOC) increased, thus resulting in a positive correlation with total N (r=0.749, *p*p254 (specific ultraviolet absorbance at 254 nm) of DOC (an indirect indicator for aromaticity in response to N inputs). In contrast to previous studies, the activity of phenol oxidase was enhanced by N inputs and also positively correlated with total N (r=0.910, *p*

Conclusion Our results showed that most of the N inputs (^{15}N-urea) to the surface of the retrieval soil cores remained as NH_4^+-N forms within the upper half (25 cm) of the profile, indicating that N transport and nitrification were negligible below 25 cm for at least 2 years in these moist acidic tundra soils. During experiment, while DOC and its aromaticity, and phenolic compounds were affected by N addition, the total amount of soil C stocks was not. In addition, we found that the activity of phenol oxidase was positively affected by N inputs.

P 2.4.04

Effect of soil particle size on CH_4 production and methanogenic archaeal community structure along a rice chronosequence

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Question: How abundance and composition of methanogenic community, a typically major archaeal group in rice soil, exert changes in soil aggregates of size classes and across soils with different duration of rice cultivation?

Methods: Undisturbed bulk soils were fractioned by low energy ultra-sonication dispersion and centrifugation into four classes of particle size fractions (coarse sand, fine sand, silt and clay). The archaeal communities from each of the four fractions were analyzed by quantitative PCR for their abundance and by denaturing gradient gel electrophoresis (DGGE) their diversity for their diversity.

Results: Among the size fractions in a single soil, high abundance of archaea and methanogens were found in both coarse sand and clay sized fractions. Coarse sand and clay sized fractions but not fine sand and silt sized fractions were subject of profound changes related to gene abundance and community diversity during prolonged rice cultivation.

Conclusions: Our results showed that archaea and methanogens were heterogeneously distributed among the PSFs, and high abundance were found in coarse sand and clay sized fractions. However, high CH4 production potential were found to be mainly in >2µm sized fractions. Archaeal and methanogenic abundance significantly increased in a single particle size fraction during the 100 years rice cultivation, especially in coarse sand and clay fractions.

P 2.4.05

Variations of Soil Organic Matter along the Upland Meadow in Wugong Mountain

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Question:

Grassland is one of the largest terrestrial ecosystem area,Wugong Mountain upland meadow have irreplaceable ecological functions value of Jiangxi province. But since Wugong Mountain in 2008 held once a year international tent stanza, numerous "tour pal" camp on the mountain meadow vegetation, devastating damage to the mountain meadow, tourist stampede bare surface has been washed into the gully erosion, serious damage to the mountain meadow retired into severe erosion to bare rock. Therefore, the restoration of Wugong Mountain degraded upland meadow ecosystem vegetation has been crunch time. In this study, through the study on soil organic matter and nutrient correlation between different levels of disturbance characteristics of meadow, organic carbon and nutrient and environmental revealed Wugong Mountain mountain meadow soil degradation process, and provide a scientific basis for the meadow ecosystem restoration.

Methods:

1. Experiments and methods

Soil organic matter by using external heating method; soil nitrogen by alkaline solution Determination of diffusion method; total phosphorus and total potassium sodium hydroxide molten - molybdenum resistance colorimetric method.

2. Data analysis methods

The data processing of Excel, correlation analysis was carried out using SPSS17.0.Table 1 The type and treatment establishment of different fertilizations in experimental forest

Results and Conclusions:

1.Different elevation gradient, surface soil organic matter content were higher than the lower soil organic matter content; the content of soil organic matter under different disturbance degree showed no significant trend changes, this is mainly because the organic matter content is related not only with the other soil nutrients content, is also related to soil temperature and human disturbance, water and other environmental factors.

2.The content of soil organic matter and soil nitrogen showed a significant positive correlation($P<0.01$), B shown that soil organic matter content and total phosphorus showed no correlation; soil organic matter and soil total potassium slightly negative correlation ($R^2=0.076$). The soil organic carbon and physicochemical properties of the regression analysis to linear regression equation: y =64.346+0.138x 1-0.514x2 - 0.445x3, where y is the soil organic matter, x 1, x 2, x 3 respectively, soil available nitrogen, total phosphorus, total potassium. In summary, effects on the nitrogen changes of organic matter in the maximum.

Acknowledgement：

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P 2.4.06

Assessment of Humic Substances quality in agricultural soils contaminated with PAH compounds

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The amount, type, and location of soil organic matter (SOM) may be one of the best integrating indicators of many physical, chemical and biological processes in soil. The active fractions of organic matter - humic substances (HS), may respond quickly to tillage and to environmental changes. Therefore, HS have been recognized as an important determinant of soil productivity in the aspect of SOM quality assessment. SOM quality represents one of the most important soil characteristics, creates the conditions for its proper functioning and is most often assessed by the HS fractions content (humic acids - HA, fulvic acids - FA, humins - Hy). Presently, different laboratory methods have been developed aiming to improve the extraction and separation of HS without disturbing their properties. One of them, is new ISO 12782-4 method based on the different solubility of HS fractions at different pH solution.

The aim of the study was to determine the soil quality by establishing the degree of SOM humification, in soils contaminated with polycyclic aromatic hydrocarbons (PAHs). The three stepwise ISO 12782-4 method was applied for evaluation of the different HS fractions. Fractions of FAs and HAs were distinguished by their dispersion and solubilization abilities, properties and average molecular weight.

Six soil materials were collected from the upper layer (0-30 cm) of agricultural land with different level of pollution and soil organic matter content. Determinations of pollutants comprised 16 US EPA priority PAH compounds by GC-MS technique. The SOM was characterized by total organic carbon content - TOC (Tiurin's method) and humic substances (HA and FA fractions). The soils exhibited high differences in the TOC content (36.5-102.3 $g \cdot kg^{-1}$), while the concentrations of humic substances (sum of C-HA+C-FA fractions) were less diversified (15.62-41.52 $g \cdot kg^{-1}$) with predominant contribution of C-HA (14.28-65.21%) in the total organic carbon pull. The ratio between concentrations of humic and fulvic acids (C-HA/C-FA) was in the range of 14.2- 25.6) and indicated on the potential mobility of C in the soil system and the relatively high degree of humification. The total PAHs concentration varied from 0.21-38.50 $mg \cdot kg^{-1}$ and was significantly correlated with the TOC content (r=0.81, p=0.001). This imply, that some soil fractions of HS deriving from natural origin play significant role in retention PAHs affecting the quality of the soil.

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P 2.4.07

Interactions between the chemical quality of crop residues and their location in the Soil: how nitrogen availability controls mineralization of C and N?

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Background and Objectives

Nitrogen (N) availability can control the kinetics of decomposition of plant residues and the net mineralization of N in soils, due to the high microbial N requirements during decomposition (e.g., Recous et al., 1995). In field conditions, overall N availability for decomposers depend on the soil mineral N content, the amount and type of plant residue, and particularly their tissue N content (i.e. C:N ratio) and the location of plant residues (incorporated or at the soil surface, as in no-tilled systems). Indeed initial residues N content can be a good predictor of the net N mineralization during decomposition. However, the studies in field experiments or laboratory incubations aimed at varying the availability of N during decomposition (either by adding N to soil, or by varying type of plant residues) showed inconsistent effects on decomposition. Therefore, the aim of our study was to investigate for a range of crop residues, the effect of the availability of N and location on the C and N mineralization. The availability of N was manipulated by varying the initial quality of the residues, the residues placement, and the supply of mineral N to the soil.

Materials and Methods

The shoots of ten species of plants were collected at flowering and harvest for cover crops and main crops species, respectively, and characterized chemically. The residues were dried at 40°C and leaves and stems were cut into pieces of 1 cm length. Mixture of leaves and stems were prepared with a ratio leaf:stem similar to the ratio in dry biomass observed in field. The soil used was a Typic Hapludalf collected from the 0-10-cm layer. Two initial soil mineral N concentrations were used, i.e. 9 mg N kg^{-1} dry soil (low N availability; 9N) and 77 mg N kg^{-1} dry soil (high N availability; 77N), obtained by adding KNO_3-N prior to incubation. The residues added at a rate of 0.6 g dry matter (DM) per pot (equivalent to a basis of 5.0 g DM kg^{-1} dry soil) were applied either on the surface (S) of soil samples or incorporated into the soil (I). C mineralization was assessed by quantifying continuous CO_2 release using NaOH trapping, at 2, 4, 7, 10, 14, 21, 28, 35, 50, 70, 90 and 120 days after start of incubation. The soil mineral N content was measured destructively, at day 0 and at 7, 14, 21, 35, 63, 90 and 120 days of incubation.

Results and Discussion

The type of residues did modify significantly the kinetics and rates of C and N mineralization in soil (not shown) as expected, and strongly interacted with soil mineral N availability and localization. For example, the residue of wheat showed +6% (S) and +8% (I) C-CO_2 evolved with high soil mineral N (77N) compared to low soil mineral N (9N). For rape residues there was no significant difference in C-CO_2 evolved whatever the soil N treatment and the residue location. This indicates that the increase of soil mineral N for high C:N wheat residues removed a N limitation of decomposition while the initial availability of N was sufficient for rapeseed residue for its optimal decomposition. Regarding soil N dynamics, we observed with wheat that net immobilization of soil N was all the more important that the availability of N increased, with the following ranking: I-77N> I-9N> S-77N> S-9N. For oilseed rape residues, it is noticeable how N mineralization was strongly influenced by residue location: residues decomposing at the soil surface induced net mineralization of N compared to incorporated residues. The amount of mineral N in soil (9N or 77N) also influenced the net N mineralization. These results suggest that microorganisms had more efficient use of N (immobilized N by gram of decomposed C) and/or lower N requirements when residues were left on the surface due to shift in microbial populations with surface decomposition.

Conclusion

The results indicate that the effects of soil-N and residue-N availability on C and N mineralization are strongly dependent of the location and type of residue in the soil. The availability of N affects both the rate of decomposition of high C:N residues and the N immobilization ratio (N assimilated per unit of C decomposed).

Recous, S., Robin, D., Darwis, D., Mary, B., 1995. Soil inorganic N availability: effect on maize residue decomposition. Soil Biology and Biochemistry 27:1529-1538.

Acknowledgements

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P 2.4.08

Litter alkalinization during gut passage contributes to the macrofauna-mediated slowing of litter decomposition: a long-term manipulation experiment with leaf litter and Bibio marci excrements

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1. Introduction

Most of the terrestrial net primary production enters the soil decomposer system as dead organic matter. Among soil organisms affecting litter decomposition, research has more often focused on microorganisms than on fauna because the assimilation efficiency of soil fauna is generally low and consequently, most ingested organic matter is only transformed from litter into excrements. Fauna excrements, however, differ substantially from the original litter, and these differences greatly affect microbial activity and decomposition. During faunal feeding or soon after excrements are produced, microbial activity is increased, and the decomposition rate is greater for the new excrements than for the original litter. As soil faunal excrements age, however, the decomposition rate decreases and becomes lower than that of the original litter. Factors causing the increase of microbial activity in new faunal excrements have often been studied mechanisms causing a reduction of microbial activity in older excrement have been less studied. This is despite the fact that soil macrofauna such as millipedes, isopods, and insect larvae can consume 20 to 100% of annual litter fall in many ecosystems and especially in temperate, broadleaf forests. The accumulation of litter-feeding macrofauna excrements may form a distinct layer in many forest soils.

2. Objectives

The aim of this contribution is to explore mechanisms that may reduce the rate of microbial decomposition in older excrements of litter-feeding macroarthropods.

3. Materials and methods

To understand why excrements of soil macrofauna often decompose more slowly than leaf litter, we fed *Bibio marci* larvae the litter of tree species differing in litter quality (*Alnus glutinosa*, *Salix caprea*, and *Quercus robur*) and then measured respiration induced by litter and excrements. We also measured respiration induced by the same litter artificially modified to mimic faunal effects; the litter was modified by grinding, grinding with alkalinization to pH=11, grinding with coating by kaolinite, and grinding with both alkalinization and coating.

4. Results

Decomposition of excrements tended to be slower for willow and was significantly slower for oak and alder than for the corresponding litter. With oak, decomposition was slower for all artificially modified litter than for non-modified litter. The reduction in the decomposition was similar for excrements and for alder and willow litter that was ground, coated, and alkalinized and for alder litter that was ground and alkalinized. ^{13}C NMR indicated that gut passage increases aliphatic components and decreases polysaccharides. Pyrolysis indicated that gut passage increases the ratio of guaiacyl to hydroxymethyl derivatives in lignin. Our findings indicate that the decreased decomposition rate of excrements might result from the removal of easily available polysaccharides, the increase in aliphatic components, an increase in the resistant components of lignin, the accumulation of microbial cell walls, and the binding of nitrogen into complexes with aromatic components. Several of these mechanisms are supported or determined by liter alkalinization during gut passage.

5. Conclusion

In conclusion, our results suggest that short-term alkalinization, litter fragmentation, and the action of digestive enzymes explain the lower rate of decomposition in excrements than in the original litter. More specifically, they cause depletion of polysaccharides, condensation of polyphenols, and binding of N. These changes result in a decrease in the C:N ratio and an increase in aliphatic components, which correspond with the reduced rate of decomposition for excrements.

P 2.4.09

Organic matter distribution in soil fragments from different cropping systems: an approach combining experimental and modelling tools

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Soil respiration is very heterogeneous at scales from the landscape to the aggregate/pore scale, but geostatistical studies suggest that much of the spatial variability is due to processes that occur atmicroscales.Microbial communities live in the soil pore network and therefore the access they have to organic substrate, oxygen and water is likely to depend ontheirlocationwithin thisnetwork as well asonthedistributionof organic carbon.Although the relationship between microorganisms and the soil pore network hasbeenstudied, to our knowledge, the relationship between pore space architecture and organic matter in hasnot. This isprobably due to the technical difficulties associated with such measurements.

The aims of the study therefore, are to identify possible correlations between pore network properties and organic carbon properties at the microscale and to map soil carbon distribution in the pore space topology. This will be achieved by relating pore architecture to organic carbon of soil fragments extracted from soils under different cropping systems (Conventional, Organic and No-tilled), which therefore have different soil structures and organic matter qualities and quantities. The descriptors of pore geometry and connectivity (interconnectedness of the space, distribution of throats diameters, clustering coefficients) will be determined by computer aided X-ray tomography (CAT), and the organic carbon quantity and composition will be measured by elemental analysis and infrared spectroscopy.

P 2.4.10

Microbial hotspots and hot moments in soil: Consequences for SOM turnover and stabilization

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Soils are the most heterogeneous parts of the biosphere, with an extremely high differentiation of properties and processes from nano- to macroscales. The spatial and temporal heterogeneity of input of labile organics by plants and animals creates microbial hotspots over short periods of time - the hot moments. We define microbial hotspots as small soil volumes with much faster process rates and much more intensive interactions compared to the average soil conditions. Such hotspots are found in the rhizosphere, detritusphere, biopores (including drilosphere) and on aggregate surfaces. Hot moments are short-term events or sequences of events inducing accelerated process rates as compared to the average rates. Thus, *hotspots and hot moments are defined by dynamic characteristics, i.e. by process rates*.

We present an overview on the localization and size of hotspots, spatial distribution, fluxes of labile C through the hotspots, lifetime and process intensities, with a special focus on process rates, microbial activities, and consequences for soil organic matter (SOM) turnover and stabilization. The fraction of active microorganisms in hotspots is 2-20 times higher than in the bulk soil. As a consequence, the intensities of microbial functioning (i.e. respiration, growth, mineralization potential, enzyme activities, RNA/DNA ratio) are up to 50 times greater in the hotspots versus bulk soil. The duration of hot moments in the rhizosphere is controlled by the length of the input of labile organics and last a few hours up to a few days. In the detritusphere, however, the duration of hot moments is regulated by the output - by decomposition rates of litter - and lasts for weeks and months. Hot moments induce succession in microbial communities and intense intra- and interspecific competition affecting C use efficiency, microbial growth and turnover. The faster turnover and lower C use efficiency in hotspots counterbalances the high C inputs, leading to the absence of strong increases in C stocks. Consequently, the *intensification of fluxes in hotspots is much stronger than the increase of pools*. Therefore, the high input of labile C into the hotpots does not proportionally increase the C content and sequestration. Moreover, maintenance of stoichiometric ratios by accelerated microbial growth in hotspots requires additional nutrients (e.g. N and P), causing their microbial mining from soil organic matter, i.e. priming effects. So, accelerated microbial growth and turnover in hotspots trigger faster turnover of SOM. Accordingly, *priming effects are localized in microbial hotspots and are consequences of hot moments, resulting in destabilization of SOM*. Our rough estimation of the hotspot contribution to microbial and biochemical processes suggested that the hotspots are mainly responsible for the ecologically relevant processes in soil.

P 2.4.11

A simple model to predict water fluxes at hydrological hotspots

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Introduction

Biogeochemical Hotspots are patches exhibiting disproportionately higher reaction rates than their surroundings (McClain et al. 2003). Redistribution of water by forest canopies creates a highly heterogeneous pattern of water input to the soil leading to the establishment of such hotspots at dripping points or stem areas that receive much larger amounts of water than bulk precipitation.

These hotspots are prone to preferential flow and likely to facilitate rapid vertical transport of dissolved and particulate substances. This might have significant consequences on SOM transport or its leaching from the soil deeper into the Critical Zone.

However, the actual relation between canopy redistribution processes and vertical transport of SOM is difficult to investigate in the field, and therefore little is known about it. Also preferential flow phenomena are usually neglected in soil carbon models, which makes them so far unfit tools to study these processes.

Methods

Here, we show a simple one-dimensional hydrological model that predicts preferential water fluxes based on Stokes-Flow. We tested and calibrated the model using precipitation, soil moisture and seepage data from sprinkling experiments using grassland mesocosms in climate chambers. While preferential flow may be more pronounced in forest soils than in our mesocosms, we expect the qualitative response of soil moisture to strong precipitation events to be similar, allowing us to apply the model to both systems.

Results

Despite its simplicity the model is able to predict water fluxes during and after strong precipitation events. We were also able to derive parameter values for different precipitation amounts and initial soil moisture contents.

Conclustions

The model will help to investigate the influence of canopy distribution on element fluxes by applying it to spatially distributed throughfall, stemflow and soil moisture measurements gathered at a natural deciduous forest site. We also intend to add our model as a preferential flow module to the COMISSION model.

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P 2.4.12

Soil organic carbon stock losses from tropical deforestation hinge on the spatially variability of the initial forest carbon stocks

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Introduction: Land-use change in the humid tropics is recognized as one of the major contributors to anthropogenic greenhouse gas emissions. The growing global demand for wood, biofuel products, (i.e. oil palm), rubber and chocolate, has caused significant deforestation across many regions of the humid tropics. In contrast to aboveground carbon stocks, comparatively little is known on the magnitude of soil organic carbon (SOC) stock changes following land-use conversion in the tropics.

Objectives: The objectives of this study were to quantify the magnitude of SOC stock changes and to understand the processes that regulate both SOC stocks and its changes following land-use conversion.

Materials and methods: Using a space-for-time substitution sampling approach, we quantified the SOC stock changes in oil palm, rubber and cacao-agroforestry plantations established on heavily weathered soils in three countries spanning the tropics: Indonesia, Cameroon and Peru. We quantified SOC stock changes by comparing undisturbed forests with adjacent plantations. In total we set up 86 plots and sampled to three meters depth. The biophysical conditions of our plots were representative of 45% of the humid tropics.

Results: This study showed that the establishment of tree plantations can decrease SOC stocks by up to 50%. The key variable that predicted SOC changes across the three plantation types was the amount of SOC present in the forest prior to conversion. This means that the higher the initial SOC stock, the higher the corresponding SOC loss when converted. The soil clay fraction played a secondary role, insofar that soils with high clay contents were less susceptible to SOC losses. Although SOC decreases were most pronounced in the topsoil, older plantations showed considerable SOC losses below 1-m depth, suggesting that a new SOC equilibrium takes decades to reach at deeper depths.

Conclusions: We recommend the default values used by the Intergovernmental Panel on Climate Change (IPCC) Tier 1 Method be adjusted to recognize the impact cash-crop plantations have on SOC stocks. Currently, the IPCC use an SOC change factor of 1 (meaning no SOC loss) for this conversion because of scarcity of SOC data. Furthermore, land-use management policies should aim to protect natural forests on carbon-rich mineral soils so as to minimize future SOC losses.

IT 2.5

Electron transfer to and from dissolved and particulate organic matter: from electrochemical interrogation to redox dynamics in peatlands

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Introduction

In many temporarily anoxic systems, electron transfer to and from dissolved and particulate organic matter (DOM and POM) plays a fundamental role in the biogeochemical cycling of carbon, nutrients, and trace elements as well as in the dynamics of pollutants. As a consequence, considerable research efforts have been directed towards characterizing the redox properties and reactivities of OM. For a long time, however, advances were challenged by methodological limitations: traditional approaches commonly relied on adding bulk chemical oxidants to the OM samples, followed by monitoring electron transfer from the OM to the oxidant. While providing some insights, these approaches were indirect and one directional (i.e., the OM redox state was inferred solely from the reduction of an added oxidant), susceptible to kinetic artifacts, and provided only limited information on OM redox thermodynamics.

Objectives

This contribution has *two major objectives*. The first, methodological objective is to introduce mediated electrochemical analysis, a novel approach to directly determine the redox properties and reactivities of OM samples. The unique capabilities of this approach will be highlighted by a systematic analysis of the redox properties of a diverse set of OM samples and by linking these properties to OM structural features. The second, process-oriented objective is to determine the thermodynamics and reversibility of electron transfer to and from OM over consecutive microbial reduction and O_2 re-oxidation cycles. Understanding this process is fundamental to assessing the capacity of OM to act as a terminal electron acceptor in anaerobic microbial respiration and, thereby, to competitively suppress methanogenesis in temporarily anoxic systems.

Materials & methods

The capacities to accept and donate electrons of OM samples and the reduction potentials of reducible moieties in selected OM samples were determined by mediated amperometric and potentiometric measurements. These measurements rely on the use of dissolved redox mediators to facilitate redox equilibration between the OM and the working electrodes in electrochemical cells. OM samples included well-characterized DOM reference materials as well as samples from northern peatlands. *Shewanella Oneidensis* MR-1 was used to microbially reduce selected DOM samples.

Results

Related to the first objective, mediated electrochemical analysis was used to systematically determine the capacities of a diverse set of OM samples to accept and donate electrons. The results support quinones and phenols (i.e., mono- and dihydroxylated aromatic structures) as the as major reducible and oxidizable moieties in OM, respectively. The results further provide evidence that long-term processing of OM in oxidative environments leads to a decrease in the phenol contents and an increase in the quinone contents.

Related to the second objective, this contribution will demonstrate fully reversible electron transfer to and from four selected DOMs over three successive cycles of microbial reduction and O_2 re-oxidation. Mediated potentiometric measurements revealed that the DOMs accepted electrons over wide reduction potential ranges. The four DOMs were microbially reduced to comparable reduction potentials, suggesting that the extents of microbial DOM reduction were controlled by system thermodynamics rather than by the capacities of the DOM samples to accept electrons. These findings strongly support that OM may act as a regenerable terminal electron acceptor in anaerobic microbial respiration in temporarily anoxic systems. Some of the implications of reversible and sustainable electron transfer to and from OM for wetland carbon cycling will be highlighted, including the potential of OM to competitively suppress hydrogenotrophic methanogenesis in these systems. These implications will be supplemented by data on the redox properties of DOM and POM collected from northern peatlands. This data provides evidence that the majority of the reducible moieties are associated with the POM rather than the DOM pools.

Conclusion

From a methodological perspective, this contribution highlights the advantages of mediated electrochemical analysis over traditional wet chemical approaches. We propose to use mediated electrochemical analysis as the standard analytical approach to assess OM redox dynamics in laboratory and field studies. General conclusions on OM redox properties and reactivities will be drawn and some imminent research questions will be highlighted.

O 2.5.01

Formation of hydrous iron oxide-vermiculite mineral phases and implications on the retention of dissolved organic matter in paddy soil

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1. Introduction

The interaction of dissolved organic matter (DOM) with the mineral phase, in particular iron (Fe) and aluminium (Al) (hydr)oxides, determines the retention, preservation and accumulation of soil organic matter (OM). However, in soil these oxides are often present, not as separated phases, but associated with or precipitated on other mineral particles, such as phyllosilicates. Interactions between metal (hydr)oxides and phyllosilicates modifies the mineral surface properties, in particular electrical charge, specific surface area and porosity, that in turn influence the retention of OM. The frequent alternations in soil redox conditions due to paddy management may induce the reductive dissolution and subsequent reprecipitation of Fe (hydr)oxides on 2:1 clays, resulting in significant modification of mineral surfaces with important, but still not well known implications on DOM retention.

2. Objectives

Although many studies have focused on 1:1 phyllosilicate-Fe oxide associations, less attention has been paid to 2:1 clay minerals. In particular, detailed investigations on the formation of hydrous Fe oxide-vermiculite mineral phases are still lacking. These minerals are particularly abundant in young hydromorphic soils where seasonal variations in redox conditions may lead to the formation a range of reactive surfaces. We therefore aimed to understand mineral surface modifications brought about by different Fe (hydr)oxide-vermiculite associations, and evaluate their interaction with a paddy-soil derived DOM.

3. Materials & methods

Four Fe (hydr)oxide-vermiculite systems (Fe-VM) with increasing proportions of Fe were prepared by neutralizing different amounts of $Fe(NO_3)_3$ in a suspension of VM. The VM and the four Fe-VM systems were characterized for their mineralogical (XRD, Fe_O, Fe_{DCB}) and surface (SSA, porosity, permanent negative charge, ζ potential) properties. The interaction between the different minerals and paddy-soil derived DOM (extracted from the Ap horizon of a Haplic Gleysol, NW Italy) was evaluated by sorption isotherms at pH 5.5.

4. Results

The precipitation of Fe (hydr)oxides on VM resulted in a decrease of negative charge density and more positive ζ potential that were correlated to the increasing Fe loading. However, even at the highest Fe content a negative charge was still preserved (5 $\mu mol_{(-)}\ m^{-2}$), and the measured ζ potential (+8 mV) was significantly lower than that generally reported for pure Fe (hydr)oxides (+40-50 mV). These findings suggest that, even at highest Fe loading, the precipitated Fe (hydr)oxides did not completely coat the phyllosilicate surface, supporting the hypothesis of a non-homogeneous distribution of the (hydr)oxide on the VM surface. Moreover, measured SSA values strongly deviated from theoretical values particularly at the highest Fe loadings, confirming that the (hydr)oxide did not precipitate as a separate phase.

VM showed a limited DOC sorption in line with the scarce affinity of 2:1 phyllosilicates for OM. Interaction mainly involved the selective retention of simple, positively charged, N-containing organic compounds, particularly abundant in the paddy soil-derived OM compared to DOM from other sources. The relative contribution of Fe (hydr)oxides to the retention of DOC on vermiculitic clay surfaces was evident even at the lowest Fe loading. The important increase in DOC sorption with increasing Fe loading was primary related to the greater contribution of Fe (hydr)oxide to the specific surface area. Here, OM binding was driven by ligand exchange and showed a selective sorption for aromatic moieties. However, at highest Fe loadings, aggregation processes during the precipitation of Fe (hydr)oxides on the phyllosilicate surface reduced the retention capacity, probably limiting the interaction of DOM exclusively to external surfaces.

5. Conclusion

Our results have shown that vermiculite may promote the clustering and formation of non-homogeneous Fe (hydr)oxide coatings in correspondence with the negative sites of the phyllosilicate. In turn, the Fe loadings in these mixed mineral phases strongly affected charge density, pore distribution and particle aggregation. This affects, not only the amount of sorbed OM, but also the binding mechanisms involved and consequently, the selective retention of particular constituents.

O 2.5.02

Soil organic matter stabilization as affected by different hydrological pathways in a small watershed under intensive agriculture

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1. Introduction

Stabilization of soil organic matter (SOM) is a major issue in the context of climatic changes where temperature and precipitations will be affected. Across and within agricultural landscapes this process is controlled by complex interactions of soil, agricultural practices and hydrologic parameters. Information on how to accurately integrate these interactions across fields, landscapes, and watersheds are lacking. To study SOM stabilization, different experimental approaches have been developed and may be used to understand how chemical recalcitrance of organic matter interacts with physical protection mechanisms. Hydrological conditions of soil may influence these stabilization mechanisms through their impact on Fe and Al oxides forms as well as the recalcitrant plant litter compound lignin, which accumulates under reducing conditions. On the other hand, SOM physical protection is also dependent of water content dynamics. Few studies have coupled these two approaches.

2. Objectives

Our objective was to evaluate the long-term effect of the interaction between waterlogging (none, temporary, permanent) and exogenous organic matter input (annual pig slurry spreading) on the different forms of SOM along two topographic transects across two different fields of a small intensively monitored catchment.

3. Materials & methods

The Kervidy-Naizin catchment is a 4.9 km² lowland catchment located in central Brittany, north-western France, characterized by an intensive agriculture, which belongs to the French network of long-term Environmental research Observatories (ORE AgrHys). Numerous hydrological and biogeochemical studies have led to an improved knowledge of water pathways (Lambert et al., 2014). Exhaustive surveys were realized to give precise information of the agricultural practices.

Plough layer horizons were sampled in March 2014, on three points of two topographic transects linked to water gradient, Kerrolland and Gueriniec, receiving pig manure (respectively 0.24MgC.ha^{-1}.year^{-1} and 0.53 MgC.ha^{-1}.year^{-1}). Samples were collected between 0 and 15 cm, placed in a rigid box, air dried until the field capacity and passed through a 10 mm sieve.

We carried out elemental analyzes of carbon (C) and nitrogen (N) using a CHN auto-analyser and selective extractions of Fe and Al oxides with citrate-dithionite-bicarbonate and ammonium oxalate. We used a chemolytic analyses of lignin by cupric oxidation. We carried out laboratory incubations to quantify mineralizable C. The aggregate fractionation done by wet sieving allowed us to measure water stable aggregates and we analyzed the C and N for each of the aggregate size-class.

4. Results

Soil organic carbon presented significant differences among the two transects, with the highest value observed in the downslope for Kerrolland (2.24 %) and in the upslope for Gueriniec (2.61 %). In poorly-drained soils, the quantity of Al and Fe oxides was lower and the proportion of amorphous oxides more important than in well-drained soils. This was observed for the two transects.

Lignin content reached a greater quantity and was less degraded in temporary waterlogged compared to well-drained soils. Considering aggregate stability values, no difference was observed among the transect of Gueriniec (62-65.6 % of water stable aggregates). For Kerrolland, aggregate stability was significantly lower downslope (39.3 % of water stable aggregates) compared to upslope (52.2 % water stable aggregates). However no significant difference in the organic carbon distribution among aggregate size fractions was observed.

5. Conclusion

Global data analysis did not show a direct link between water regime and physical stabilization and C storage, but a direct link was observed with lignin degradation as well as forms of Fe and Al oxides. A comparative analysis of the results between the two transects must be done in order to understand their specific behavior towards SOM stabilization. The study was conducted at a period corresponding to the end of high water level. It should be completed by a dynamic follow-up in the time of the studied processes.

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Acknowledgments

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O 2.5.03

How tropical peat C compound composition depends on land use intensity?

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Tropical peat carbon (C) compound composition is largely unstudied subject, despite that it largely determines the decomposition potential of these globally important C storing ecosystems. Yet, there is an urgent need for this information due to advancing utilization of the peatlands. Our aim is to examine the C compound composition in association to depth in the peat profile, under land uses differing by management intensity.

Our samples were from an undrained peat swamp forest and from three altered sites, which formed a continuum of increasing land-use intensity (drainage-affected forest; drained, deforested degraded open site; drained, deforested, site under cultivation). Land use at the altered sites had lasted 20-30 years. The sites were located at the same watershed in Central-Kalimantan, Indonesia. Peat samples were taken from depths covering the mostly oxic (10-15 cm), frequently water-logged (40-45 and 80-85 cm) and permanently water-logged, anoxic (110-115 cm) conditions. To determine the C compound composition we analyzed concentrations of C, N, hemicelluloses, cellulose, Klason's- and acid soluble lignin, and extractives (acetone-water soluble).

Site type explained 33.4% and sampling depth 18.9% of the peat C compound composition. In the forests, the average concentrations of N, total hemicelluloses, cellulose, and acid soluble lignin were higher (50.0%, 71.5%, 3.3% and 54.3%, respectively) and concentrations of C, extractives, and Klason's lignin were lower (2.2% and 11.4%, respectively) than at the open sites. Surface peat in the forest sites was similar (-10 cm depth), but at the -40cm depth the drained forest and open sites were more similar. The topmost peat (-10 and -40cm) in open sites differed clearly from undrained forest, but the differences decreased with depth.

In undrained peat swamp forest most advanced peat decomposition status is reached in water saturated conditions in the peat profile, while reclaimed land uses express most advanced decomposition status in peats closer to the surface. The more intense the land use, the more recalcitrant the surface peat was. Even though the land use (cultivation, fires) mainly affects to the surface peat, land use exposes also the less decomposed deeper peat for oxidation increasing the potential decomposition activity of this "old" peat.

O 2.5.04

Carbon isotopes as indicators of past and present environmental change in peatlands

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Peatlands in pristine status act as a carbon sink as a historical archive of environmental conditions by accumulation of organic matter in their water saturated soils. Our hypothesis is that stable carbon isotope depth profiles indicate peatland degradation induced by drainage, climate or land use change. Aerobic decomposition leads to an enrichment of ^{13}C in aerated layers, whereas anaerobic conditions may either induce a uniform depth trend owing due to very low decomposition rates or even a shift to depleted $\delta^{13}C$ due to accumulation of recalcitrant substances. We took peat cores from different peatlands in Sweden (climate change), Finland (drainage for forestry) and Germany (land use change, drainage) and analysed them for their stable carbon isotope depth profiles, complemented by ^{14}C analysis.

In the three northern Swedish palsa peatlands stable carbon isotopes depth profiles along a degradation gradient indicated historical palsa uplifting by permafrost as well as recent palsa degradation. The changes in decomposition processes were radiocarbon dated and indicated permafrost aggradation in this region between 110 and 800 years.

In a northern Germany temperate peatland along a land use gradient stable carbon isotopes indicated peat degradation due to land use intensification as well as historical degradation of a presently near-natural site. At all three sites, including the near-natural, $\delta^{13}C$ values increased with depth, indicating aerobic decomposition at all sites. Other biogeochemical soil parameters, like ash content and radiocarbon ages, support these data with a low degradation at the near-natural site as well as strong degradation at the managed sites.

In a temperate bog of the Black Forest, southern Germany, $\delta^{13}C$ values increase with depth in the upper part of the profile at the dry site which is in contrast to the wet site showing a uniform depth pattern in the first 40 cm. These different $\delta^{13}C$ depth profiles reflect the different decomposition processes between the sites with aerobic decomposition at the dry site and anaerobic decomposition at the wet site.

In a natural bog and a natural fen in Finland stable carbon isotope depth profiles are uniform throughout the whole profile indicating anaerobic decomposition without stable carbon isotope fractionation. In central Europe none of the studied sites showed a depth profile of $\delta^{13}C$ comparable to the two natural sites in Finland. Obviously none of the investigated peatlands in Germany can be considered undisturbed without even slight degradation.

We could show in various peatlands, that stable carbon isotopes in peat depth profiles are a useful tool to identify environmental change as well as degradation by a change in decomposition processes of the peatland in the last several hundred years.

O 2.5.05

From Bog to Bug to Bird - linking peatlands past, present and future carbon dynamics to management, climate change and ecosystem services

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Peatlands cover about 3% of the world's surface but store over 30% of its soil organic carbon. However, carbon stock estimates are still very uncertain mainly due to spatial measurements of peat depth and accurately assessing bulk density. Crucially, peatlands provide many ecosystem services which are linked to these carbon stocks and an 'intact' bog status (i.e. net carbon sink). There are many threats to this 'intact' status and the integrity and longevity of peat carbon stores including draining for extraction or farming, burning to encourage vegetation changes, and climate change. Many drained peatlands are under restoration and peatlands have previously survived changes in climatic conditions, but effects of vegetation management on peatland carbon dynamics are underexplored. Notably, carbon and hydrological cycles are closely linked by sensitive ecohydrological feedbacks mediated by plant community responses. However, our current understanding about how these systems function or might respond to future environmental change is still limited, including both, process-level understanding and modelling capacity.

In the UK an important issue is burning to encourage heather plants for grouse shooting, which alters vegetation and soil carbon dynamics with important feedbacks on key ecosystem services affecting carbon, water and greenhouse gas emissions as well as biodiversity. We urgently need research to inform which management strategy may be most effective at preserving and growing the long-term carbon store in the peat and supporting the associated ecosystem services as well as sustaining viable economic communities.

Firstly, we discuss model attempts to understand past peatland developments in order to gain confidence in our model predictions of future climate change impacts on peatlands. A key to better predictions about their futures might lie in better understanding their pasts. For this will introduce latest modelling approaches using the MILLENNIA model (Heinemeyer et al., 2010) of building up peat during the Holocene (~8k years ago) based on climate reconstructions and exploring past, present and futures of peatlands based on reconstructions, real observations and scenarios. In addition we link model predictions to peat cohort data such as ^{14}C radiocarbon and also to *testate amoebae* based water table reconstructions (Swindles et al., 2015). We shall also explore impacts of peat depth and bulk density measurement uncertainty on landscape scale and national carbon stock estimates.

Secondly, we present findings from an ongoing five year Defra-funded catchment-scale study on three (replicated) peatland sites in north-west England which compares different peatland managements, namely burning heather *versus* mowing it. We combine net ecosystem exchange and soil respiration measurements with CH_4 and fluvial (DOC and POC) fluxes to create carbon budgets for the different managements. Interannual carbon budgets for burning, mowing and leaving vegetation uncut will be presented and we shall explore drivers behind observed change including individual carbon flux components.

Finally, we shall link peatland (bog) management to biodiversity ranging from bug to bird, specifically considering cranefly abundance in relation to being a food source for several rare upland bird species (Carroll et al., 2011). We conclude with a summary about implications from this kind of work and highlight potential future work needed to address remaining key challenges in our understanding of peatland carbon dynamics and hydrology, necessary to better predict peatland futures under a changing environment.

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P 2.5.01

Greenhouse Gas Emissions and Organic Matter Dynamics in Flooded and Drained Everglades Peatlands

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The soils in the Everglades ecosystem of the southern USA are primarily organic in nature and developed under flooded conditions. Changes to this ecosystem include nutrient loading, altered hydrologic conditions, and cultivation. These anthropogenic factors have significantly altered soil organic matter dynamics, especially within the cultivated lands of the Everglades Agricultural Area. Stimulation of enzyme activity by these anthropogenic factors has accelerated organic matter cycling processes in the Everglades. Soil depths have decreased from several meters to a meter or less in many areas. Major factors controlling this soil subsidence include land-use patterns, water-table depth, and nutrient enrichment. The fate of the oxidized organic matter in the Everglades is of concern globally as various greenhouse gases (N_2O, CO_2, CH_4) exhibit different global warming potentials. It is necessary to better understand how anthropogenic factors influence organic matter cycling and decomposition, and the types and quantity of greenhouse gases produced and emitted to the atmosphere. Carbon dioxide is the most significant greenhouse gas produced under both flooded and drained conditions in Everglades soils, with less than 10% of total greenhouse gas production as N_2O and CH_4. However, soil flooding has the effect of decreasing total greenhouse gas emissions and slowing rates of organic matter cycling, allowing for soil accumulation.

P 2.5.02

Soil type-depending effect of paddy management: composition and distribution of soil organic matter

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Introduction

Paddy soils may originate from many different types of soil and they are highly modified by human activities. These soils are mostly managed under inundated conditions, a management which is considered to favour soil organic matter (SOM) storage and further it is supposed that rates of SOM decomposition are slower under anaerobic than under aerobic conditions.

Objectives

Therefore we focused on the organic carbon (OC) accumulation and composition in major soil types that are typically used for rice cultivation in Asia. Andosol, Vertisol and Alisol sites (tropical climate of Java, Indonesia) as well as Fluvisol and Alisol sites (sub-tropical monsoon climate, PR China) were compared, as they represent a large range of soil properties to be expected in Asian paddy fields. To evaluate the impact of paddy management on SOM, paddy soils and agricultural soils which are not used for paddy rice production (non-paddy soils) were chosen.

Material & Methods

Paddy rice at all of the above named sites is cultivated under flooded conditions followed by an upland crop (Fluvisol: rice-upland crop and others: rice-rice-upland crop). At each site, soil depth profiles from three adjacent independent paddy and non-paddy soils were sampled. Bulk soil samples were analyzed for OC concentrations by elemental analysis and the content of lignin-derived phenols were extracted by CuO oxidation. SOM composition was measured by solid-state ^{13}C NMR spectroscopy. For the latter purpose, bulk soil samples of the upper-most A horizon were treated by HF in order to concentrate the OC content and to reduce paramagnetic effects of iron-containing silica minerals.

Results

Paddy soils derived from Fluvisols and Alisols (China) showed higher OC concentrations in the topsoils compared to the respective non-paddy soils. However, other soil types did not show the expected higher OC sequestration under paddy management. Paddy soils derived from Alisols (Java) had (20 mg g^{-1}) very similar OC concentrations compared to those of respective non-paddy soils (24 mg g^{-1}). The Vertisol sites were characterized by the lowest OC concentrations out of all investigated soil types, of 15 mg g^{-1} in paddy and non-paddy soils. Paddy-derived Andosol had the highest topsoil OC concentrations of 42 mg g^{-1}, but were only slightly higher in the respective non-paddy soils (37 mg g^{-1}).

Solid-state ^{13}C NMR spectroscopy showed that SOM quality and quantity does not considerably differ neither between paddy and non-paddy soils nor in all of the investigated soil types. The content of lignin-derived phenols was relatively low in all soils under study and were only higher in paddy-derived Alisol (China) and Andosol. The Alisols (China) showed higher total VSC concentrations in paddy soils of 12 g kg^{-1} OC compared to those of non-paddy (6.0 g kg^{-1} OC). Paddy-derived Andosols had significantly higher total VSC concentrations in paddy soils of 7.0 g kg^{-1} OC compared to non-paddy with 4.0 g kg^{-1} OC.

Conclusions

Paddy management does not necessarily led to higher OC storage. Significant accumulation of lignin, caused by paddy management, could not be confirmed by the present study.

SOM composition, revealed from solid-state ^{13}C NMR spectroscopy, showed an unchanged SOM quality and quantity, indicating no accumulation of lignin compounds under paddy management. Further, extracted lignin-derived phenols were low in all soils types. Therefore, selective accumulation of lignin due to paddy management could neither be confirmed by CuO oxidation method. Only a weak trend which may indicate a slight enrichment of lignin-derived phenols were observed only in Alisol- (China) and Andosol-derived paddy soils. Therefore, we assume the paddy management does not promote accumulation of lignin compounds, which in turn causes higher the OC concentrations in paddy soils compared to non-paddy soils. It seems that site specific incorporation of crop residues and properties of the initial soil type are probable more important for OC amounts and composition than the effect of paddy management itself.

P 2.5.03

Coating Potassium Nitrate and Urea Fertilizers by Some Organic and Inorganic Materials to improve their Dissolution and Releasing Characteristics

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This work describes the method of producing physically prepared slow - release fertilizers to provide an insoluble coating on granules of water - soluble fertilizers. The fertilizers chosen are potassium nitrate and urea. Stearic acid, calcium hydroxide, paraffin was, fatty acid and talk are the materials used to prepare four types of coating varying in their composition. These types of coating are referred to by a number of examples : Ex_1, Ex_2, Ex_3 and Ex_4.

The granules of coated fertilizers were tested for their dissolution in water at 20 and 40 °C. It was found that coated potassium nitrate has lower dissolution than coated urea. As the temperature was raised from 20 to 40 °C, the dissolution rate increased for both fertilizers. The treatments Ex_3 and Ex_2 have the best (lowest) dissolution rate, respectively. The Ex_4 treatment recorded the worst values due to that the strength of the granules was quite poor.

Releasing rate of potassium nitrate and urea fertilizers in sandy soil at 25 and 50 °C and field capacity 20 and 40 % was tested. Increasing temperature increased the releasing rate. Moisture content had lower effect. Potassium nitrate fertilizer recorded lower values of releasing than urea. Among the treatments, coating of both fertilizers decreased their releasing rate in the following order, $Ex_3 > Ex_2 > Ex_1 > Ex_4$ and finally the uncoated treatment.

Key words:

Slow - release fertilizers, dissolution rate, releasing rate, potassium nitrate, urea, sandy soil.

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Figure 1

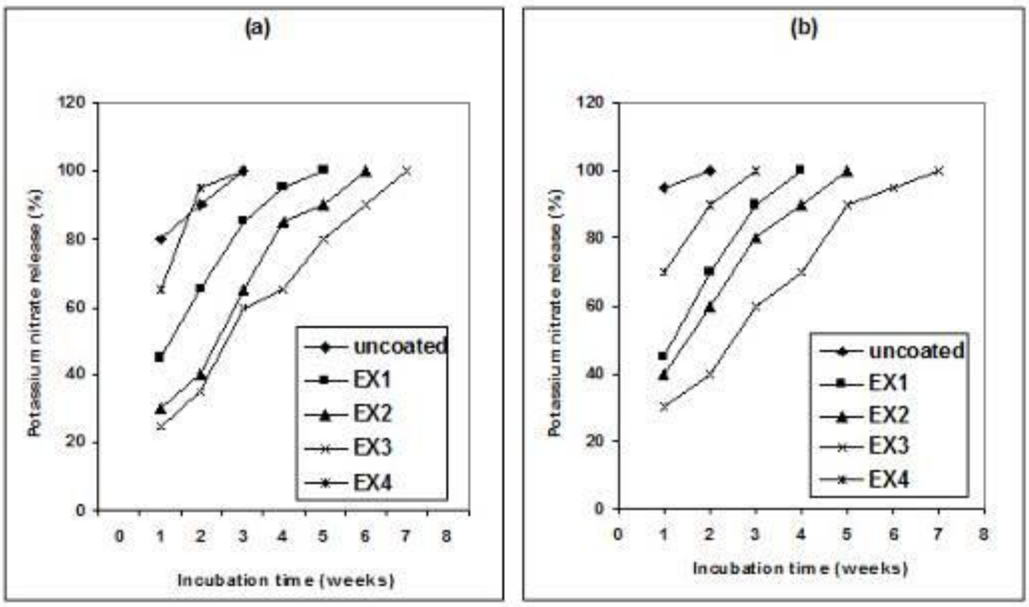

Fig. (8) Releasing rate of uncoated and coated potassium nitrate in sandy soil at 40 % field capacity

a) at 25 °C b) at 50 °C

a) at 25 °C b) at 50 °C

Figure 2

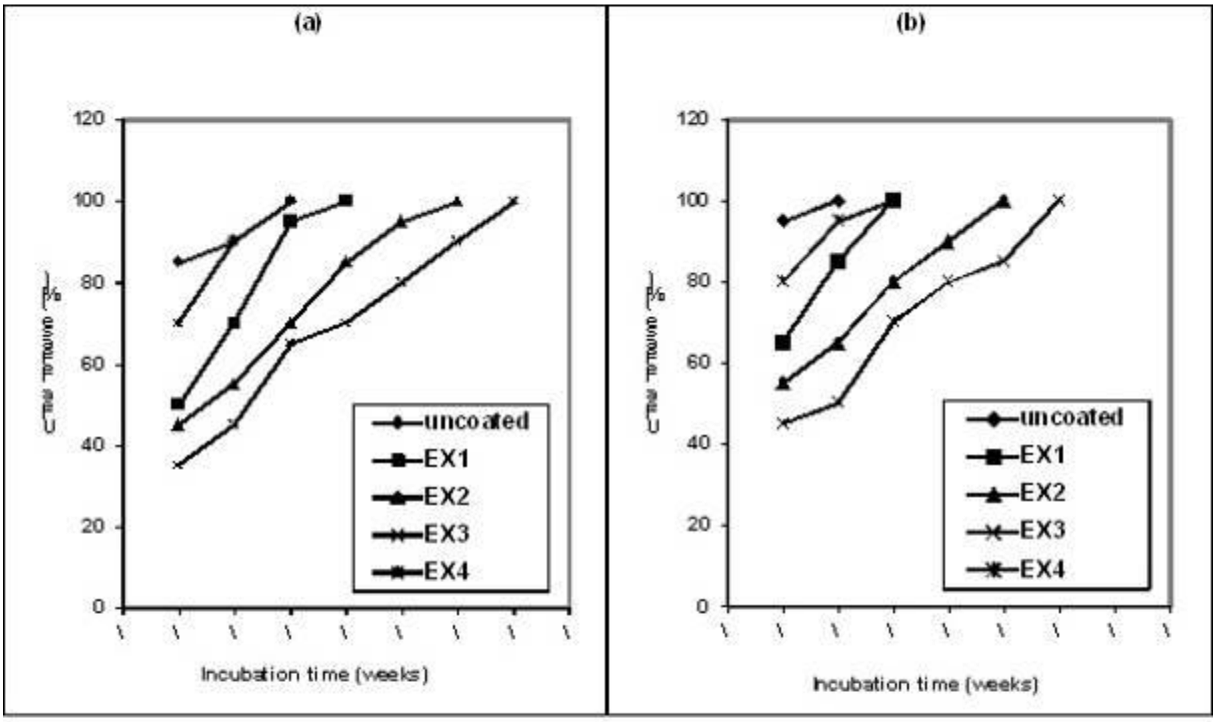

Fig. (9) Releasing rate of uncoated and coated urea in sandy soil at 40 % field capacity

a) at 25 °C b) at 50 °C

P 2.5.04

How rice roots form their surrounding: Gradients of oxides, silicates and organic matter in the rhizosphere of a paddy soil

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1. Introduction

Most of the rice (*Oryza sativa*) worldwide is grown under flooded conditions in bunded fields (paddies). Inundation during long periods of the year leads to anoxic conditions in the soil. The rice plant is well adapted to these conditions by being able to transport oxygen via aerenchyma from the atmosphere to the roots. This plant mediated O_2 transport also influences the adjacent soil. Driven by the O_2 leakage into the rhizosphere, reddish ferric oxides and ferric hydroxides precipitate along the root channels. Thus, radial gradients of ferric Fe and with it co-precipitated organic substances form.

2. Objectives

Detailed investigations of element gradients on a submicron scale within the oxide coatings are still missing. Nano-scale secondary ion mass spectrometry (NanoSIMS) analyses can help to visualize and study the interplay of the various compounds of soil at a submicron scale like, e.g., the attachment of organic material to minerals or the architecture of microstructures. The aim of the present study was to evaluate the composition and size of oxide coatings around rice roots concerning the distribution of organic matter and its spatial relation to oxides and silicates.

3. Materials & methods

Samples were taken from the plough pan of a paddy field close to the National Rice Research Centre, Castello d'Agogna (Pavia, Italy). Intact soil aggregates were air-dried, embedded in epoxy resin and then cut and polished in order to obtain a surface with low topography. Reflected-light microscopy was used (mm to µm scale) to visualize the aggregate architecture and to identify root channels in the embedded aggregate. In the next step, scanning electron microscopy (SEM) was applied to obtain images of high resolution and to define distinctive spots for subsequent NanoSIMS analyses.

Using the Cameca NanoSIMS 50L at TU München, we simultaneously detected ^{12}C, $^{12}C^{14}N^-$, $^{28}Si^-$, $^{32}S^-$, $^{27}Al^{16}O^-$ and $^{56}Fe^{16}O^-$ at several areas around root channels in order to distinguish between organic material and different mineral particles (e.g. oxides, clay minerals). Beside single 40 x 40 µm sized spots, mosaics of 20 x 20 µm sized images were combined to demonstrate the gradient from the surface of the root channels into the soil matrix. The image data of all detected secondary ions was analysed using line scans and designation of regions of interest (ROI) to evaluate relative occurrences and spatial distributions.

4. Results

First results reveal $^{56}Fe^{16}O^-$ associated with higher occurrences of $^{12}C^{14}N^-$ and $^{32}S^-$ in distances between 0 and approx. 20 µm around root channels, where no $^{28}Si^-$ has been detected. This indicates a distinct zone of oxide-associated organic matter in direct vicinity of the root channel. At distances larger than approx. 20 µm from the surface of the root channels, higher occurrences of $^{28}Si^-$ and $^{27}Al^{16}O^-$ indicate the predominance of silicates (e.g. clay minerals). In addition to the oxide- and silicate-dominated zones in the matrix around root channels, we identified oxide-encrusted root cells with high occurrences of $^{56}Fe^{16}O^-$ and $^{27}Al^{16}O^-$. Within these cell structures, strong linear relationships were identified between $^{27}Al^{16}O^-$ and $^{12}C^{14}N^-$ (r^2= 0.91) and between $^{32}S^-$ and $^{12}C^{14}N^-$ (r^2=0.85). However, no relationships were found between $^{27}Al^{16}O^-$ and $^{56}Fe^{16}O^-$ and between $^{12}C^{14}N^-$ and $^{56}Fe^{16}O^-$.

5. Conclusion

The whole vicinity of the rice root is strongly influenced by oxygen diffusion. The results revealed that the oxic zone around rice roots can be subdivided in distinctive sub-zones. We identified a distinctive zone of approx. 20 µm around the root channels, where exclusively oxide-associated organic matter occurred. This zone can be clearly distinguished from a clay mineral-dominated zone. In addition, oxide-incrusted root cells revealed coexisting regions of Fe (hydr)oxides and Al-organic complexes.

P 2.5.06

Greenhouse gas emissions from a continuously and intermittently flooded Bangladeshi paddy field in relation to redox potential, soil moisture and soil solution chemistry depth profiles

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1. Introduction

The emission of green house gases (CH_4, CO_2 and N_2O) from rice paddy fields is influenced greatly by several factors like soil redox potential (Eh), availability of labile organic carbon and oxidants for soil organic matter (SOM) degradation.The alternate aerobic and anaerobic cycling of rice fields declines CH_4 emission and enhances N_2O emission, often in contrast to continuously flooded fields. In irrigated rice soils, soil moisture level, Eh and levels of dissolved organic carbon (DOC) and reduced species like NO_3^-, Mn^{2+}, Fe^{2+} etc. differs strongly between depth increments soil layers. But relation of these dynamic depth profiles with bulk soil CH_4 and N_2O emissions have not been resolved.

2. Objectives

The evidence of an integrated beneficial effect of water saving irrigation management on GHG emission is still lacking for young floodplain paddy soils in Bangladesh. Our objective is to understand how depth distributed Eh, moisture, DOC, Fe and Mn content drive CH_4, N_2O and CO_2 emissions. We set up a paddy field experiment at the Bangladesh Agricultural University in the 2015 Boro season. We hypothesize that green house gas emission from paddy soils are mostly governed by soil moisture profiles and Eh profiles, rather than bulk soil levels of DOC or NO_3^-.

3. Materials and methods

The cultivated rice variety (BRRI dhan28) was grown for 14 weeks under three water management practices (continuous flooding (CF), Alternate wetting and drying (AWD) and dry seeding (DS)). To explore our main hypothesis, we compared global warming potential (GWP) based on cumulative emissions of CH_4, CO_2 and N_2O at several sampling events (closed chamber/GC).The soil Eh at four different depths was measured continuously by a HYPNOS III data logger an Eh-probes system. Soil moisture tension was monitored regularly via Electronic Tensiometers with hypodermic needle (SMS 25000 S). DOC, Fe and Mn in soil solution, collected from three depths with rhizon solution samplers, were measured at regular interval.

4. Results

The Eh(mV) decreased sharply in both AWD and CF plots within 1st week and stabilized near -600mV in both CF and AWD treatments over all soil depths. Eh peaked for several days close to 0mV at drainage events in AWD mostly at 5cm and several times also at 12.5 and 20.5cm depth. After 70DAT, reductive conditions (-300 to -400mv) in AWD and CF and even in DS (so as to 84DAS) due to continuous flooding resulted in CH_4 fluxes (10-30 mg m^{-2} h^{-1}) in case of the AWD and CF treatments. Between 14-70DAT CH_4 emission rate of 0-20 mg m^{-2} h^{-1} was irregular in the AWD plots and progressive under CF. During the drainage and re-flooding events both CH_4 emission and Eh at different depths fluctuates abruptly in AWD treatments. Mean CH_4 fluxes in DS plots are lower than AWD and CF plots throughout the season. Analysis of N_2O, CO_2, DOC, Fe and Mn and volumetric soil moisture levels are on-going and will be presented in detail at the workshop.

5. Conclusion

Most strikingly, both rate and magnitude of the drop of Eh in the Mymensingh floodplain soil was unusually large. Even under AWD, strong reducing conditions are seen at times even at 5cm depth and continuously at 30cm depth. We therefore also anticipate fast preferential reduction of NO_3^-, Mn^{4+} and Fe^{3+}, preceding methanogenesis under both CF and AWD. The young age of non-calcareous Bangladeshi floodplain soils developed from Ganges and Brahmaputra alluvial sediments with low pedogenic Fe content may explain these observations. Our partial results already indicate that GWP-benefits of water reducing management may be less than anticipated in these floodplain soils, when compared to studies in other areas.

The analysis of remaining soil chemical parameters will provide a more process-oriented insight in the biogeochemistry of non-continuously flooded paddy soil systems.

Figure 1

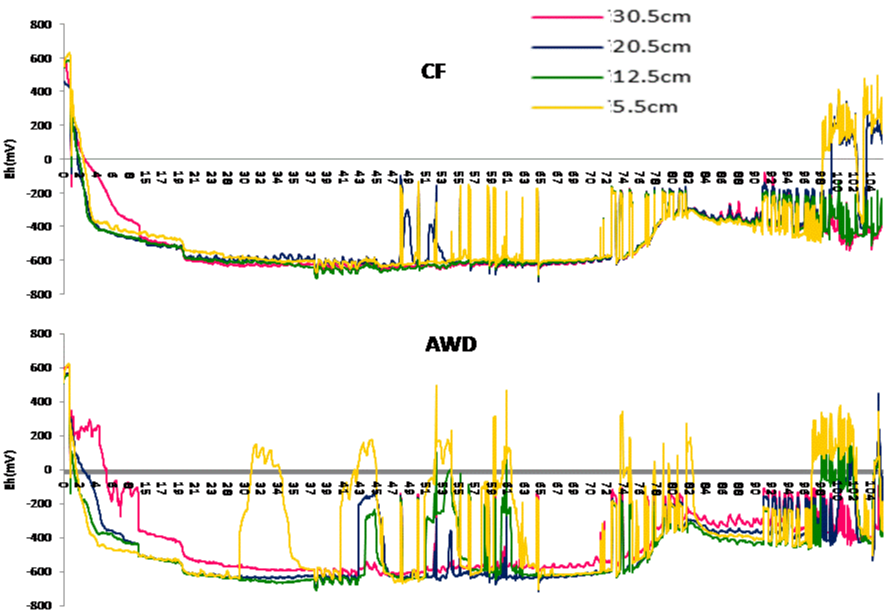

Fig. 1 Evolution of soil redox potential (Eh) in the Bangladesh Agricultural University Soil Science Dept field experiment (CF: continuous flooding, AWD: safe alternate wetting and drying) at four depth increments

Figure 2

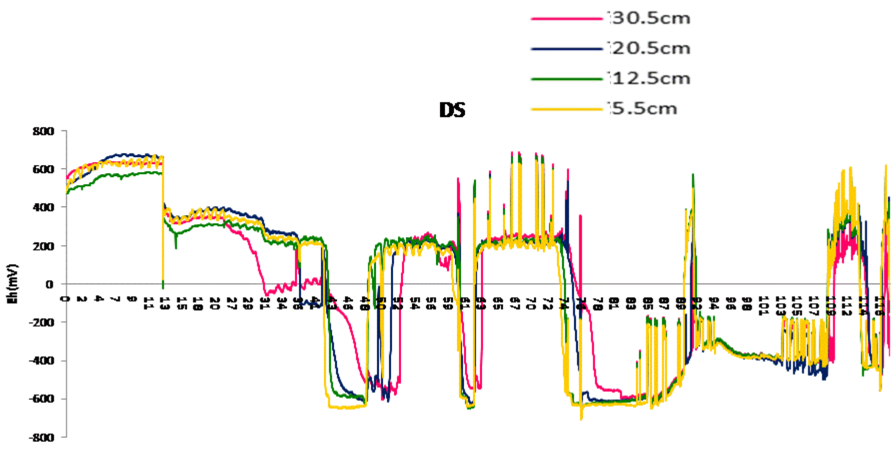

Fig. 2 Evolution of soil redox potential (Eh) in the Bangladesh Agricultural University Soil Science Dept field (DS: dry seeding) at four depth increments

P 2.5.08

DOC-iron relation under fluctuating redox conditions in Phaeozems and Gleysols

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Present study focuses on the spatial pattern, seasonal dynamics and interrelationships between redox conditions (E_H), dissolved organic carbon (DOC) and dissolved iron in headwater wetlands. Altogether eight profiles were studied along two toposequences. These toposequences are located in Völgység region and in Danube-Tisza Interfluve (Hungary, Central Europe). Each profiles represent core parts and boundaries of vegetation induced patches (ecotopes). Seasonal and diurnal dynamics of porewater temperature, pH, E_H, have been recorded and porewater have been sampled in each profiles. DOC and iron were measured by C/N analyser and fl-AAS.

Spatial pattern results significant differences in studied environmental factors even within small area.

Higher E_H measured generally in nettle *(U. dioica)* covered Phaeozems, while the most reductive conditions prevailed in vegetation boundaries: sedge *(C. riparia)* - reed *(Ph. communis)*. These boundaries were characterized by mollic Gleysol and gleyic Phaeozem. Temporal variability of redox conditions partly depended on the physiological activity of plants and the saturation of the wetland soils too. The seasonal fluctuation in redox potential is only determined by vegetation: the E_H values decreased from March to August. In E_H values we also observed strong diurnal dynamics.

As similar as E_H, DOC also showed diurnal and seasonal fluctuations. The decreasing E_H always caused increasing DOC content, the correlation coefficient was strong between them (Spearman’s rho -0.840). DOC values in the boundaries were 3-4 times higher than in core part of the ecotopes.

Reductive conditions increase solubility of iron as the E_H range of the Fe reduction process (Fe^{3+} to Fe^{2+}) is between +200 and -100 mV. In our field-scale measurements four redox ranges have been identified where solubility of iron is increased (+320 to +270, +80 to +70, +30 to +20 and -160 mV). These ranges not definitely appeared in all studied spatial units, it seems that they were specific to the local vegetation. The increasing DOC content led to increasing amount of dissolved iron (Spearman’s rho 0.988) when E_H was higher than +100 mV. Under +100 mV the concentrations of DOC remained constant, while dissolved iron content increased further, so in this range there is a direct correlation between the amount of dissolved iron and the redox conditions (-0.897). Our results suggest that the increased iron solubility under slightly reductive conditions (> +100 mV) is generated by organic complexation of iron.

Acknowledgement

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P 2.5.09

Do Fluctuating Redox Conditions Increase Rates of Soil Organic Matter Degradation?

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Relating soil organic matter degradation to geochemical conditions is the key for predicting the sensitivity of soil respiration to anthropogenic pressures. Under either static oxic or anoxic conditions reactants become depleted and products build up, potentially reducing the energetic efficiency of the reaction. In an oscillating redox environment, the system is far from thermodynamic equilibrium thereby supplying more labile organic carbon substrates to be used for microbial energy and growth. It also reduces the problem of accumulation of toxic intermediates. While previous studies have shown enhanced organic matter degradation under changing redox conditions in both soil column experiments and stirred bioreactors, the roles of moisture content and redox potential on SOM degradation have not be elucidated (Parsons et al., 2013, Rezanezhad et al., 2014). Therefore, the objective of this study is to evaluate the relative impacts of both static and oscillating redox conditions on soil organic matter degradation using stirred soil suspensions in bioreactors. Soils were collected from the *rare* Charitable Research Reserve field site located in Cambridge, Ontario, Canada. A set of three identical 1L bioreactors (Applikon ®) containing soil suspensions (93 g/ L) were prepared using a carbonate buffered artificial groundwater (AGW) solution matching the aqueous chemistry of the field site. Static oxic (bioreactor 1) and anoxic (bioreactor 2) conditions were maintained by continuously sparging with air and N_2, respectively. Oscillating redox conditions were induced in bioreactor 3 by sparging with air (1 day) and N_2 (6 days) giving a total of 4 redox cycles. All suspensions were stirred at 500 rpm at 25°C and run simultaneously for 28 days. Bioreactors were sampled at regular intervals and analyzed for various chemical concentrations and microbial activities including greenhouse gases (CO_2, CH_4 and N_2O), anions, low molecular weight organic acids, DIC, DOC/TN and soil enzymatic activities. DOC in the fluctuating bioreactor increased during each reducing period and decreased to below detection limits during each subsequent oxic period. This decrease in DOC was coincident with increased gaseous CO_2 concentrations during each oxic cycle thereby suggesting respiration of the DOC produced in each preceding reducing cycle. These cyclic trends were not observed in either static or oxic bioreactors and suggest a mechanism whereby fluctuating redox conditions increase rates of SOM degradation by supplying fresh fermentation products during reducing periods thereby increasing microbial heterotrophic activity in soils. In this presentation, the impacts of oscillating versus static redox conditions on greenhouse gas emissions and microbial dynamics will be discussed.

P 2.5.10

Reconstructing organic hummock formation and carbon storage in permafrost soils in northern Canada using tree ring records

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Introduction and objectives: Why are the large amounts of organic matter stored in permafrost soils? In Northwest Territories of Canada, black spruce forest exhibits the largest soil organic C (SOC) stocks among permafrost ecosystems. Organic matter decomposition can generally be limited by cold climate, water flooding, and input of recalcitrant litters. In addition to these processes, black spruce forests can develop mounds and troughs called hummocky soil structure. This process is hypothesized to play roles in enhancing SOC storage, however, history and functions of hummock soils in SOC accumulation are still unclear. Development of hummock soil structure could induce tree tilting, as black spruce trees typically grow on the shoulder of hummock soil. Tree rings of reaction woods could record tree tilting and soil hummock dynamics (Fig. 1). Using tree ring analyses and litter decomposition experiments, we attempted to reconstruct hummocky soil dynamics and their impacts on SOC storage over 200 years.

Materials and methods: Soil C stocks, micro-relief, and organic/mineral soil thickness were measured in black spruce forest (BSF) on fluvial sediments in Northwest Territories, Canada. To analyze environmental factors regulating SOC storage, we compared soil C stocks in BSF with those in tundra (TND) on fluvial sediments and white spruce forest (WSF) on the upland soil derived from glaciofluvial sands. To analyze the relative importance of soil condition and substrate quality on organic matter decomposition, the following environmental parameters were also measured: soil temperature and moisture, aeration index [Eh, reducible iron (Fe) oxides] of soils, and the decomposition rates of litters (lichen, moss, and root litters) and cellulose filter paper buried in the soils. To reconstruct the history of soil hummock formation, tree ring widths were measured year by year. The magnitude of tree tilting was calculated by the maximum tree ring width dividing by the minimum tree ring width.

Results and Discussion: Tree ring analyses suggested that hummock soils were formed through freeze-thaw cycles over 200 years. The magnitude of tilting increased with air temperature, which suggested that permafrost thawing in warm summer and re-freezing induced development of hummocky soil structure. This provides diverse habitats, dry mounds for lichen and wet troughs for moss. Mass loss rates of cellulose filter paper were lower in the BSF and TND soils (20 to 30%) than in the WSF soil (80%), while those of lichen and moss litters were consistently small at all sites. The development of hummocky soil micro-topography resulted in accumulation of sparingly-decomposable lichen in mounds and accumulation of moss in troughs. The thick layers of lichen and moss litters in BSF appeared to limit deep melting of permafrost soil during summer. Soil water dynamics indicated that seasonal flooding events were observed following spring snowmelt and permafrost melting in summer. Rapid snowmelt and water percolation enhanced aeration in sandy WSF soil, while BSF soils were saturated by water flooding on impermeable permafrost layer. The redox cycles of iron were recorded as accumulation of oxalate-extractable Fe oxides. The SOC stocks in BSF and TND soils were significantly ($p < 0.05$) greater than in WSF soil. When the regression analyses were conducted using the dataset from the other eleven soil profiles, there was a positive correlation between soil C stocks and free Fe oxides. Cold climate and poor drainage, which are imposed by hummock soil structure, contribute to the largest C stocks in black spruce forests.

Conclusion: Tree ring analyses suggested that the hummocky soil structure could be formed by freeze-thaw cycles, especially thawing events of warmer summer over ca. 200 years. Development of hummocky soil structure accumulates lichen and moss litters. Cold climate under thick organic layer and poor drainage on shallow permafrost table can enhance SOC storage.

P 2.5.11

Analysis of upland peat catchments using trace element geochemistry and geophysical methods.

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1. Introduction

70% of UK drinking water is derived from upland peat catchments. Degradation of these peatlands through overgrazing or drainage is not only important with regards to the global carbon budget (as they are transformed from carbon sinks to sources), but also for water treatment costs. As the peat dries and compresses water flows more rapidly through the drainage ditches and erosion gullies, increasing costly flood events further downstream. This erosion also increases the DOC content of the water, which requires greater expenditure on treatment to make it suitable for domestic consumption. DOC can carry pollutants, or react with chlorine that is used as a disinfectant during treatment, producing trihalomethanes, which are thought to be carcinogenic. The damaged peatlands are also no longer able to intercept atmospheric pollutants meaning those, in addition to the contaminants previously retained in the soil, degrade the raw water quality of the catchment, further increasing water treatment costs.

The Garron Plateau in County Antrim, which acts as the catchment for Dungonnell reservoir (owned by Northern Ireland Water), is one of the best examples of intact blanket bog in Northern Ireland. The area is a designated ASSI, SAC, SPA and a RAMSAR site, however previous sampling and analysis undertaken by NIEA in 2004, determined the area to be in unfavourable condition, primarily as a result of years of overgrazing. A restoration programme has since been put into place in an attempt to restore approximately 2000ha of the ASSI to favourable condition.

2. Objectives

The main aim of the project is to perform a series of geochemical analyses to determine the biogeochemical processes that are occurring within the samples taken from the previously assessed healthy, degraded and restored areas. Geophysics will also be used to show the different physical characteristics (depth, stratigraphy and redox properties) at each location. Results will allow comparison between the three locations to determine whether or not the restored peat has similar characteristics to the degraded or healthy peat, and account for these differences.

3. Methods

Molybdenum (Mo) is a trace element found in the soil and is required for growth of most biological organisms including plants and animals however it is highly soluble and easily leached from soils. Under specific conditions, such as those in a healthy peat, Mo binds to tannins and tannin compounds in soils and is less likely to be leached away and is bioavailable to microbes. Fourier Transform Infrared Spectroscopy (FTIR) can be used to determine the form of Molybdenum present (as free inorganic or bound to organic material) in each sample to determine how nitrogen is being cycled by microbes and give an indication of the health of the peat at each location.

Stable isotope analysis of carbon, nitrogen and sulphur from the peat samples and hydrogen and oxygen from porewater samples will give an indication of the relative biological activity occurring within each area, also indicating the health of the peat. In addition, carbon, oxygen and nitrogen isotopes in soil gas will give an idea of the flux of CO2 to the atmosphere. It will also give an indication of how long the carbon has remained in the peat. To provide further evidence of the data collected, redox, dissolved organic carbon (DOC) content and pH measurements of the surrounding water as well as geophysics across each area can also be used to assess the quality of peat and water table fluctuations across the site.

4. Results

Some preliminary FTIR and stable isotope results are shown as figure 1 and figure 2, respectively.

The FTIR results (figure 1) show differences in the characteristics of the peat from each location. The most apparent is that after 135hrs of air-drying, the degraded peat is not able to hold as much water as the restored and healthy.

The amide I and II results are also lower in the degraded peat and the Mo results show a sharper spike of Mo in the degraded peat.

The isotope results (figure 2) show that the majority of the samples at each location have similar results and cluster together. However some outliers are present and may be due to free-draining samples. Geophysics will aid in interpretation of the results through monitoring of water table fluctuations over time.

5. Conclusions

The project aims to promote the potential of peatlands as not only significant global carbon sinks but more locally as catchments that must be protected due to their ability in greatly reducing water treatment costs, regulating catchment hydrology and as important habitats of flora and fauna. The data gained throughout the project will provide information on peat restoration that can be used in other upland catchments across NI and the UK.

Figure 1

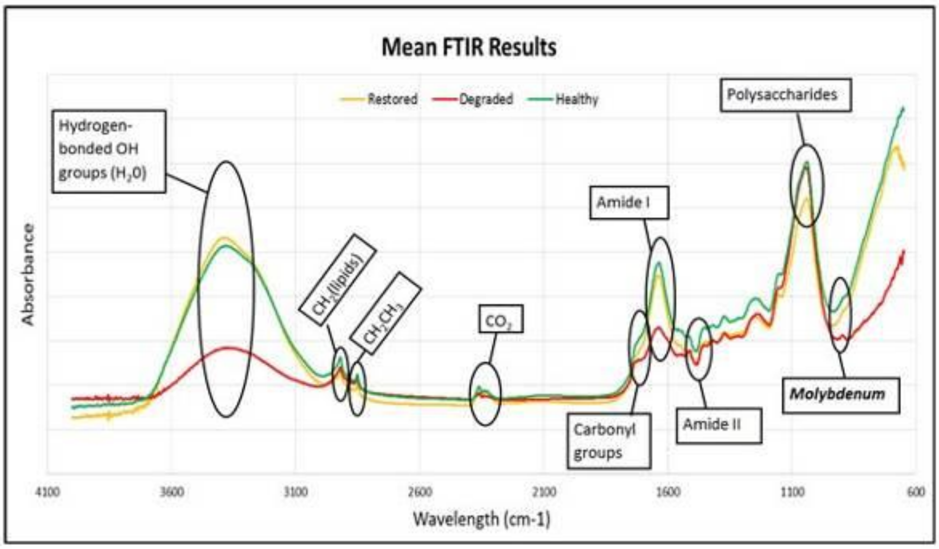
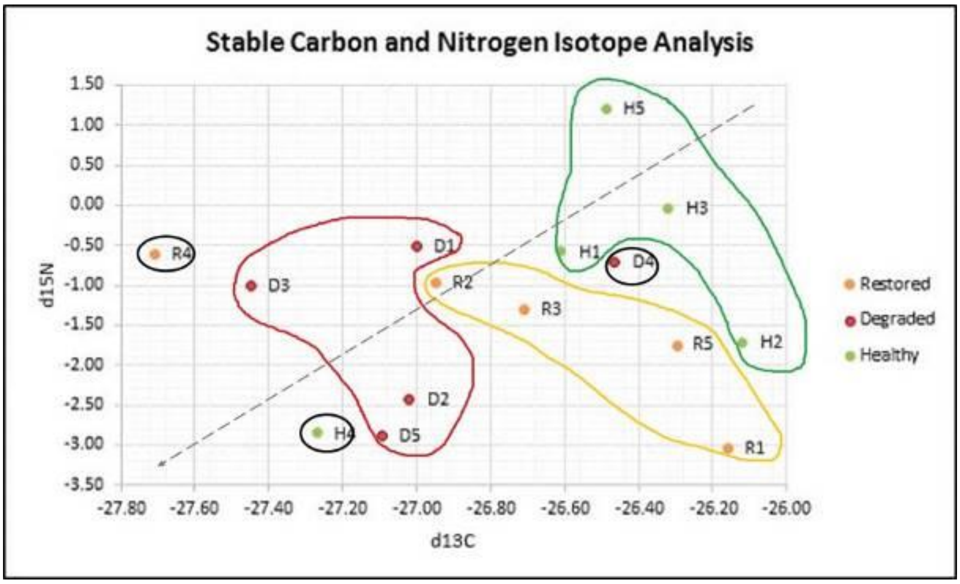


Figure 2



P 2.5.12

Gradual replacement of chemical fertilizer with organic manure in paddy soils

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There is 230,000 hectares paddy soils in Guilan province, in north of Iran. In cultivation months of rice in Guilan (April and May), 500 ton chemical fertilizer is required for each month, which provided 50 % only, because of their cost, in last 4 years. Also because of environmental concerns, it is recommended to reduce application of chemical fertilizers. One of the solutions for this issue is to replace organic fertilizers such as vermicompost, slowly, which has been examined in this field experiment. There is wood-paper factory, which produces paper and tea factory which provides black tea from tea green leaves, in Guilan province. These two factories have a lot of organic waste material for composting in trade level. Providing nutrients from organic source and its effect on soil properties and rice yield has been examined in this research. Waste materials were collected from tea and wood-paper factories and mixed with cow dung with ratio of 30, 30 and 40 percent, respectively and 300 local earthworms were added. Irrigation and aeration has been done in control condition, weekly, till vermicompost has been processed. Vermicompost were first class in the case of C/N, pH, EC, and total N, P and K. In first class vermicompost, amount of P_2O_5 and K_2O should be more than 1 %. Paddy soil with 1.5 % OC was selected in research farm in faculty of agriculture- university of Guilan. After soil sampling from 0- 25 cm and soil test, soil plowing and paddling, has been done in entire field. Factorial experiment design in 4 rate of chemical fertilizer (0, 50, 75 and 100 % according of soil test) and vermicompost in 3 levels (0, 1 and 2%) were added in 36 plots with 10 m^2 area, in three blocks and replications (4× 3 = 12, 12 × 3= 36) and vermicompost were mixed with subsoil thoroughly, in the end of winter. Total P, 70 % of K and N from chemical fertilizers was added in each plot before cultivation. N from urea, P from triple super phosphate and K from KCl sources, were used. Two months after vermicompost application, rice seedlings were transferred to the plots and irrigation done, carefully and equally without water stress during vegetative and reproductive growth. The rest of chemical fertilizers were added in tillering time. Finally, for 3 weeks, irrigation was stopped and yield of each plot were harvested in last month of summer and weighted carefully. After one month’s storage, paddy rice has been converted to white rice in milling laboratory in Rice Research Institute in Rasht-Iran. The maximum weight of paddy rice get with 50 percent chemical fertilizer without vermicompost but in the case of white rice, the result approved that there was no differences between combination treatments and only chemical fertilizer treatments. Single vermicompost treatments were better than others. After harvesting, soil sample analysis shown that under reduced condition, organic manure cannot be decompose within 6 months and drainage system is necessary under reduced condition in paddy soils, however, SOM content increased to 4 and 4.5 %, in 1 and 2 % vermicompost treatments, respectively.

Sharma,A.R.,and B..N.Mitra. 1991. Effect of different rate of application of organic and chemical fertilizers in a rice-based cropping system. J.Agric.Sci. 117(3) :313-332 Hernandez ,A.,H. castillo.,D.ojeda.,A.arras.,J.Lopez and E.sanchez. 2010.Effect of vermicompost and compost on lettuce production .CHIL.Journal of Agriculture Research.70(4):583-589

P 2.5.13

Fertility and CO_2 emission on erosion affected soils of West Siberia

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Snowmelt erosion is one of the widespread processes leading to decrease of soil fertility in the most valuable agricultural lands in the world. Severe climatic conditions inSiberia, including large quantities of snow, ice-sheeting on soil and a short period of snowmelt, are reasons for the intense erosion processes in this Russian region (Tanasienko et al., 2011). The West Siberian territory is favourable for agriculture and at the same time a lot of fertile Chernozem soil are slopes with gradients of 1-3°; 8% of the ploughed lands are steeper slopes. The anthropogenic impact on Siberian soils has not exceeded 120 years, but when taking into account the rapid development of the erosion processes, slightly eroded soils are observed to transform into moderately eroded, and then to strongly eroded soils, if no measures are taken against erosion (Tanasienko, 2003, Yakutina et al, 2015). Soils subjected to erosion are characterised by a decrease in fertility and crop yield as a result of soil structure degradation and plant nutrient depletion (Pimentel et al., 1995; Yavtushenko, Makarov 1996; Lal, 2010). Main stable features of fertility that decrease in the eroded soils are humus thickness and SOM content.

The aim of the current study is to describe the impact of erosion and deposition processes on soil properties and consequently on microbial activity and CO_2 emission.

The area of study is located in the forest-steppe zone of West Siberia. Field experimental sites are situated on theterritoryofBolotninskyand Toguchinsky regions located right ofNovosibirsk(Near-Salair drained plain). Structure patterns of the geomorphic composition of the study area are: Watershed areas, slopes with different orientation, valleys of ephemeral streams and valleys of streams and small rivers deeply cut into the plain surface. Non-eroded and eroded soils used in field experiment are classified as Haplic Chernozem (Glossic, Siltic) and Haplic Phaeozem (Siltic).

The basic soil properties measured in the laboratory, were: Soil organic matter (SOM)/carbon (SOC), total N (TN), pH_{H2O}, nitrates (NO_3-N) exchange-absorbed ammonium (NH_4-N). Additionally, rewetted soil samples were adjusted to 50% of field capacity and placed in a Respicond IV automated respirometer for the continuous measurement of CO_2 evolution during 10 days at20°C.

Intensive use of land on slopes and cultivation of crop without fertilizers lead to changing main indicators of soil fertility. Estimation of productivity and fertility of eroded lands parameters is compared with non-eroded soils, which occupy the flat plakor part of the hill. In the ploughed layer (0-20 cm) of moderately eroded soil in comparison with the non-eroded plot, a 1-3 times decrease of carbon and nitrogen was registered. Carbon losses in the ploughed layer of eroded soils were 68% for Chernozem and 27% for Phaeozem soils. High correlations between the content of the SOM, Ntot, and the degree of erosion of soil (r = -0,56 and r = -0,82) have testified not only about the impoverishment of the upper limits of organic matter, but also the degradation of potential fertility as a whole. The C:N ratio is significantly higher in Chernozem eroded soils: the ratio in eroded Haplic Chernozem and Phaeozem was 1:17 and 1:15 respectively, in comparison with the ratio in non-eroded Chernozem (1:11) soil. Direct correlation (r = +0.40) between the C:N and the degree of erosion are indicated on the interdependence of content of these elements on the slope ecosystems. High amount of released CO_2 was observed on the non-eroded soil, reduced to 50 % on eroded soils. In turn, sediments and fallow land contribute to emitted CO_2 on the slope. Uneven redistribution of SOM and nitrogen due to snowmelt along the slope occurred during early spring. Additional sediments on the surface served as a signal to enhance or inhibit the soil microbial community activity, and consequentially a changed process of SOM and nitrogen mineralization in soils on different elements of the slope.

Thus, long-term, extensive use of soil on the slopes has led to decrease of fertility. Transformation of the arable eroded soils to the fallow land reduced the rate of losses of important agronomic parameters. Released CO_2 on the fallow soil is a result of change of phytocenosis, intensification of activity of soil microorganisms and bio-chemical processes. Rational use of fallow lands is one of the ways of restoring humus content and stabilising degradation, especially on the slope agroecosystems.

Thanks to the Russian Fond of Fundamental Research, who has supported represented investigations (Project № 14-05-31321-mol-a).

P 2.5.14

Sensitivity of the Potentially Mineralizable Soil Organic Matter to Extreme Climatic Conditions

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Introduction

Wetting and drying are natural factors that initiate the growth and death of soil microorganisms, the stabilization and destabilization (decomposition) of soil organic matter due to various mechanisms including hydrophobic interactions, aggregation-disaggregation and dissolution of organic compounds which as a result lead to change of mineralization potential in the soil.

Objectives

Indicate the effect of different soil moisture conditions on the mineralization potential of gray forest soil.

Compare loss C-CO2 from the soil with content of potentially mineralizable carbon in the soil at the end of experiments.

Materials and methods

Pot experiment with the gray forest soil included trials with plants (corn) and bare fallow. Following regimes of soil moisture were created:

1) Constant, conditionally optimal soil moisture (approximately 28 mass %) over the growing season.

2) Constant, relatively deficient soil moisture (about 12-15% mass %) over the growing season.

3) Repeated cycles of drying up to the wilting leaves and wetting up to optimal soil moisture.

Control of soil moisture was taken every two or three days. Gas sampling was carried out using closed chambers. Soil samples were collected at the end of the pot experiment. The potentially mineralizable content of soil organic carbon (SOC) was measured by biokinetic method based on (i) aerobic incubation of soil samples under constant temperature and moisture conditions during 158 days, (ii) quantitation of C-CO2, and (iii) fitting of C-CO2 cumulative curve by a model of first-order kinetic. Total soil organic carbon was measured by Tyrin's wet chemical oxidation method.

Results

Continuous drought under permanent deficient of moisture in the soil favored the preservation of potentially mineralizable SOC (Table 1). Two repeated cycles of drying-wetting did not reduce the potentially mineralizable carbon content in comparison with control under optimal soil moisture during 90 days of experiment. The emission loss of C-CO2 from the soil with plants was 1.4-1.7 times higher than the decrease of potentially mineralizable SOC due to the contribution of root respiration. On the contrary, decrease of potentially mineralized SOC in the soil without plants was 1.1-1.2 times larger than C-CO2 emissions from the soil in result of stabilization processes (Table 2).

Conclusion

Different soil moisture regimes lead to essential changes of mineralization potential in the gray forest soil. The amount of mineralization loss soil carbon via C-CO2 emission is directly associated with the decrease ofpotentially mineralizable carbon.Drought conditionsare areason for temporarily sequestration of SOCpotentially mineralizable under optimal moisture.

This work was supported by RSF. Project number 14-14-00625.

Figure 1

Table 1. Changes in the content of potentially mineralizable carbon in the soil as a result of optimal, deficient and periodic soil moisture

Treatment	mg/100 g	% Corg
Initial soil before the experiment	102±1	7.0
Corn*		
Optimal moisture	63±0	4.8
Deficient moisture (drought)	71±1	5.5
Periodic moisture (two drying-wetting cycles)	68±0	5.2
Bare fallow*		
Optimal moisture	51±0	3.7
Deficient moisture (drought)	64±0	4.5
Periodic moisture (two drying-wetting cycles)	57±0	4.1

* Note: Soil samples take out after 90 days of experiment

Table 2. Mineralization loss of organic carbon from the soil under different moisture regimes, mg/100 g

Treatment	Decrease of potentially mineralizable SOC	Cumulative amount of C-CO_2 emission for 90 days
Corn*		
Optimal moisture	39	67
Deficient moisture (drought)	31	43
Periodic moisture (two drying-wetting cycles)	34	52
Bare fallow*		
Optimal moisture	51	47
Deficient moisture (drought)	38	31
Periodic moisture (two drying-wetting cycles)	45	39

IT 2.6

Linking pools and fluxes of soil organic carbon

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Introduction

Input and losses of organic carbon (OC) from soils are important ecosystem fluxes determining soil carbon storage and the role of soils as source or sink of CO_2. The turnover time links soil C stocks and fluxes, as it is defined as the C pool size over the annual C flux at equilibrium. Accordingly, the CO_2 efflux from soils can either be measured directly, as soil respiration, or by determining soil C stocks and their turnover time. Both approaches have their limitation. It is for example notoriously difficult to separate heterotrophic from autotrophic respiration in the field, and turnover time estimates based on radiocarbon analyses require equilibrium and knowledge about time lags before fixed plant C is entering the soil or soil compartments. The combination of both approaches can be used to verify the results and give interesting insights in the dynamics of soil OC.

Methods

The Hainich National Park is an old-growth deciduous forest in central Germany. Heterotrophic soil respiration was measured with root exclusion. Soil OC stocks and their radiocarbon (^{14}C) content were determined up to 60 cm soil depth in bulk samples and density fractions. Soil samples from different layers were also incubated in the laboratory and the CO_2 evolution per g OC was determined. Furthermore, labelled root litter was incubated in the field to study its fate and transfer to the mineral associated fraction.

Results

Annual heterotrophic soil respiration was on average 436 g C m^{-2} yr^{-1}. Laboratory incubations revealed that around 40% of this flux is probably derived from the litter layer, 35% from the topsoil, and 25% from the subsoil. Accordingly, C turnover times would be 28 years for the total soil profile. In 0-5 cm depth, the annual flux would be 101 g C m^{-2} with a turnover of 23 years. This is not in agreement with results of a ^{14}C-based standard one-pool model. This suggests either a turnover of 3 years or 118 years for 0-5 cm with corresponding CO_2 fluxes of 1022 or 23 g C m^{-2} yr^{-1}. As bulk soil C is composed of a mixture of labile and stable C, looking at density fractions might give a better picture. Here, the same ^{14}C-based modelling approach suggests turnover times of 11 years for the free light fraction (fLF), 102 years for the occluded light fraction (oLF), and 119 years for the mineral associated fraction (HF), resulting in total C fluxes of 39 g C m^{-2} yr^{-1}. This flux can be increased by assuming a lag-time for root litter input, which reduces turnover times of the fast fLF. A lag-time of 4 years would for example lead to total fluxes of 47 g C m^{-2} yr^{-1}.

A repeated ^{14}C inventory in 2004 and 2009 revealed that also the HF has a fast cycling component. But it is not possible to constrain the amount and turnover time of the fast fraction with these two time points. It possibly ranges from 43 to 83% of HF-OC and from 11 to 27 years. The chemical oxidation of HF-OC with H_2O_2 revealed that 6% of OC in the HF has a turnover time of 1750 years, while the larger part has a turnover of 10 or 63 years. A turnover time of 10 years would lead to unrealistically large fluxes, while no ^{14}C change would be detectable between 2004 and 2009 with a turnover of 63 years. This result shows that while this harsh chemical treatment is able to isolate a fraction with very old C, it also does not separate the soil into a homogenous fast and slow fraction which can be used to estimate fluxes.

However, for the ^{14}C approach one also has to consider that carbon transported from one fraction to the next is already pre-aged. We still know comparatively little about the partitioning of new C entering the soil between respiration and transfer to the oLF and HF, or how much is leached as dissolved organic carbon (DOC) and possibly sorbed in deeper soil layers. In a field experiment, we found that after 1.5 years of field incubation, about 20% of labelled root derived C entered the HF while 60% were lost either as CO_2 or DOC.

The flux-approach suggested that a quarter of bulk soil fluxes were derived from subsoils. But very old average subsoil ages suggest almost no subsoil fluxes. The chemical fractionation of the HF revealed that also the oxidized OC is getting older with depth. Accordingly, the fLF should have a large contribution to total fluxes, as 45% of this fraction is found in the subsoil with modern radiocarbon ages. We will calibrate the soil profile model COMISSION, which explicitly represents mineral associated C, for the Hainich site, to see how our model understanding fits with the observed data.

Conclusion

Our results suggest that fluxes are good constraints when studying pools and ^{14}C-based turnover times. While the ^{14}C-based approach tends to underestimate fluxes, the flux approach alone gives no information on the C sources and the presence of old, stable C.

O 2.6.01

Partitioning of litter carbon fluxes between CO_2 and DOC using a MODEX approach

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As litter decomposes a fraction of its carbon is lost to the atmosphere as respired CO_2, while 0-39% is transferred to the soil through the processes of leaching and fragmentation. It is now recognized that a large fraction of this litter carbon input to SOM occurs through the leaching of dissolved organic matter (DOM), particularly during the early phases of decomposition. The DOM contribution to the soil may be utilized by microbes, stabilized in the soil, or leached further through the soil profile. The rate of DOM leaching from litter to the soil, as well as its chemical composition has strong implications on the degradability or long-term storage of litter derived C in the soil. In a combined modeling and experimental study (MODEX), we investigated the contribution of different types of decomposing litter to CO_2 and DOM fluxes during decomposition. We found strong relationships between the % hot water extractable C in the litter and the lignocellulose index to DOM and CO_2 fluxes during decomposition. We also found evidence for N controls on DOM production during decomposition, which are currently being further explored. We characterized changes in litter and DOM chemistry during the incubation using acid and neutral detergent fiber methods, as well as mid-IR-FTIR, to investigate what litter components were contributing to the fluxes over time. We utilized these experimental results, other literature values, along with a Bayesian Hierarchical framework to parameterize a new Litter Decomposition and Leaching Model (LIDEL). LIDEL is structured as a new sub-model within the DayCent model framework. It mechanistically represents how non-structural, cellulose and lignin components of litter, as well as the C:N ratio, control the efficiency with which microbes utilize litter C and transform it to CO_2, DOC and microbial products in the soil. The ability to predict DOC leaching from litter to the soil based on litter chemistry and CO_2 efflux greatly enhances our ability to model carbon transformations during decomposition to connect litter pools with C fluxes to the atmosphere and soil.

O 2.6.02

Decomposition of ^{13}C labeled roots and shoots of three winter crops under no-til field conditions

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Little is known about the decomposition rates of intact plant roots under no-tilled (NT) field conditions. This knowledge is important to estimate the carbon sequestration potential of crops. The objective of this experiment was to estimate the amounts of C mineralized from roots and shoot residues decomposing simultaneously in actual field conditions under NT.

The experiment was conducted at Federal University of Santa Maria (UFSM), Rio Grande de Sul (RS), Brazil in 2013 and 2014. Wheat (*Triticum aestivum* L.), pea (*Pisumsativum* L.) and vetch (*Vicia sativa* L.) plants were grown inside polyvinyl (PVC) cylinders (20 cm i. d. and 30 cm l), hydraulically forced into the field of sandy loam textured Typic Paleudalf. After 20 days of emergence, crops were pulse labeled weekly with $^{13}CO_2$ in the field until the flowering stage. Wheat and pea plants were harvested at maturity and vetch plants at flowering. The above-plant parts were dried, kept separately and analyzed for the C and ^{13}C contents, N and chemical fractions. Initial characteristics of roots and soil were also determined. The treatments used for the decomposition study were designed by combining ^{13}C labeled shoots with unlabeled roots (LS) and unlabelled shoots with ^{13}C labeled roots (LR) (root + soil), resulted in six treatments, WLS and WLR for wheat, PLS and PLR for pea and VLS and VLR for vetch (hereafter, “paired treatments”).The stems were cut into 10 cm pieces and a mixture of leaves and stem of each crop were placed inside soil cylinders at a rate of 5 Mg ha^{-1}. Alkali traps were used to measure total soil respiration during 180 days of field decomposition. Total C-CO_2 and ^{13}C-CO_2 emitted were measured periodically during 180 days, for all paired treatments, and the contributions of roots, shoots and soil to total were determined over time.

No significant differences in total C-CO_2 emitted were found between paired treatments of wheat (WSL and WRL), pea (PSL and PRL) and vetch (VSL and VRL), allowing to use the paired treatments for calculating the respective contribution of roots, shoots and soil to total respiration. There was also little differences in cumulative apparent mineralization between the three types of crop residues, with 54 ± 8.8 % added C for wheat, 54 ± 3.4 % added C for pea and 51 ± 3.4 % added C for vetch which could be explained by rather similar initial chemical composition of the plant residues. The calculations based on dilution equation with paired treatments, indicated first that soil (SOM) mineralization was the major CO_2 source over the incubation. Then the mineralization of root residues were always higher than that of shoot residues:73 % added root C vs. 45 % added short C for wheat, 76 % added root C vs. 48 % added shoot C for pea, 73 % added root C vs. 51 % added shoot C for vetch. Therefore the results showed clear differences in the decomposition of intact roots and above-ground residues during 180-day “incubation” under field conditions.

The faster roots decomposition observed, besides higher lignin content and lower soluble fraction, suggests that the residues location, the soil-residue contact, the more favorable soil moisture are important factors that significantly promoted roots decomposition. This work provides a framework for further studies focusing on the actual decomposition and contribution to soil C of “intact” roots residue under field conditions.

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O 2.6.03

Microbial communities, functional genes and nitrogen cycling processes in forest floors under four tree species

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How nitrogen (N) is cycled in forests is important for understanding ecosystem productivity, and the role of forests as sinks and sources of greenhouse gases. To determine the effects of tree species on N cycling, we studied two sites within a common garden experiment. We used the ^{15}N pool-dilution method to estimate gross and net rates of N mineralization and nitrification in forest floor soils from western red cedar (*Thuja plicata*), western hemlock (*Tsuga heterophylla*), Douglas-fir (*Pseudotsuga menziesii*), and Sitka spruce (*Picea sitchensis*). We used qPCR to determine the bacterial and fungal abundance under each tree species, and the abundance of functional genes associated with nitrification (AOA *amoA*, AOB *amoA*) and denitrification (*nirS*, *nirK*). Microbial communities for AOA *amoA* and *nirS* differed amongst tree species, while AOB *amoA* and *nirK* did not. This suggests that tree species foster different abundances of nitrifying and denitrifying functional groups, and differences in pools and fluxes of N. The genetic potential for denitrification was strongly influenced by the abundance of ammonia oxidizers within forest floors. Functional genetics were related to rates of N cycling processes suggesting the method can be used to explore the mechanistic link between tree species effects on soil microbes, and the nitrogen cycling processes regulated by those microbes.

O 2.6.04

Soil pH increased by liming decreases mineralisation of added plant residues and existing SOM pool

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1. Introduction

Lime is widely used in agricultural production to create and maintain a soil pH suitable for plant growth. Long-term liming can be expected to increase soil pH and increase organic matter input to soils. This additional flux of C into the soil may be physically stabilised by the change in structure that liming can also induce, increasing the pool of slow-turnover SOM. Alternatively, the additional organic matter may be easily decomposable (fast turnover pool) and thus highly susceptible to priming when new crop residues are added. Liming history may also affect nitrogen (N) transformations in the soil, via the change in pH and also by the addition of new SOM.

2. Objectives

The objectives of this study were threefold: 1) To assess the effect of liming history on the decomposition of existing SOM and added crop residues; 2) To quantify the priming effect of added crop residues on the decomposition of existing SOM; 3) To quantify the N transformations induced by different liming histories and the interaction with added crop residues. The study was designed to test the following hypotheses:

• Historically limed soils will exhibit greater total OM decomposition

• Historical liming will increase the rate of decomposition of added crop residues

• The priming effect of added crop residues will be greater in historically limed soils

3. Materials & methods

^{13}C-labelled wheat resdiue was applied to 8 soils from long-term lime trials which spanned a range of pH and initial SOM contents. The soils were incubated for 3 months at 25°C and 80% field capacity. The flux of CO_2 from the SOM pool and the residue pool were characterised by trapping the evolved CO_2 in NaOH, titration against HCl and precipiation with $SrCl_2$ to form a $SrCO_3$ precipitate for IRMS analysis, at 1 week, 1 month and 3 months. Microbial biomass C and N, extractable organic C and N, pH, NO_3^- and NH_4^+ were measured at 1 and 3 months.

4. Results and Conclusions

Initial results indicate decreasing CO_2 release with increasing soil pH, resulting from the historical applicaiton of lime. Total CO_2 flux is dominated by the effect of the added residue. The effect of pH is clearly evident in the CO_2 released from the added residue pool, with a decrease in the mineralization of wheat residue with increasing soil pH. Increases in pH by historical liming are also associated with decreases in the mineralization of the existing SOM pool. Further analyses are underway to elucidate the mechanisms involved.

O 2.6.05

In situ seasonal hysteresis in litter heterotrophic respiration in a warm-temperate forest

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1. Introduction

In forest soil, heterotrophic CO_2 efflux source consists on various substrates (e.g., leaf litter, root litter, coarse woody debris, SOM). The components of heterotrophic respiration are of interest because each can differently respond to environmental factors (temperature, moisture) due to their physical and chemical property, and their location in the soil. Thus, the monitoring the flux and the controlling factors of individual component can lead to accurate quantification of heterotrophic respiration and thus, soil carbon dynamics. Most heterotrophic respiration is derived from recently produced material including labile carbon (Trumbore, 2000), and the variability in the CO_2 efflux affects soil respiration on short time scale despite of small fraction of soil organic carbon because of rapid decomposition (Gu et al., 2004). Among heterotrophic CO_2 sources, the leaf litter layer (L layer) is a significant reservoir of labile carbon and a large potential source of CO_2 efflux from forest soil. The CO_2 efflux from the L layer (R_{LL}) is strongly affected by environmental factors, especially moisture. However, there is little information about evaluation of temporal variation in R_{LL} and the response to instantaneous environmental changes such as moisture and temperature because of the difficulty of the direct measurement of R_{LL} and water content of the L layer (W_{LL}) in situ.

2. Objectives

In this study, focusing on rapid wetting and drying cycle of the L layer, we evaluated response of their CO_2 efflux to environmental factors (W_{LL} and temperature) using direct and continuous data of R_{LL} and environmental factors measured for two years.

3. Patients & methods or Materials & methods

This study was performed in a warm-temperate deciduous forest (Yamashiro experimental forest), Kyoto in Japan. The L layer mainly consists of *Quercus serrata* Thunb. and the thickness is about 3 cm. We directly measured in situ R_{LL} and W_{LL} every one hour for two years (January in 2013 to December in 2014), by using the designed methods. To continuously measure CO_2 efflux from the L layer only, we developed an approach for measuring R_{LL} by using an automated chamber method in a treatment area in which all potential CO_2 sources (e.g., SOM and fine roots) except for the L layer were replaced with combusted granite soil (non-organic soil) (Ataka et al., 2014, PLOS one). Also, W_{LL} was measured with capacitance sensors which some intact leaf litter was closely attached with rubber band (Ataka et al., 2014, Appl. Environ. Soil Sci.). To evaluate contribution of R_{LL} to soil respiration (Rs), we also measured Rs near the treatment area of R_{LL}. Additionally, we measured the potential microbial activity using substrate induced respiration method (SIR) every month from December 2013 to November 2014.

4. Results

In the result, R_{LL} dynamically varied from nearly zero to about 0.07 mgCO_2 m^{-2} s^{-1} and the temporal variation in the contribution to Rs changed from nearly zero to 51 % throught the measurement period. R_{LL} substantially showed seasonal variation following temperautre changes. On short-term scale (rainfall events), R_{LL} increased with W_{LL} and, subsequently, decreased following drying of the L layer. The R_{LL} and W_{LL} reached a peak during or one day after rainfall events, and fell to pre-wetting levels within 2-4 days after rainfall events. Thus, temperature responses of R_{LL} strongly depend on W_{LL}. The contribution of annual R_{LL} to Rs was 8.6 %. Moreover, the relationship between R_{LL} and temperture under the high W_{LL} (>1.5 g g^{-1}) showed seasonal hysteresis behavior; R_{LL} in spring is about 3 times higher than that in fall under similar temperature condition. Moreover, SIR also showed seasonal hysteresis behavior; higher in spring than that in fall.

5. Conclusion

Temporal variation in the contribution of R_{LL} to R_S varied from nearly 0% to 51% following rapid wetting and drying cycle of the L layer. It indicates that R_{LL} is significant component of transient temporal variation in Rs associated with rainfall events. Moreover, R_{LL} showed seasonal hysteresys behavior due to decrease of the potential microbial activity with the decomposing process of the L layer. These suggest that quantying effect of interaction between environmental factors and substrate quality on heterotrophic respiraiton need to understand soil carbon dynamics.

O 2.6.06

Soil organic carbon pools, fluxes and stock change following conversion to tropical perennial pasture in New South Wales, Australia

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Introduction

Conversion of cultivated land to tropical perennial pasture has been promoted in temperate/sub-humid New South Wales (NSW) for enhanced production, soil conservation, improved soil condition and carbon storage. As a result, these tropical pastures have been established extensively on agricultural lands across much of northern NSW but little is known of their actual effect on soil organic matter cycles. Tropical pastures are dominated by C4 species which contrast with the C3 crop species that have been grown historically. This provides an opportunity to use stable isotope (δ13C) analysis in combination with conventional methods (LECO) to examine SOM turnover and the changes in soil organic carbon (SOC) stocks, pools and fluxes that take place through time down the soil profile as a result of this land-use change.

Objectives

Here we examined 30 sites near Gunnedah, NSW, where conversion to tropical pasture had taken place within the last 20 years. At these sites, we aimed to determine the nature of change in SOC stock and the contribution of “new” carbon to the soil profile that had resulted from this land-use change. At a long-term, experimental field site, we undertook repeat sampling (0, 7 and 11 years) to provide more detailed and controlled examination of the processes and mechanisms of change in SOC stocks, pools and fluxes through time resulting from pasture conversion.

Materials and Methods

Thirty sample sites were established across the Liverpool Plains near Gunnedah in northern NSW. All sites had been converted from conventional cropping to tropical perennial pastures at some point in the last two decades and each was paired with a control site.

All soils were sampled on a randomized grid design to 0-30cm depth in 0-5, 5-10, 10-20 and 20-30cm depth increments using an undisturbed core method. At the long-term experimental site, a smaller number of additional samples were also collected to 1.0m depth. Bulk density was calculated for each individual sample.

The nature of change in SOC stock was determined by analysis of total SOC (LECO). Using stable isotope analysis (δ13C) in both bulk soil, SOC fractions and DOC, we determined the quantity, rate and mechanisms of “new” carbon addition to soils and the net effect on SOC stock. From these data we could infer mechanism and fluxes of SOC change.

Results

A strong response to pasture establishment was observed in soil carbon with up to 35% addition of “new” carbon in the 0-30cm layer, although this enrichment diminished with increasing soil depth. However, total SOC stock was largely unchanged despite this carbon addition.

Analysis of SOC fractions indicated a dominance of surface inputs to the concentration of SOC and redistribution processes principally through DOC translocating new carbon to depth in the soil. These analyses provide an insight into the turnover and dynamics of SOC pools, DOC and their importance to SOC distribution and fluxes following this profound land use change.

Conclusions

Tropical pastures in this environment undoubtedly add significant quantities of carbon to previously cultivated soils but SOC turnover processes are such that this need not result in long-term increase in SOC stock. Soil organic carbon concentrations are driven by surface inputs and processes of transport to deeper layers principally through dissolved organic carbon.

O 2.6.07

Field vegetation dominates the forest clear-cut carbon balance after stump harvest

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Introduction

Stump harvest is widely discussed as a means to produce bio-energy in Sweden. However, the effects on the forest carbon (C) balance and thereby the substitution efficiency of stumps as bio-energy are yet unknown. Primarily, CO_2 emissions from stump-harvested clear-cuts should be lower due to smaller amounts of decomposable material ("direct effect"). On the other hand, increased CO_2 emissions caused by soil disturbance and changes in CO_2 uptake because of effects on vegetation development are expected ("indirect effects"). To assess the substitution efficiency of tree stumps these effects on the C balance have to be known and quantified. The overall climate impact of stump harvest can then be estimated by up-scaling to a rotation period and relating stump decomposition to instant burning.

Objectives

We aimed at quantification of the C balance of different forest clear-cuts with and without stump harvest as a base for estimation of the substitution efficiency of tree stumps as bio-energy. Different site conditions and degrees of disturbance were evaluated to indicate where, how and when stump harvest is most beneficial for the climate system.

Material and methods

During three years we did campaign-wise measurements of CO_2 fluxes at adjacent pairs of forest clear-cuts of which one was subject to stump harvest. Measurements were done by the eddy-covariance method with combined sonic anemometers and open-path gas analyzers (IRGASON, Campbell Scientific, Logan, USA). The site-pairs were placed in mid Sweden and northern Sweden and differed in climate, fertility and degree of disturbance. Measurements were done for a couple of weeks on each site, covering all seasons on all sites.

In addition, continuous flux measurements were done at one stump-harvested site and related to chamber measurements of an adjacent, non-stumped clear-cut.

Results

On the continuous site, where the field vegetation was unaffected by stump harvest, a small, increasing trend towards higher CO_2 emissions was observed after stump harvest. These emissions were strongest during the third year, when they more or less balanced the emission reduction caused by the absence of stumps (the direct effect). But in contrast, on most sites a small reduction of CO_2 emissions was observed immediately after stump harvest, which, however, was accompanied by an even stronger decline of CO_2 uptake by field vegetation. The reason was a reduction of the amount of field vegetation as a side-effect of stump harvest. Thereby, the C balance changed towards larger net C losses after stump harvest. This trend was visible at all sites, but to different extents depending of the abundance of field vegetation and the degree of disturbance.

Conclusions

The rate of vegetation development rather than the degree of soil disturbance seems to be the key factor controlling the forest C balance after stump harvest. Initially, the stump harvested sites emitted more CO_2 than the non-stumped clear-cuts, indicating an indirect effect that reduces the substitution efficiency. However, field vegetation is likely to recover quickly on the stump-harvested sites due to the efficient soil scarification that goes along with the disturbance. Thereby the extra emissions are expected to be counteracted by increased uptake during the forest recovery period. Together with the surprisingly low gross emissions from the soil after stump harvest we expect the substitution efficiency to be fairly good on the long run. However, additional radiative forcing by instant burning instead of slow decomposition of stumps has also to be considered.

O 2.6.08

The fate of above- and below-ground litter across ecosystems and its feedback to climate

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Question: Litter input rate into soil surface as well as into soil profile is experiencing substantial changes under global climate and management changes. Across ecosystems, it is unclear about the mechanisms controlling aboveground and belowground litter decomposition, and how litter decomposition responses to climate and management changes.

Methods: Combining data assimilation with decomposition model, we synthesized datasets in the literature enabling the tracing of CO_2 fluxes evolved from fresh carbon inputs. The datasets included observed data from 143 independent experiments under different ecosystems and substrate inputs. A one-pool litter decomposition model is fitted to the datasets. A multilevel regression model was used to assessed the effects of climatic conditions (soil temperature and moisture), soil properties (pH, clay and sand content, C:N ratio), and the litter quantity and quality (C:N ratio, root exudates-like and plant residue-like substrates) on the derived decomposition rates of the three pools.

Results: The results indicated that the three-pool model could well predict the litter mass loss with time. However, the fitted decomposition rates varied widely depending on experimental conditions and characteristics of the litter. For root exudates-like litter substrates, its decomposition depended on soil temperature and moisture, and soil C:N ratio. For plant residue-like substrate being applied on the soil surface, its decomposition also associated with soil temperature and moisture, but the degree and extent of the association changed with substrate amount and quality. For plant residue-like substrate being buried, however, soil properties including pH, clay and sand content, soil C:N ratio override climatic and litter variables to impact its decomposition. The regression model was used to infer the fate of litter under different scenarios representing potential consequences of climate and management changes.

Conclusions: The results in this study will benefit effective estimates of soil carbon balance across ecosystems under changing above- and below-ground inputs as consequences of climate and land management changes.

O 2.6.09

The challenge of linking soil C fluxes and pools: The case of the IPCC emission factors for drained tropical peatlands

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Tropical peatlands in their pristine state are among the most C-rich ecosystems on earth with average C densities of 200 Mg C ha^{-1} in their phytomass and 200-900 t C ha^{-1} per meter of soil. In Southeast Asia peat swamp forest are being deforested at an alarming rate, releasing huge amounts of greenhouse gases into the atmosphere during fire events, either wild or for land-clearing, and following drainage and cultivation of e.g. oil palm. Characterizing the magnitude of these emissions is critical in the policy arena, given the extent of worldwide oil palm expansion and the recurrent major haze events caused by Indonesian peat fires. Given the lack of wetland and more specifically peatland emission factors in the 2006 IPCC guidelines for national greenhouse gas inventories, new specific guidelines were published by the IPCC in 2014. The soil C flux approach was the prevailing method used for developing the emission factors across all regions. The rationale for using this method for the tropical emission factors was based on data availability and the fact that it is nearly impossible to measure the changes over time in peat C stocks. However an alternative approach was considered; this consists in monitoring peat subsidence or absence of subsidence and assigning it a portion which is due to SOM mineralization. This talk will present the results from both approaches and their discrepancies.

P 2.6.01

GHG quantification from rice production system using δ13C natural abundance

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Elevated GHG emissions particularly methane (CH_4) from lowland rice production systems leads to high global warming potential (GWP). The strategies such as, altering water and residues (carbon) management practices are assumed to be essential to mitigate the GHG emissions from flooded rice system.

We investigated the relative contribution of added organic amendments and native soil carbon on GHG emissions in flooded rice, and the potential of drainage on reducing either of the two fluxes. Rice plants were grown in pots under control conditions in growth chamber with 2×2×3 factorial design. The treatments were: an arable soil with two different carbon pools (Check: 1.3 and 2.5%); two water regimes (mid-season drainage and early plus mid-season drainage); three nutrient treatments (control, maize straw and maize compost). We hypothesized that i) methane emission would increase according to the amount of labile carbon in the amendments, ii) that early season drainage will as effective as mid-season drainage in reducing emissions from the amended materials and iii) that drainage will be ineffective in reducing soil-C derived methane.

The highest accumulative methane was observed from labile C source (straw) under mid-season drainage from both high (198.6 g m^{-2}) and low (258 g m^{-2}) C-soils. Alternatively, highest accumulative nitrous oxide was observed under control treatment (mineral fertilizer) with early drainage from both high (10.2 g m^{-2}) and low (12.1 g m^{-2}) C-soils. Early drainage in combination with midseason drainage has a strong effect on CH_4 emissions reduction from flooded rice production. Background soil C has no effects on CH_4 and N_2O emissions in relation to drainage practices in short period. Total organic C suddenly declined following mid season drainage in all tratments. To investigate the contribution of background soil C and added organic amendments, the gas and water samples will be analysed for δ13C CH_4 emission and total dissolved organic C.

Similar field experiment is required for real and important implications for the choice of relevant and realistic mitigation practices (early vs. mid-season drainage) as well as short and long-term implications of use of organic amendments on GHG emissions without any compromises on rice yield.

P 2.6.02

Impact of residue addition on soil nitrogen dynamics in temperate cereal-legume intercrops

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Nitrogen (N) is an essential nutrient for plant productivity and soil microbial activity. Thus, soil N transformations are key processes that drive soil fertility, ecosystem functions and services. The primary goal of this study was to evaluate the flow of N from added soybean or maize residues in soil from two differently configured cereal-legume intercrops and in cereal and legume sole crops. This was achieved through a short-term incubation study using the $\delta^{15}N$ natural abundance method. Soil total N (TN) was not significantly different ($p<0.05$) among treatments. Residue addition significantly increased ($p<0.05$) N concentration in the light fraction (LF-N) and soil microbial biomass (SMB-N) compared to the Cont (non-residue amended) treatment; and was significantly different ($p<0.05$) between intercrops and sole crops. The SMB-N decreased significantly (0.05) with time in residue amended treatments but not in Cont treatments. Intercrops amended with soybean residue had a significantly greater ($p<0.05$) SMB-N, but was significantly lower ($p<0.05$)) in maize amended intercrop treatments. Treatments amended with soybean residue were significantly enriched $p<0.05$)) in $\delta^{15}N$-TN and $\delta^{15}N$-LF. The $\delta^{15}N$-SMB was significantly enriched ($p<0.05$) compared to the residues and $\delta^{15}N$-TN. Residue amended treatments had significantly lower ($p<0.05$) N_2O emissions than Cont treatments. However, N_2O emissions were not significantly different ($p<0.05$) between soybean and maize amended treatments, nor between intercrop and sole crops. Emissions of N_2O stabilized in all treatments, including the Cont, after 70 days of incubation. Our results demonstrate that the effect of maize or soybean residue addition influenced soil N transformations in sole crops and intercrops.

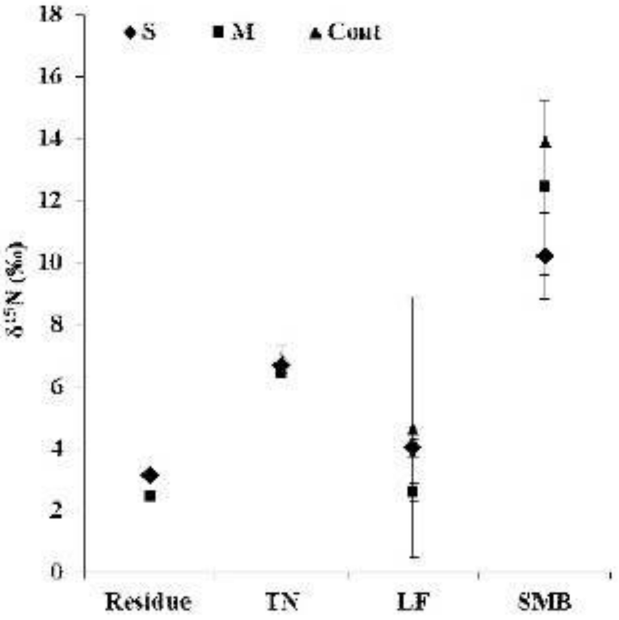
Figure 1

Figure 1
Schematic of the incubation experiment design with three replications per treatment.

Figure 2

Figure 2

Overall mean values of $\delta^{15}N$ (‰) of soybean and maize residue, soil total nitrogen (TN), soil light fraction nitrogen (LF-N) and soil microbial biomass nitrogen (SMB-N) for treatments with added soybean (S) and maize (M) residues and control (Cont) treatments with no residue added.



P 2.6.03

Characteristics of N_2O emission pathways and related microbial community after ammonium nitrogen fertilization from a calcareous vegetable soil

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Nitrous oxide (N2O), as the most important greenhouse gas (GHG) emitted from dryland soils is a more effective GHG contributed greatly to climate warming. N2O is mainly produced by bio-processes mediated by microorganisms such asautotrophic nitrification, nitrifier denitrification, de-nitrification, heterotrophic nitrification etc. Due to the increased planting area and intensive management for example higher nitrogen application rate, frequent irrigation and planting-harvest cycles, N2O emission from vegetable soils may contribute great share in the nation GHG inventory. Identifying the specific pathways of N2O emission and their proportion in N2O emission from vegetable soils may reveal more scientific understanding on targeted mitigation practices.

This study aims to identify the contribution of different N2O pathways on N2O emission and the dynamic changes within 18d when ammonium nitrogen is fertilized in calcareous vegetable soil adopting different air inhibitor or inhibitor combination. In the mean time, the abundance, diversity and community composition of nitrifier (eg. Ammonia-oxidizing Bacteria-AOB and Ammonia-oxidizing Archaea- AOA) and denitrifier (eg. nirS, nirK and nosZ) were investigated at the key point (ie. higher ammonium content, higher nitrate content, medium content both ammonium and nitrate) using q-PCR and high-throughput sequencing method.

METHODS: We used both the combined gas inhibitors or single gas inhibitor (ie. C2H2, H2, O2, O2+C2H2) to distinguish the different pathways of N2O emissions. Soil microbial molecular ecological methods were also used such as qPCR and high-throughout sequencing technologies to detect the copy number, diversity and relative abundance of main nitrifiers and de-nitrifiers related with relative pathways.

Following **conclusions** were drawn in this study.

Contributed 30% and 56% share of cumulative N_2O emissions respectively during 18d, autotrophic nitrification and nitrifier denitrification were two main N_2O producing processes after ammonium was fertilized. The proportion of produced N_2O in the total N_2O emission fluxes were decreased from 60% to 3% for nitrifier denitrification and 30% to 23% for autotrophic nitrification with the increase of incubation time since fertilization during 18 days period.

Contribution of denitrification to the cumulative N_2O emissions in 18 days incubation was limited, explaining 14% N_2O emission share, and its share showed increase from 9% in the higher ammonium content period (day1-day6) to 58%-70% in the higher nitrate content period ()day9-day18) to the N_2O emission fluxes.

Abundance of AOB and AOA did not show significant change during 18 days incubation after ammonium fertilization, but the relative proportion of different species were varied . One of specie ie. *Nitrosomonas _sp._AL212* of Nitrosomonas and four species including *Nitrosospira_sp._Wyke2, Nitrosospira_sp._PJA1, Nitrosospira_sp._EnI299,* and *Nitrosospira_sp._EnI299* of Nitrosospira accounted higher proportion at higher ammonium content period. These species may contribute greatly to nitrification and nitrifier denitrification.

The characteristics of three denitrifier (nirS, nirK, nosZ) showed different during 18 days incubation after ammonium fertilization. With the continuing of incubation, denitrifier with nirS gene function was expresses increase in the dimension of diversity; denitrifier with nirK gene function showed increase in the aspect of abundance; denitrifier with nosZ gene function showed different proportion in the total nosZ community.

P 2.6.04

Formation of pedogenic carbonates by tillage and straw incorporation and their contribution to carbon storage in soil

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The importance of tillage and straw return on soil organic carbon (SOC) is well established, but their effects on soil inorganic carbon (SIC), which is the potentially important carbon storage due to its far longer turnover times compared to SOC, has been poorly studied. The objective was to study the impact of land use change and tillage practices on SOC and SIC content down to 160 cm depth in a semi-humid/semi-arid region of China. The SOC and SIC content and stocks were measured, and $\delta^{13}C$ values were used to calculate the percentage of pedogenic carbon (PC) and lithogenic carbon (LC) in the total SIC. The experiment consisted of three treatments initiated 13 years before, i.e., Tillage and Straw return (TS), Tillage without straw return (T), and Straw return without tillage (S). A natural fallow plot (F) was used as a reference to assess the impact of land use change from natural vegetation to intensive agriculture 39 years ago. Over the 39-year period, tillage caused decrease in SOC in TS compared to F plot. TS and T lost up to 160 cm depth 0.16 and 0.09 Mg SOC ha^{-1} yr^{-1}, respectively. However, Straw increased SOC for 0.12 Mg ha^{-1} yr^{-1}. Contrary to loss of SOC, TS and T increased SIC for 2.13 and 1.82 Mg ha^{-1} yr^{-1}, which was higher than F and S. There was also an increase of 0.87 Mg SIC ha^{-1} yr^{-1} in S that was higher than F only. PC and LC among the tillage treatments revealed that PC in TS treatment was higher than S and T at all the depths, but the differences were not significant. LC stocks were significantly lower in S compared to TS and T, indicating the dissolution of LC in S. Maximum potential for PC formation depends on Ca^{2+} and Mg^{2+}, which was provided by irrigation water. However, tillage and straw incorporation influenced Ca^{2+} and Mg^{2+} availability. The loss of SOC due to tillage was offset by the gain in PC formation in TS and T treatments. This implies that the biogenic CO_2 released during the decomposition of organic matter played an important role in the formation of pedogenic carbonates. With decreased decomposition of SOC in no-tillage in S treatment, the PC were formed at the expense of dissolution and re-precipitation of LC. These results indicate that the PC should be considered during estimation of soil carbon stocks and the development of optimal irrigation, tillage, straw management and land-use practices.

Key words: Land use; Tillage; Straw return; Soil organic carbon; Soil inorganic carbon; Pedogenic carbonates; Stable C isotopes.

Figure 1

Table I Soil organic carbon (SOC), soil inorganic carbon (SIC), and total carbon (TC) stocks (Mg C ha^{-1}) depending on soil depth*

Treatments	0-20 cm			0-100 cm			0-160 cm		
	SOC	SIC	TC	SOC	SIC	TC	SOC	SIC	TC
F	21.0±1.1a	17.1±5.0b	38.1±4.5b	57.9±4.7a	108.6±3.9b	166.5±0.8a	71.3±4.6a	189.4±14.2c	260.7±16.0b
TS	22.6±1.6a	25.3±2.3a	47.9±2.7a	45.7±4.6b	144.1±9.9a	189.8±10.9a	65.1±5.6a	270.5±3.1a	335.58±5.9a
T	23.3±4.7a	21.0±1.5ab	44.3±5.1ab	51.7±8.4ab	136.3±6.4ab	187.9±12.5a	67.0±11.1a	258.5±19.9a	326.38±28.6a
S	24.0±0.8a	20.9±3.0ab	44.8±1.3ab	57.0±2.4ab	124.4±11.3ab	181.5±13.5a	75.8±1.7a	222.6±8.4b	298.40±9.9ab

Values are mean ± standard deviation.

Where F: natural fallow; TS: tillage and straw return; T: tillage without straw return; S: straw return without tillage.

Different letters within a column indicate significant differences (P<0.05) between the treatments.

Figure 2

Table 2 Stocks (Mg C ha^{-1}) of pedogenic carbon (PC) and lithogenic carbon (LC) depending on soil depth

	0-20 cm		0-100 cm		0-160 cm	
Treatment	PC	LC	PC	LC	PC	LC
TS	8.32±1.51 a	16.93±1.51 a	41.56±2.19 a	102.54±10.74 a	97.05±5.47 a	173.43±7.88 a
T	5.93±2.80a	15.08±1.35 ab	34.40±10.11a	101.87±4.14 a	93.47±20.56a	164.97±5.79 a
S	6.13±0.59 a	14.72±1.46 ab	37.67±11.19 a	86.74±1.82 b	78.23±12.55 a	144.34±4.21 b

Values are mean ± standard deviation.

Where TS: tillage and straw return, T: tillage without straw return, S: straw return without tillage.

Different letters within a column indicate significant differences (P<0.05) between the treatments.

P 2.6.05

Impacts of tillage, fertilizer type and plant residue input on soil carbon sequestration rates on an Andosol in northern Japan: a comparison of results from soil carbon stock change and carbon balance

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1. Introduction

Field management practices that can enhance soil carbon (C) sequestration and contribute to mitigating the increase in atmospheric CO_2 concentrations have attracted growing interest for Japan's farmers and policymakers. On a plot scale, several approaches have been used to assess the impacts of field management practices on soil C sequestration rates in agricultural land although limitations and uncertainties inherent to those approaches exist. One is the direct measurement of differences in soil C stocks for a certain period of time. Another approach is the measurement of differences between CO_2 emissions from soil under root exclusion and organic C inputs from composted animal manure and crop residues.

2. Objectives

We assessed the impacts of tillage, fertilizer type and plant C input on soil C sequestration rates on an Andosol, a well-drained volcano ash-derived soil in northern Japan. The results from the above-mentioned two approaches were compared in terms of impacts of those field management practices on soil C sequestration rates.

3. Materials & methods

The 4-year crop rotation field experiment was conducted at the Hokkaido Agricultural Research Center, NARO from April 2007 to March 2011. Crops tested were potato (May 2007 to September 2007), winter wheat (September 2007 to July 2008), sugar beet (May 2009 to October 2009) and soybean (May 2010 to October 2010). The experimental field was set up in a split plot design with three factors. Each treatment combination was replicated twice.

The main plot factor was ''tillage''. Under conventional plow-based tillage (CT), the soil was cultivated by inversion tillage to a depth of roughly 0.25 m after harvest to incorporate crop residues and composted cattle manure into soil. Under reduced tillage (RT), one harrowing to a depth of roughly 0.12 m was used for seedbed preparation before sowing.

One of the equal subplot factors was "fertilizer type". Under chemical fertilizer (CF), compound fertilizer containing N, P and K was banded on a planted row concurrently with seeding at rates depending on crop type and local government fertilizer recommendation. Under manure fertilizer (MF), composted cattle manure was applied at a rate of 40 Mg ha^{-1} on a fresh weight basis before each cropping.

The other subplot factor was "plant residue input". Crop residue return typical of crop rotations at the study area constituted normal plant residue input (NI). Under high plant residue input (HI), plant residue input was maximized by (i) replacement of potato with sweet corn, a high residue-producing crop, (ii) return of all wheat residue biomass (stubble and straw) and (iii) use of green manure oats in the fallow season after winter wheat harvesting.

Soil C stock change for the 4-year study period was assessed by measuring soil C stocks in June 2007 and June 2011. Five soil samples at different depths (0-5, 5-10, 10-20 and 20-30 cm) were taken from each plot, and composite soil samples were sieved (2mm) and used for measuring C contents. Core samples for different depths were also taken to measure soil bulk densities. Because bulk densities taken in 2007 and 2011 were different, the soil depth in 2011 was adjusted so that soil mass considered could be equal between 2007 and 2011.

Carbon balance for the 4-year study period was assessed by subtracting CO_2 emissions from soil (root respiration excluded) from total organic C input to the soil (i.e. inputs from below-ground and above-ground residue biomass, composted animal manure and green manure). CO_2 emission from soil was measured by a static closed chamber technique.

Iron plates were installed into 0.3 m depth of soil for root exclusion. Gas sampling to determine CO_2 fluxes was conducted at 9 a.m. every 10 days from April 2007 to March 2011 (133 times in total).

4. Results

Soil C sequestration rates measured by C balance were greater than those measured by soil C stock change (Fig. 1). The main reason was that decomposing plant residues and animal manures found in soil samples are excluded in the assessment under soil C stock change while those materials were included under C balance. Despite the result, the two approaches had the same ANOVA results showing that "fertilizer type" and "plant residue input" had significant impacts on soil C sequestration rates although significance levels differed but none for "tillage" (Table 1).

5. Conclusion

1) We compared soil C sequestration rates in northern Japan's cropland with the most frequently used two approaches when the sequestration rates were assessed on a plot scale.

2)In my presentation, the difference in the results from the two different approaches will be discussed, taking into account the limitations and uncertainties inherent to approaches used.

Figure 1

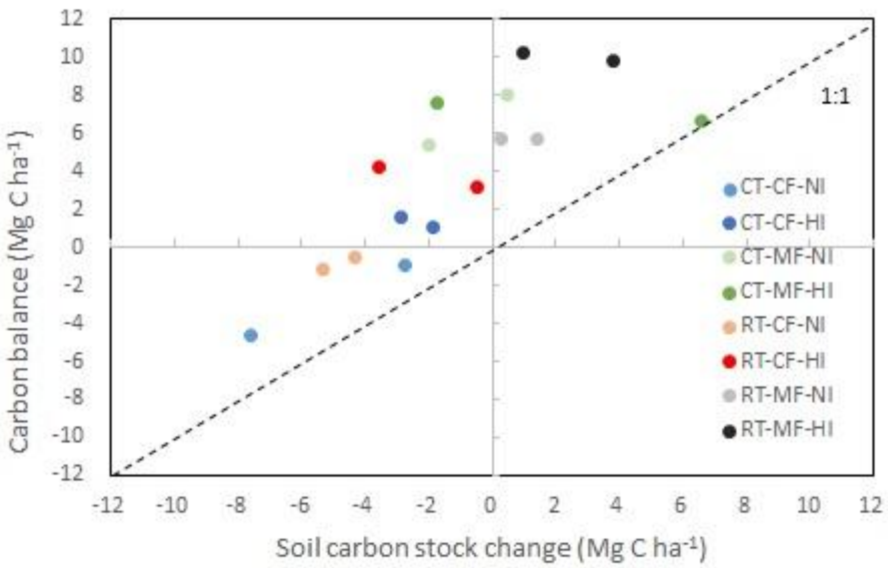

Fig.1 A comparison of soil carbon sequestration rates from soil carbon stock change and carbon balance for the 4-year study period.

Figure 2

Table 1 The results of ANOVA for soil carbon sequestration rates determined by soil carbon stock change and carbon balance

	Soil carbon stock change	Carbon balance
Tillage (T)	ns	ns
Fertilizer type (F)	**	***
Plant resiude input (P)	*	**
T x F	ns	ns
T x P	ns	ns
F x P	ns	ns
T x F x P	ns	ns

***, **, * and ns represent the significance levels of 0.001, 0.01, 0.05 and no significance, respectively.

P 2.6.06

Content, composition and fate of sugars in the soil

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Sugars are the most abundant organic compounds in the biosphere because they are monomers of all polysaccharides. We summarize the results of the last 40 years on the sources, content and fate of sugars in soil and discuss their main functions. We especially focus on sugar uptake and utilization by microorganisms as this is by far the dominating process of sugar transformation in soil compared to sorption, leaching or plant uptake. Moreover, sugars are the most important carbon (C) and energy source for microorganisms.

Two databases have been created and analyzed. The 1st database focused on the contents of cellulose, non-cellulose, as well as hot-water and cold-water extractable sugars in soils (348 data from 32 studies). This database enabled determining the primary (plant-derived) and secondary (microbially and soil organic matter (SOM-) derived) sources of carbohydrates in soil based on the galactose+mannose/arabinose+xylose (GM/AX) ratio. The 2nd database focused on the fate of sugar C in soil (734 data pairs from 32 studies); only papers using ^{13}C- or ^{14}C-labeled sugars were considered. Analysis of ^{13}C and ^{14}C dynamics enabled calculating the: 1) initial rate of glucose C decomposition in soil, 2) mean residence time (MRT) of C of the initially applied sugars, 3) MRT of sugar C incorporated into microbial biomass and SOM pools.

The content of hexoses was 3-4 times higher than that of pentoses for both cellulose and non-cellulose sugars. This is because hexoses have two sources in soil: plants and microorganisms. The GM/AX (of non-cellulose sugars) ratio revealed a lower contribution of hexoses in cropland and grassland soils (ratio 0.7-1) compared to forest (ratio 1.5). The ratios for plant residues revealed high GM/AX values (1.5) for coniferous litter, reflecting high input of hexoses to soil sugars.

Based on experiments with ^{13}C- or ^{14}C-labeled glucose, the initial rate of glucose mineralization was 1.1 % min^{-1}. Considering this rate along with the glucose input from plants and the glucose C content in soil solution, we estimate that only about 20% of all glucose in soil solution originates from the primary source - decomposition of plant litter and rhizodeposits. The remaining 80% originates from the secondary source - living microorganisms and their residues. The estimated MRT of sugar C in microbial biomass was about 230 days, showing intense and efficient internal recycling within microorganisms. The assessed MRT of sugar C in SOM was about 360 days, reflecting the considerable accumulation of sugar C in dead microbial biomass and its comparatively slow external recycling.

Thus, the very rapid uptake of sugars by microorganisms as well as intensive microbial recycling clearly demonstrate the importance of sugars for microbes in soil. We hypothesize that the most important function of sugars in soil is to maintain and stimulate microbial activities. Consequently, sugars are strongly responsible for plant-microbial interactions in the rhizosphere and for microbial mobilization of nutrients by accelerated decomposition of SOM - by priming effects. Based on the assessed MRT, we conclude that the actual contribution of sugar C (not only whole sugar molecules, which are usually determined) in SOM is much higher than the 10 ± 5% commonly measured based on their content.

P 2.6.07

The impact of the C/N ratio on the respiration and retention of substrate C in soils

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Introduction

It has been argued that C-rich substrates may not be effective to build up soil organic matter if insufficient availability of other nutrients, and nitrogen in particular, limits the incorporation of substrate C into microbial biomass (Kirkby et al. 2014). Concerning soil organic matter management, this implies that substrates with a narrow C/N ratio may provide a more efficient organic matter supply than substrates with a wide C/N ratio.

Objectives

We studied organic matter balances after application of straw and catch crop biomass to soils in an incubation experiment, considering different levels of N supply with fertilizers. The aim was to evaluate to what extend C/N ratios of substrate additions to soils in arable farming must be considered in the assessment of soil organic matter management.

Material and Methods

Two incubation experiments were conducted based on ISO 16072:2005-6. The *C* experiment at cold temperature (8°C) focused on the turnover of catch crop biomass (here: *sinapis alba*), while the *W* experiment aimed at the survey of straw turnover atwarmer temperature (20°C). Both experiments comprised treatments with the addition of specific fertilizers that were intended to induce different CN ratios in the soil-substrate-mixture (C: CC=catch crop biomass, CC+BGS=CC+biogas slurry, CC+CS=CC+cereal straw; W: BGS=biogas slurry, MF=mineral N fertilizer, CS=cereal straw, PS=pea straw, CS+BGS, CS+MF), and the necessary controls (empty, SOIL=soil only). The incubators were filled with 1g substrate-DM and 100g soil-DM each. C and N amounts were recorded based on weight and C and N contents in aliquot samples. Due to the DM-based application, C and N additions were varied between treatments. The experiments were carried out over 300d, respectively. During that time, 14 CO2 measurements took place in each experiment. In addition, remaining C and N amounts and microbial biomass have been measured, but data are still being processed.

To analyze the effect of the ratio of added C and N quantities on substrate C and N retention in the soil we calculated C retention and correlated this to CN ratios in the added substrates and in the soil-substrate mixtures (Analysis of correlation). Further, we analyzed how far C respiration and C retention differed between treatments each experiment (ANOVA).

Results

We observed significant negative correlations between C/N ratios in the soil-substrate-mixtures and C retention in both experiments (r=-0,82 in *C*, r=0,80 in *W*). Cumulative C respiration was statistically different between bare soil and the treatments with added *sinapis alba* biomass in the *C* experiment, and between the soil and high-N fertilizer treatments (MF, BGS) on the one hand and the straw treatments on the other hand in *W*. Yet, due to the different initial C additions, C retention rates were more differentiated: All treatments were statistically different from each other in *C* and followed the order SOIL > CC+BGS > CC > CC+CS . In *W*, the situation was more complicated. Most important, pure straw treatments (CS, PS) could be differentiated from all straw treatments with fertilizer additions and from soil and soil+fertilizer treatments. C retention in *W* followed the order SOIL,MF,BGS > CS+BGS > CS+MF > CS,PS.

We did not observe any significant priming effects in the experiments, even though MF treatments had slightly lower C retention compared to SOIL. Vice versa, additional N supply lead to higher C retention in CS+MF compared to CS.

Conclusion

Our results apparently confirm the conclusion of Kirkby et al (2014) that C retention in soils can be limited by N availability. Until now we, of course, do not know whether retained substrate C is just remaining undecomposed C, or has been incorporated into microbial biomass. Still, these results will be available soon. If the negative correlation between C retention and C/N ratios is confirmed, this situation should be considered in the assessment of organic matter management on arable soils. Further, it should be studied under what conditions the positive impact of N supply on C retention is off-set by priming effects.

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P 2.6.08

Soil CO_2 efflux and concentration under drip irrigation in dry-land agriculture, China

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In northwest China, plastic mulching is an effective method to increase crop production. Soil CO_2 efflux and concentration in dry-land agriculture can be greatly affected by this cropping system. This study aims to examine whether covering fields with plastic film affects CO_2 emission and concentration in cotton field. The experiment included mulched and non-mulched treatments. Soil CO_2 efflux and CO_2 concentration were measured in the ridges and furrows from July to October in 2013. In the ridges, mean soil CO_2 effluxes were 0.069 and 0.076 g CO_2-C·m^{-2}·h^{-1} for mulched and non-mulched treatments, respectively. In the furrows, mean soil CO_2 effluxes were 0.065 and 0.051 CO_2-C·m^{-2}·h^{-1} for mulched and non-mulched treatments, respectively. In summary, cumulative CO_2 emissions were 546.09 and 548.72 g CO_2-C·m^{-2} for mulched and non-mulched treatments. CO_2 concentrations in the ridges were higher in the mulched treatment (ranged from 10.01 to 28.28 mg·L^{-1}) than the non-mulched treatment (ranged from 4.91 to 24.28 mg·L^{-1}). However, in the furrows, we only observed a significant increase in CO_2 concentration of 4.33 mg·L^{-1} in the mulched treatment relative to the non-mulched treatment at 40 cm depth. In addition, soil CO_2 efflux increased exponentially with soil temperature, and the temperature normalization of soil CO_2 efflux to 10 °C decreased once soil water content was below or above threshold value. Furthermore, plastic mulching also changed the temperature sensitivity of soil CO_2 efflux and the optimal soil water content for CO_2 emission, respectively. On the basis of these results, we found that plastic mulching significantly impacts on soil CO_2 effluxes and CO_2 concentrations in the furrows and ridges, respectively. However, the cumulative CO_2 emissions were not significant reduced. Our results also suggest that the application of bivariate model combined with soil temperature and water content better predicts soil CO_2 efflux both in mulched treatment and non-mulched treatment.

Keywords: Soil CO_2 efflux; Soil CO_2 concentration; Plastic mulch film; Arid region; Cotton field

P 2.6.09

Phosphorus partioning between roots and microorganisms: A novel ^{33}P labeling approach

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Our knowledge about the seasonal variation of microbial phosphorus uptake is limited compared to other key nutrient elements. An initial hypothesis suggested that the dynamics of P uptake and mineralization by microorganisms in temperate forest soils exhibit a seasonality anti-cyclic to plant P uptake. Therefore, the ratio of microbial P to labile P increases by the transition from acquiring ecosystems (in spring) to recycling ones (in fall).

To investigate this, intact soil-plant mesocosms containing Ah horizon with 1 year old *F. sylvatica* were removed from the P-rich field site Bad Brueckenau and the P-depleted field site Luess in Germany. During incubation under controlled conditions, seasonal pulse labeling by ^{33}P-orthophosphate was performed at 5 time points over the course of one year. ^{33}P recovery in microbial compounds of organic and mineral soil horizons was determined 7 and 30 days after the labeling. This procedure accounts for temporal changes in P allocation and also considers the rather slow P transport from the mycorrhiza into the plants and other microorganisms. For the first time we analyzed the ^{33}P incorporation into total PLFA and consequently provide a new technique for the analysis of P uptake by microorganisms, which has clear advantages compared to P quantification after chloroform fumigation.

Microbial P incorporation exhibited a distinct peak during the summer months, coinciding with the seasonally largest amount of microbial biomass in the soil. Only small differences between spring and fall were found. A concurrent development was seen in the ^{33}P uptake rate per day, where spring and fall showed a very similar pattern of a slow, continuous incorporation. In contrast, during summer the ^{33}P uptake was nearly completed after seven days. This was especially evident in the soil from the P-depleted Luess field site. The microbial P uptake of the organic upper soil layer exceeded that of the mineral soil by a factor of 10 to 20 at both field sites.

This points to the soil C content and consequently the amount of microbial biomass as the determining factor for the microbial P uptake. In contrast, seasonal plant P uptake pattern seem to play a minor role suggesting a higher competitiveness of soil microorganisms for phosphorus than plants.

P 2.6.10

Are relative carbon partitioning coefficients a suitable tool for quantifying soil carbon inputs? I. Finding the temporal optimum for collecting samples after pulse labeling

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Abstract for poster 1 of 2:

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Quantification of the carbon (C) inputs of crops is necessary to evaluate the roles of plant species within ecosystems. Pulse labeling of plants can provide detailed information regarding the flow of recently assimilated C into the subsurface. However, to quantify C inputs from plant roots, it is important to ensure that the distribution of a C tracer within a plant-soil system represents the actual partitioning of net fixed C. Unfortunately, only limited information is available regarding if and when sampling pulse labeled plants can provide sufficiently precise partitioning coefficients. Therefore, ^{14}C tracer kinetics of mobile and stable C pools, belowground respiration and net assimilation were analyzed. Our results imply that sampling the plant-soil system beyond the 15th day after labeling can provide relative C partitioning coefficients that approximate the actual distributions of net fixed C from the day of labeling. Furthermore, the asymptotic behavior of the ^{14}C tracer kinetics imply that the precision of the C partitioning coefficients will increase when sampling is delayed until the 21st day after pulse labeling. In addition, our results show that under favorable conditions the plant developmental stage had little effect on the optimal sampling time.

P 2.6.11

Are relative carbon partitioning coefficients a suitable tool for quantifying soil carbon inputs? II. Estimation of the C input into soil by dynamic linking of ^{14}C partitioning coefficients and shoot growth

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Abstract for poster 2 of 2:

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The calculation of carbon (C) inputs from crop roots is complicated by the highly dynamic nature of C assimilation and partitioning in plant-soil systems. Therefore, this study used spring rye to demonstrate two C estimation methods, a simple method and a more complex method. The methods, which consider the C dynamics to varying degrees, were compared in terms of their information content and precision. The method that dynamically links the relative C partitioning and the absolute C assimilation provided C flux values with 10-fold higher precision than those of the easy C estimation method, which was based on the usage of means and medians of the relative C partitioning coefficients from the growing season. The investigations indicated that 18± 2% of the net assimilated C was transferred into the subsurface of spring rye over the entire growing period, and the easy C estimation method was not able to obtain this result. In addition, it was found that nearly half of the C amount is transferred downward between elongation growth and the last boot stage; that root growth, respiratory turnover and rhizodeposition are strongly positively correlated with one another; and that maximum root growth precedes maximum shoot growth.

P 2.6.12

Belowground carbon dynamics under zero tillage management of tropical, perennial C4 grasses cultivated for biofuel production

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The use of conservation management practices during the cultivation of biofuel feedstocks may help to sequester soil organic carbon (C), thereby providing an offset to some or all of the carbon dioxide (CO_2) emissions associated with production including land use change. Perennial grasses gained increasing attention for being non-food crops with the potential to mitigate negative consequences within the production system due to their high yield and low requirements for fertilizer, pesticides, and water compared to other crop types. In addition, tropical C4 perennial grasses such as napier grass (*Pennisetum purpureum*) and Guinea grass (*Megathyrsus maximus*) also may store a large amount of C in soil compared to annual crops due to their extensive belowground root system and zero-tillage, or ratoon, cultivation. The objective of this work was to determine the primary drivers of soil C change following cultivation of a fallow field in perennial grasses under zero-tillage management. Multiple C pools (e.g., above and belowground C in biomass and soil) and fluxes (e.g., total belowground C flux, soil CO_2 efflux, and root decay) were measured following cultivation of napier and Guinea grass and structural equation modeling employed to identify the drivers of soil C stock for 18 months post land use change. Further, soil C dynamics were determined using a combination of soil physical fractionation, laboratory incubation, and copper oxide (CuO) oxidation and extraction with quantification of root-derived compounds by gas chromatography. We found that grass varieties with low root lignin concentration, which was significantly related to rapid root decomposition, resulted in the greatest amount of total soil C during three harvest cycles, following conversion of fallow field to ratoon harvested perennial grasses. Root lignin concentrations (measured by a forage summative method) ranged from 17.9 to 21.0%; Guinea grass had greater root lignin concentrations than napier grass ($p<0.001$). Roots with low lignin concentration decomposed rapidly; however, the residue and associated microbial biomass and byproducts accumulated as soil C as opposed to being lost from the system as CO_2. Consistent with the root lignin concentrations, the Guinea grass roots decayed slower compared to napier grass roots ($p=0.004$) and had a higher root C concentration than the napier grass ($p=0.001$). Eighteen months post land use conversion and cultivation, C accumulated within the aggregate protected pools (i.e., the occluded light fraction isolated by a combination of density and ultrasonic disruption) ($p<0.050$), root-derived organic matter from the planted grasses (as detected with CuO extracted and quantified lignin phenols and cutin/suberin substituted fatty acids) accounted for much of the accumulated C within the aggregates, and total C stock rebounded to baseline levels following an initial decline. Land use conversion during cultivation does not always lead to loss of soil C when conservation management practices are observed, and the subsequent accumulation of C belowground may provide a substantial benefit to the environmental and economic sustainability of a renewable fuels system.

P 2.6.13

Carbon stock changes in mineral soils of ploughed lands in Russia during the period 1990-2012.

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Keywords: *carbon cycle, croplands, carbon dioxide, climate change.*

Agricultural activities influence carbon (C) stocks in ploughed agricultural soils and, depending on species of crops, level and methods of the management, and soil fertility might result in the net carbon dioxide emissions to the atmosphere or C sequestration by soils.

The goal of our investigation was an assessment of C balance in mineral ploughed soils of Russia from 1990 to 2012.

Estimates of the annual change in soil C stocks of ploughed lands was conducted by the balanced analysis between the amount of C compounds entering into soils and C losses from them in accordance to early developed model (Romanovskaya, Karaban', 2007). C inputs to soil include applications of organic and synthetic fertilizers, liming procedures, and incorporation of crop residues (both above- and below-ground biomass). To estimate annual C losses we considered erosion and deflation as well as soil respiration. As an object of our investigation the soils under one-year crops, perennial crops and fallow areas were chosen. Initial data for our analysis were taken from official statistical data of the Federal Statistical Service for the respective years of the period 1990-2012.

Crop residues are the main sources of anthropogenic C compounds applied to ploughed soils in Russia and almost fully determine the total amount of C input (from 70.6% in 1990 to 91.1% in 2012). The contribution of organic fertilizer is less significant, ranging from 28.3% in 1990 to 8.6% in 2012, while the share of other sources account for 1.3% and 0.3% in 1990 and 2012 respectively. During the considered period the contribution of fertilizers decreased by approximately 3 folds due to the reduction of their application in the agricultural soils in Russia as a result of economic changes. Main volume of C losses associated with soil respiration and is about 98.8% of the total C losses in 2012.

By the comparison of estimates obtained for total annual C input into soils and annual C losses of ploughed lands we estimated annual C balance during 1990-2012. The results show that within the period considered the total annual C balance for ploughed soils of Russia is negative and corresponds to net C losses (emission of carbon dioxide to the atmosphere). The average annual net C losses are about 36.0 mln. tones (-0.34 tones C/ha) with maximum in 1991 - 68.8 mln. tones (-0.52 tones C/ha) and minimum in 2008 - 18.6 mln. tonnes C (-0.20 tones C/ha). In 2012 C balance in ploughed soils of Russia was about - 30.8 mln. tonnes C (-0.34 tones C/ha).

P 2.6.14

Estimation of soil organic carbon in croplands of Moscow region by using the DNDC model

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A soil is the basic agent of the carbon storage in biosphere and may absorb atmospheric carbon or emit it depending on conditions. In our research we have modelled the soil organic carbon (SOC) dynamics in croplands of Moscow region, Russia.

The DNDC (DeNitrification-DeComposition) is a process-base model of carbon and nitrogen biogeochemistry in agricultural ecosystems and is applicable in wide range of geographical regions. The entire model is driven by four primary ecological parameters, namely climate, soil, vegetation, and management practices.

Meteorological conditions (maximum and minimum air temperature and precipitations) were taken from climate data of All-Russia Research Institute of Hydrometeorological Information - World Data Centre (RIHMI-WDC).

Major of soil characteristics include clay fraction, bulk density, pH and SOC content at surface soil (0-10 cm). To determine this data we used literature reference data for ploughed soils of Moscow region.

The most important crops in Moscow region (such as winter and spring wheat, winter rye, oat, barley, potato, corn, buckwheat and fallow) were used as examples in our modelling. In accordance with biological characteristics of crops varieties cultivated in European Russia, we have corrected their thermal degree days for maturity and water demand as it was in DNDC.

For cropping system parameters we have specified crop yields, applied amount and types of fertilizers and manure, depth of ploughing and tillage. The most difficult step was to find out actual Julian days when seeding, harvesting, plowing, fertilizing and etc. are happen.

Initial modelling of SOC in croplands of Moscow regions showed that results of DNDC running are sensitive to the changes of all parameters, but the most significant factor is a percentage of clay fraction in soil. Dependencies of SOC dynamics from most sensitive factors have been developed in our research. Current results of the modelling showed possibility to emit CO_2 in the atmosphere from croplands soils if there are sand texture or row crops, and to absorb atmospheric CO_2 in case of clay soils, grain or cover crops. Overall regional SOC dynamics is implicit yet.

We are planning to continue this research in both directions by elaborating of used parameters and extension of analyzed regions.

P 2.6.15

P cycling in the organic layer changes with moderate addition of nutrients in a tropical montane forest in Southern Ecuador

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The increasing input of atmospheric nitrogen (N) influences biogeochemical cycles. An increased input of N might influence nutrient fluxes beyond the N cycle, by promoting biomass production and thereby increasing the demand for other nutritional elements such as phosphorus (P). Important components of the biological P cycle in soil are mineralization and P uptake by plants and microorganisms. We expect more P mobilization, e.g. by enhanced enzyme activity that releases inorganic P from organically bond P and increased gross mineralization under N- and/or P fertilization. In the framework of a nutrient manipulation experiment (NUMEX) in a tropical montane forest in Southern Ecuador, we investigated if moderate P and N fertilization along an altitudinal gradient (1000, 2000, and 3000 m a.s.l.) influences phosphatase activity, P immobilization by microorganisms and P net release. The aim was to mimic increasing atmospheric nutrient deposition, as it is predicted for this region, by adding N and P in ecosystems where primary production is supposed to be co-limited by N and P. We sampled the organic layer and mineral soil of fertilization (N, P, N+P) and control plots to determine phosphatase activity. In the P and N+P treatment, we found a decreased phosphatase activity in the organic layer (mean ± standard error (SE): P addition 1000 m -0.7 ± 0.2; 2000 m -0.5 ± 0.2; 3000 m -0,5 ± 0.1 µg p-NP g-1 h-1; N+P addition 1000 m -1.0 ± 0.3 ; 2000 m -0.3 ± 0.1; 3000 m -0.6 ± 0.3) but not in mineral soil. An increased inorganic P supply due to fertilization reduces the need to synthesize enzymes for P mobilisation. These findings indicate that the ecosystems have difficulties to benefit from the additional P supply and maybe other factors may constrain nutrient demand of organisms. In comparison with that, N addition stimulates growth and therefore increases the demand to mobilise P. Anyway, we found no differences in phosphatase activities between control and N addition plots, maybe because of the low quantity of added N. These results together with the quantification of P fluxes between different pools (mineralization, immobilization, sorption) using an isotopic approach with ^{33}P, might help to understand the ecosystems reaction towards atmospheric N and P addition.

P 2.6.16

Lower greenhouse gas emissions from a cultivated organic soil than from adjacent set-aside farmland in Sweden

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Introduction

Cultivated organic farmland is a considerable source of greenhouse gases (GHG), and conversion to perennial fallows is a mitigation option presently discussed in Sweden. However, there is a lack of data to support decisions, in particular on quantitative emissions, effects of cultivation, and to parameterize models that describe ecosystem processes.

Objectives

We intended to quantify GHG budgets from cultivated and set-aside farmland on organic agricultural soils at adjacent fields to estimate the effect of cultivation on farmland GHG fluxes. The results may serve as a base for decision makers that influence national and international choices within agriculture.

Material and methods

Fluxes of CO2 and H2O were continuously measured during four years from two adjacent fields, cultivated and set-aside, on drained organic soil in central Sweden. We did continuous measurements by the eddy-covariance technique. On the set-aside field we even measured fluxes of CH4 continuously; on the cultivated one only during shorter campaigns. Point-measurements of CO2, CH4 and N2O fluxes along transects in each field were conducted four times per year using chambers. The soil was characterized according to N-profiles, decomposition state, C/N ratios and other soil-physical and chemical properties. Soil subsidence was estimated by annual area leveling and spatial variations in hydrology were characterized by conductivity measurements. Groundwater level was monitored continuously in tubes. Cultivation activities were documented and analyzed.

Results

Surprisingly, the ground water level and soil water content turned out to be lower in the set-aside field than on the cultivated one, despite more intensive drainage of the latter. This was probably due to subsidence in the cultivated field that was estimated to 10 cm.. Consequently, CH4 emissions were higher at the cultivated site as recorded in the chambers, while a consistent uptake of CH4 was measured from the set-aside field.

The soil pools of C and N were larger at the set-aside field, and the depth profiles differed characteristically.

Despite the higher N pool in the set-aside soil, no significant emissions of N2O were measured from there. Instead, low fluxes of N2O were recorded from the cultivated field.

Biomass production varied considerably between the years on the cultivated, while it was fairly constant at the set-aside field. On both fields, all almost all biomass was left in the field, since the cultivated field was used as a “bird-field” for wildlife feeding.

During years with normal yield, the cultivated field was a sink of CO2, while it was more or less neutral during a year with reduced yield. In total, , it was a net sink of C and a small source of CH4 and N2O, although total emissions were small in terms of CO2 equivalents. The set-aside field, on the other hand, was consistently a source of CO2 and a small sink of CH4, while it appeared neutral in terms of N2O. Even here, fluxes of CH4 and N2O were small in terms of CO2 equivalents.

Conclusions

We unexpectedly conclude that cultivation on the organic soil investigated was more beneficial for the GHG balance than perennial fallow. Part of this result may be attributed to the fact that almost all biomass was left in the cultivated field and, thus, contributed to the soil C pool.

P 2.6.17

Estimating the effect of land management practices on soil carbon stocks using the Landscape-DNDC model

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Introduction

Within Europe (EU-15) it has been estimated that the C storage potential of cropland is c. 90-120 Mt C/yr (Smith 2004). For croplands in the UK, the mean greenhouse gas mitigation potentials for all cropland management practices range from 17 to 39 Mt CO_2-eq per 20 years (Fitton *et al.* 2011). Considerable uncertainties are associated with the C balance of European croplands and recent studies have suggested that the rate of C loss from them is less than earlier reports suggest. This paper models scenarios using Landscape DNDC (LDNDC) to assess the impact of agricultural management upon soil carbon stocks that represent realistic management options, including 1) an increase in residue returns to the soil 2) reduction of tillage, 3) +/- 50% fertiliser rates and 4) the incorporation of manures. LDNDC is a process-based model for simulating biosphere-atmosphere-hydrosphere exchange and processes at site and regional scales. The LDNDC model is a new model framework that is based on the biogeochemical site scale model De-Nitrification De-Composition (Li 2001) and incorporates a series of new features with regard to process descriptions, model structure and data functionality (Haas *et al.,* 2013).

Materials and Methods

LDNDC was validated using data obtained from Rothamsted Research's long-term agricultural experimental plots in Hertfordshire, England. Data for three winter wheat plots were used, including a mineral-fertilised plot and two manure application plots. This dataset was chosen as soil carbon measurements were available since 1975 as well as management practices and soil characteristic have been monitored since 1844 for which the model could be validated against. Scenarios included increasing residue returns from 15% (baseline) to 30% and 50% residues remaining. LDNDC describes tillage intensity in terms of depth tilled as opposed to machinery used. Conventional tillage was assumed to be at 20cm depth for the baseline with scenarios focused on describing the reduction of tillage depth to 10cm and zero tillage. Three applications of ammonium nitrate (AN) fertiliser were applied as standard practice for winter wheat plots. These doses were applied on 6th April, 26th April and 7th May each year. To determine how the quantity of AN application influences soil carbon stocks, ±50% application quantities of AN were applied (F+50 and F-50). The combination of AN and manure fertiliser application in comparison to AN-only are also investigated at standard rates and -50% application quantity. A scenario of +50% manure application was not run as this is unlikely to occur in the UK due to Nitrate Vulnerable Zone regulations. LDNDC was run to a soil depth of 23 cm to agree with the validation runs. Running the model to 100cm did not change shape of the curves for the different scenarios, but total SOC stocks were higher because of the additional carbon stocks between 23 and 100 cm.

Conclusion

The modelling work highlighted the potential benefits of reduced tillage, incorporating residues and manures to the soil carbon stocks. Nevertheless, the models are based on assumptions. With respect to minimum tillage, current experimental research would indicate that minimum tillage does not increase the soil C stocks in the soil but merely redistributes the soil C. The modelling results also highlighted that in terms of mitigation it is important to consider the full budget, not just the effect on soil C. Moreover, the modelling work only considered a limited number of sites and therefore may not fully reflect geographical variation in soils and climates across Europe.

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O 2.7.01

Linking the terrestrial and aquatic carbon fluxes at a catchment scale

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Intro / problem statement

Quantifying the lateral fluxes of carbon from land to inland waters is critical for the understanding of the global carbon cycle and climate change mitigation[1]. However, the crucial role of rivers in receiving, transporting and processing the equivalent of terrestrial net primary production in their watersheds has only recently been recognised[2]. In addition, the fluxes of carbon from land to ocean, and the impact of anthropogenic perturbation, are poorly quantified[3]. Therefore, a mechanistic understanding of the processes involved in the loss and preservation of C along the terrestrial-aquatic continuum is required to predict the present and future contribution of aquatic C fluxes to the global C budget[3]. Cross-disciplinary research is required to reveal the complex processes and mechanisms governing the lateral transport, transformation and delivery of C from soils to fluvial environments.

Objectives

This pilot study examines the effect of land use and agro-management on the fate of organic matter within two headwater catchments in Cornwall (UK) in order to develop a methodological framework for investigating C-cycling across the entire terrestrial-aquatic continuum. More specifically, we aim to:

- Characterise the spatial heterogeneity of soil erosion driven lateral fluxes of SOC.
- Quantify soil heterotrophic CO_2 respiration rates in relation to soil erosion.
- Examine the link between terrestrial SOC input into the fluvial environment and total aquatic metabolism.
- Trace the terrestrial versus aquatic origin of C along the river reaches and in lake sediments at the catchment outlet.

Research Methodology / Outcomes

The 3D spatial distribution of SOC has been investigated by sampling three depth increments (i.e. 0-15cm, 15-30cm and 30-50cm) along 14 hillslope transects within two sub-catchments of ~2km^2 each. In total, 80 terrestrial sites were monitored and analysed for total C and N, and bulk stable $^{13}C/^{15}N$ isotope values, while ^{137}Cs was used to obtain a detailed understanding of the spatial - temporal variability in erosion driven lateral fluxes of SOC within the catchments[4]. The relative contribution of terrestrial and aquatic C was examined along the river reaches as well as in lake sediments at the catchment outlet by considering *n*-alkane signatures[5]. Heterotrophic soil respiration was measured bi-weekly on 3 occasions at a sub-set of 40 locations in order to link the rates of soil erosion in different geomorphological and land use classes to CO_2 losses. Simultaneously, total aquatic metabolism was measured over 24-hour periods along the river reaches to investigate the potential contribution of soil erosion related SOC input to the fluvial environment.

Conclusions

By linking the C accumulation rates over decadal timescales from both terrestrial and aquatic sources as recorded in lake sediments to the measured rates of soil erosion and terrestrial & aquatic CO_2 respiration rates, this study has paved a way towards a novel and cross-disciplinary approach to investigate and further improve current status of knowledge as regards C-cycling across the entire terrestrial-aquatic continuum.

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O 2.7.02

Dependence of amount and composition of stream dissolved organic matter on catchment land use

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In the recent years an increasing number of studies has investigated the dependence of stream dissolved organic matter (DOM) amount and composition on catchment land use. Based on this information, several consistent observations were found: i) stream DOM load is strongly affected by catchment soil hydrology, with agricultural land use resulting flashy, unequally distributed DOM loads; ii) dissolved organic carbon concentration in streams is usually best predicted by wetland cover and soil organic matter content, whereas dissolved organic nitrogen concentration is usually best predicted by agricultural land cover in the catchment; iii) the main effect of agriculture on DOM composition is the destruction of soil organic matter (SOM) complexes by tillage coupled with mineral fertilizer addition, which results in the release of aromatic, high-molecular, yet microbially processed DOM with low C:N ratios to streams; iv) the microbial character of stream DOM in streams with agricultural catchments can result in higher processing of this DOM within freshwater ecosystems. It can be concluded that DOM amount and composition in streams is highly dependent on the type and intensity of the disruption of catchment hydrology and SOM within catchment soils. Thus, potential ecological effects of the altered DOM amount or composition in fresh waters are strongly linked to the management and status of the catchment soils.

O 2.7.03

Mechanisms of production of storm stream dissolved organic matter (DOM) in headwater catchment: a high-frequency molecular scale study

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The transfer of dissolved organic matter (DOM) at soil-river interfaces controls the biogeochemistry of micropollutants and the equilibrium between continental and oceanic C reservoirs. Stream dissolved organic matter (DOM) in headwater catchments is conceptualized as the result of the flushing of pre-existing soil DOM reservoirs activated by the modification of water flow paths. However, previous data on lignin proxies (low-frequency; molecular analysis) and from the high-frequency monitoring of color DOM by fluorescence spectroscopy have been interpreted as evidences for an in-stream partitioning between particulate organic matter and DOM. Since those mechanisms, flushing versus partitioning, would produce different DOM, they could impact differently DOM ecological services. As a consequence further investigations have been performed to understand the origin of stream DOM. The evolution of the chemical composition of stream DOM was investigated by thermally assisted hydrolysis and methylation using tetramethylammonium hydroxide coupled to a gas chromatograph and mass spectrometer during inter-storm conditions and five storm events with a high-frequency sampling in order to gain new insights on this question.

In inter-storm conditions, stream DOM is inherited from the flushing of soil DOM, while during storm events, the modification of the distribution of chemical biomarkers allows the identification of three additional mechanisms. The first one corresponds to the destabilization of microbial biofilms by the increase in water velocity resulting in the fleeting export of a microbial pool. The second mechanism corresponds to the erosion of soils and river banks or the mobilization of sediments leading to a partition of organic matter between particles and dissolved phase. The third mechanism is linked to the increase in water velocity in soils that could induce the erosion of macropore walls, leading to an in-soil partitioning between soil microparticles and dissolved phase. The contribution of this in-soil erosive process would be linked to the magnitude of the hydraulic gradient following the rise of water table and could persist after the recession, which could explain why the return to inter-storm composition of DOM does not follow the same temporal scheme as the discharge.

O 2.7.04

Is there a size-limited dissolved organic matter reservoir activated by the rise of the water-table and transfer across the landscape from upland to stream?

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In soils, seasonal variability of the water-table level induced by hydro-climatic changes has been shown to be responsible for modifications of water flow paths and involved in export of Dissolved Organic Matter (DOM). During hydrological year, a progressive decrease of DOM concentration in rivers have been recorded in different watersheds. Two hypothesis have been proposed to explain this phenomenon: (1) progressive depletion of DOM reservoir in wetland areas that reforms during summer (2) combined exportation of a limited DOM reservoir from upland domains and an unlimited reservoir from wetland areas, gradually connected to the river by the rise of water-table level.

These two hypothesis have been tested in an agricultural catchment, belonging to the French Critical Zone Observatory AgrHyS. Soil solutions have been sampled along an altitudinal gradient, in organo-mineral and albic horizons. Two areas have been sampled (1) upland domain (K3) where water-table level is close to the surface in wet season (2) wetland area (K1) where water-table level reach the surface and stay above during wet season. Our basic hypothesis is that DOM composition could be different in the two reservoirs and analysing the seasonal variability of DOM composition could be a way of differentiating between the two hypotheses. Sampling of soil solutions was conducted once a week, from October 2013 to February 2014, using water traps. Samples have been filtered at 0.2µm, analysed for DOM and freeze-dried for isotopic ($\delta^{13}C$) and molecular analysis (thermally assisted hydrolysis methylation - gas chromatograph / mass spectrometer).

In upland domain, DOM concentration showed a gradual decrease from 13 to 4 $mg.l^{-1}$ when water-table level increase and reach the surface. At the same time, concentrations in K1 solutions increase with a maximum at 16 $mg.l^{-1}$. This increase occurred when the water-table reach the surface in K3, resulting in hydrological connection between upland, wetland domains and river. Simultaneously, the molecular and isotopic signature characteristic of K3 soil solutions was recorded during two weeks in K1 soil solutions.

Thus, the results from this study appears to be in agreement with the second hypothesis, implying the existence of a limited DOM reservoir, located in upland domain, and exported by the rise of water-table level.

O 2.7.05

Tracing organic matter export from permafrost soil to ocean sediments in the Siberian Arctic

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Various lipid biomarkers have been used to trace terrestrial input into aquatic sediments. Most of these proxies are based on leaf wax lipids such as long-chain *n*-alkanes or *n*-fatty acids. It remains, however, problematic to directly reconstruct the delivery of soil organic matter (SOM) into rivers and the ocean. Recently, new lipid-based proxies have been developed using bacterial membrane lipids offering the potential to identify soil erosion rather than (aboveground) plant input. These proxies include the index BIT based on glycerol dialkyl glycerol tetraethers (GDGTs; Hopmans et al., 2004) and the R_{soil} index based on bacteriohopanepolyols (BHPs; Zhu et al., 2011).

The aim of this study was to identify the input of permafrost soil-derived organic matter into marine sediments off the Lena River delta in the Laptev Sea using the R_{soil} and BIT indices. The Siberian Lena River is one of the largest Arctic rivers and contributes about 18% dissolved and 12-14% particulate organic carbon of the total annual discharge into the Arctic Ocean. River bank erosion is an important mechanism transferring permafrost-derived organic material into the Laptev Sea. In this study both the sources and sinks of SOM were investigated to characterise the soil end member range of BIT and R_{soil} in the Lena delta as well as to assess the transport pathways and spatial dispersal of SOM into the Laptev Sea as implied by both proxies. Furthermore, potential effects of degradation were investigated.

We analysed different soil profiles of characteristic cryogenic structures of the polygonal tundra and cliffs in the Lena delta as well as marine surface sediments from the Laptev Sea. Samples were extracted and processed using standard techniques. GDGTs and BHPs were analysed using normal-phase LC-MS and reversed-phase LC-MS/MS methods following established protocols.

The BIT index values for the investigated soils shows a narrow range and values close to 1 (0.96 to 1.00) typical for soils. R_{soil} ranges between 0.2 and 0.8 being mostly lower than recently published R'_{soil} values (0.7 - 0.8) of terrestrial ice-rich deposits (Yedoma) in the Siberian Kolyma river catchment (Doğrul Selver et al., 2015). The R_{soil} values are also lower compared to samples from Alaskan peats (0.4 - 0.8; Taylor and Harvey, 2011). This indicates that it vital to define specific end-member ranges for different Arctic source regions.

A weighted terrestrial end-member $R_{soil\text{-}w}$ value was determined, which should be expected in surface sediments off the river mouth if the delta polygonal tundra soils were the main permafrost-derived SOM source to these sediments and if all BHPs would be equally well preserved during transport. The weighted $R_{soil\text{-}w}$ index was calculated averaging the investigated soil sites using average bulk density and landscape cover of the polygon tundra.

The analysis of both proxies in marine sediments along cross-shelf transects from the river mouth to the Laptev Sea are in progress. In conjunction with existing data from other high latitude regions including the Kara Sea, East Siberian Sea, the Chukchi Sea, and the Beaufort Sea, they will provide a better understanding of the fate of soil material exported to the Arctic Ocean.

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O 2.7.06

Organic Matter and Trace Metals transfer to surface waters from Tropical Peatlands

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Introduction

In South East Asia, tropical peatlands have degraded rapidly since deforestation, conversion to agriculture and drainage all accelerated in the late 1970s (Miettinen et al., 2011). This abrupt change in land use has induced massive release of carbon from peatlands to the atmosphere because of enhanced decomposition of organic matter (Couwenberg et al., 2010). Fluvial export of dissolved organic matter (DOM) is a significant component of the carbon budget of tropical peatlands(Moore et al., 2013; Gandois et al., 2014). However, relatively little data has been collected to characterize the impact of peatland degradation on river water quality.

Objectives

This study investigated the effects on river water composition of tropical peatland degradation. We focus on the release and transformation of dissolved organic matter and associated trace metals in rivers that drain peatlands.

Materials & methods

The study site is located in West Kalimantan, Indonesia near the city of Pontianak on the island of Borneo. Samples were collected from the Ambawang River, a black river draining a watershed entirely covered with peatlands with different land uses: mixed agriculture, oil palm and acacia plantations, and from the Kapuas Kecil, in which the Ambawang river flows down to the mouth to the China Sea. River and drainage canal water was sampled during the dry and the wet season in 2013 and 2014.

In addition major elements and dissolved organic carbon (DOC) analysis, samples were analyzed for Dissolved Organic Matter (DOM) composition (Fluorescence Excitation Emission Matrices (FEEM) and PARAllel FACtor (PARAFAC) analysis and isotopic ($\delta^{13}C$) signature), as well as trace metals (ICPMS) and lead isotopic (HR-ICPMS) composition.

Results

Black river, as compared to the Kapuas Kecil has a specific chemical composition: anoxic (DO <0.5 mg/l), very acidic (pH: 3.18 +/- 0.26) with high DOC concentrations (35,8 +/- 3,4 mg/l) and enriched in selected trace elements (Al, Fe, Ni, Pb).

The proportion of the main fluorophores (humic-like, C1 and C2) identified via PARAFAC analysis of fluorescence of DOM evolves as water flows downstream along the Ambawang River and is correlated with an increase of $\delta^{13}C$ signature of DOM. This suggests, in addition to the low dissolved oxygen concentration, instream DOM processing in the black river, and potential release of CO_2 and CH_4.

In addition to higher concentrations observed in the black river, the isotopic composition of lead in the river water has a specific anthropogenic signature, close to the one measured in Indonesian aerosols (Bollhöfer et Rosman 2000; Valentine et al., 2008). This is consistent with the hypothesis that lead, accumulated in the past by atmospheric deposition, is now being released by peatland degradation. This process appears to also release other trace metals.

Conclusion

This study highlights that drainage of peatlands in SEA is a global environmental issue, with consequences for the carbon cycle, including DOM release to surface water, as well as metallic pollutants dispersion to surface water. Degraded tropical peatlands appear to constitute a secondary source of lead for surface waters.

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Captions:

Figure 1: DOC (mg/l) concentrations in WR (White River : kapuas kecil), DC (Drainage Canal), and BR (Black River : Ambawang river).

Figure 2 : Drainage canals in tropical peatlands converted to agriculture.

Figure 1

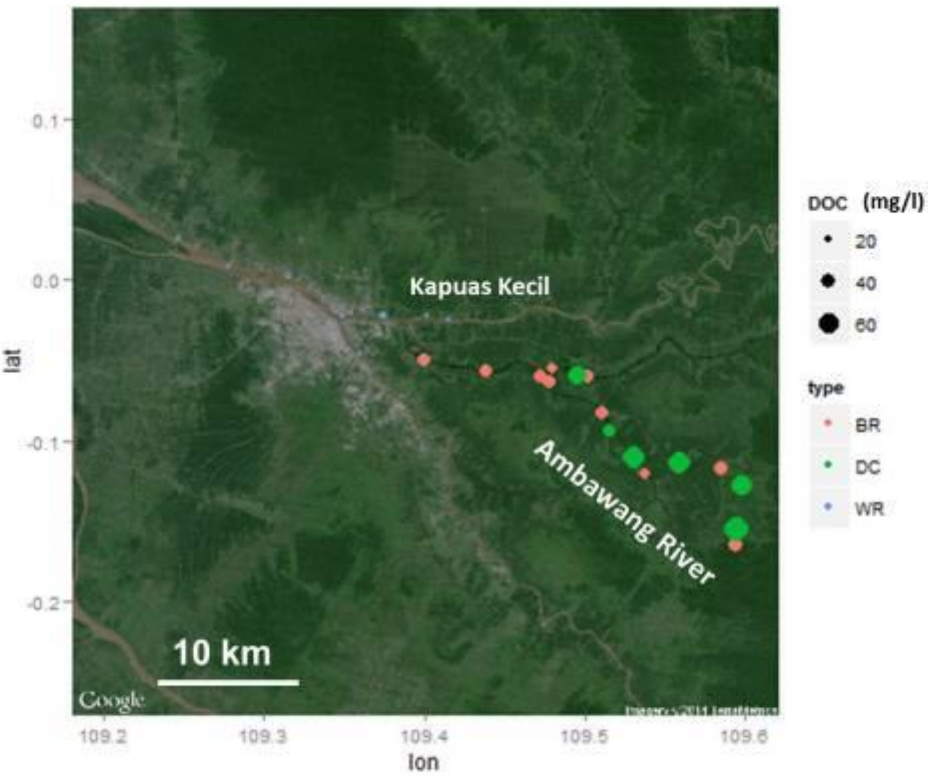

Figure 2

P 2.7.01

Organic carbon dynamics in India

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Soil organic carbon (SOC), the major component of soil organic matter, is extremely important in all soil processes such as water holding capacity, and the soil's ability to form complexes with metal ions and supply nutrients. Organic carbon (OC) enters the soil through the decomposition of plant and animal residues, root exudates, living and dead microorganisms, soil biota, and atmospheric deposition. In this work, the distribution of organic carbon in ambient aerosols, rain water, soil and ground water of urban city: Raipur city of central India (21° 12′ 36″ N, 82° 18′ 0″ E) is described. The mean concentration of OC in the ambient air, rain water, soil and ground water was found to be 50 µg m^{-3}, 250 mg l^{-1}, 180 mg kg^{-1} and 6.0 g l^{-1}, respectively in year, 2009. The correlation of OC with carbonate carbon(CC), metals and ions in various components: air, rain, soil and water are discussed. The effect of meteorology i.e. temperature, wind speed and wind direction in the atmospheric carbon contents are discussed.

P 2.7.02

Concentrations and fluxes of dissolved organic carbon in drainage water from agricultural land

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1 Introduction

Loss of soil organic carbon (SOC) from agricultural soil weakens soil structure and increases the risk of erosion. In addition to decomposition, SOC can escape to surface waters as dissolved organic carbon (DOC) and as adsorbed onto eroded soil particles. Increased DOC concentrations in surface waters have been reported across Europe and North America (e.g. Evans et al. 2005, Lepistö et al. 2008). The data on the DOC load from agricultural soil is limited but some studies have reported increased concentrations in river waters when there is high proportion of agricultural land in the catchment (Mattsson et al. 2005).

2 Objectives

In this study we aimed to quantify the DOC load from agricultural land and to study the effects of farming practices on DOC loss. Biodegradability of DOM from ploughed and no-till soil was investigated in an incubation study.

3 Materials & methods

Two of the experimental sites located in Jokioinen Southern Finland (Yöni, Kotkanoja) and had soil clay content over 60% and topsoil C% on average 5.4 and 3.4, respectively. The third site located in Toholampi (Central Ostrobothnia) and had sandy soil with topsoil C% on average 5.0. Management practices (each replicated with two times) in Kotkanoja were conventional ploughing and no-till with spring cereal cultivation. In Yöni and Toholampi the studied farming practises were organic manure fertilisation (grass & cereals) and mineral fertilization (cereals). At Yöni two permanent grassland plots were also included. For two years, the discharge volume was measured in total at Yöni and at other two sites the surface runoff and tile drainage flow were measured separately. The biodegradable DOM pool was studied in a 2-month incubation experiment with Baltic Sea bacteria.

4 Results

At Yöni field, the average DOC concentration of drainage water varied between 8.7 and 16.7 mg l^{-1} being highest in permanent grassland plot. In Kotkanoja, the DOC concentrations in surface runoff water from no-till plots (9.3 - 13.8 mg l^{-1}) were slightly higher than in ploughed plots (9.1 - 11.4 mg l^{-1}) but in Toholampi the manure fertilisation did not affect the average DOC-concentrations (6.3 - 19.9 mg l^{-1}). DOC concentrations in runoff waters were higher during the first year (2012-2013) compared to the second year (2013-2014) in Kotkanoja and Toholampi experimental sites. Variation between the years was smaller in tile drainage water and no management-induced differences were detected (mg l^{-1}). Yearly DOC load varied between 25 - 52 kg ha^{-1} depending on location, farming practices and weather conditions. In Jokioinen over 60% of the DOC load came with the autumn flow. Seasonal distribution of discharge differed in Toholampi, where DOC load during winter and spring flows were high. DOC loss also increased with increasing C% in topsoil. During the two-year experiment, we could not distinguish clear management-induced differences in the total DOC load. In the autumn the share of bioavailable DOC in discharge water varied between 6 - 17%.

5 Conclusions

DOC load originated from agricultural land was comparable to boreal forests with similar soil type. Discharge is the most important factor determining DOC load but prevailing weather conditions may have great impact on the timing of DOC load entering the water courses. The studied agricultural practices did not affect the load, but the higher C content in the surface soil appears to increase the DOC-load suggesting that agricultural practices leading to organic carbon enrichment in topsoil may increase the load from fields.

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P 2.7.03

Shift of soil chemical and biological properties with the plant succession in Poyang lake in China

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Introduction Global warming is currently one of the major environmental problems, due to greenhouse gases (CO_2 and CH_4 etc.) increasing emission, which is closely related to the stability of soil carbon library. Better understanding of soil carbon library and its composition and distribution is the basis of effectively restraining global warming.

Objectives Wetland, as an important carbon pool, plays a key role of "switcher" in holding and releasing of greenhouse gases. Poyang lake, the largest freshwater lake in China, has 3130 km^2 wetland area, and as we know, its average temperature is 0.42°C higher in 1991-2003 than in 1961-1990, and even average temperature will rise over 1.62°C in the next 50 years. So characteristical analysis of soil organic carbon (SOC) related to greenhouse gas emissions or global climate warming are very important to demonstrate the effect of plant types on them.

Materials & methods Nanjishan Nature Reserve site (28°53'N, 116°20'E) and Nothern Wucheng town, Yongxiu county (29°14'N, 116°01'E) of Poyang Lake in China were selected for this study. Both of these sample sites are effected by the seasonly / periodically changes of water levels. From October to May, the experiment sites experienced three stage from low water season, average water season to high water season, with the peak of vegetative cover and species richness in average water season. From aquatorium/lake to land, five succession stages was demonstrated with (1) bare land, (2) Zizania latifolia Turcz., (3) Carex cinerascens Kükenth., (4) Triarrhera lutarioriparia L. Liu, (5) Phragmites australis (Cav. v) Trin. ex Steub., and each succession stage contained three duplicate plots. In each plot, we randomly sampled five soil samples and mixed them together, with location information recorded (using a Global Position Systems Magellan 500). The mixed soils were divided into two parts, one is for soil microbial respiration and enzyme activiety, and the other is for soil physical and chemical properisties analysis. And these sampling works replicated three times with different water lever (November, January, and April).

Results Results showed that soil active organic matter had no significant difference among the five treatments (7.25-7.93 g kg^{-1}), with a lower value in Zizania latifolia (7.25 g kg^{-1}). Catalase activity was the highest in Zizania latifolia (0.264 mg $KMnO_4$ g^{-1} min^{-1}) and lowest in Phragmites australis (0.143 mg $KMnO_4$ g^{-1} min^{-1}). while urease and sucrase were highest in Triarrhera lutarioriparia (2.559 mg NH_3 - N g^{-1} d^{-1} and 0.503 mg glucose g^{-1} d^{-1}), and lowese in bare land (0.605 mg NH_3 - N g^{-1} $d^{-1}$and 0.240 mg glucose g^{-1} d^{-1}). All of the three enzyme activities had no significnat difference among the five treatment. Microbial respiration was significantly lower in bare land (4.13 µg CO_2-C·day^{-1} mg^{-1}) and Phragmites australis (5.08 µg CO_2-C·day^{-1} mg^{-1}) than in the Zizania latifolia (7.89 µg CO_2-C·day^{-1} mg^{-1}), Carex cinerascens (7.38 µg CO_2-C·day^{-1} mg^{-1}) and Triarrhera lutarioriparia (7.92 µg CO_2-C·day^{-1} mg^{-1}) ($P<0.05$).

In this study, we found that soil temperature, pH and soil moisture content were important factors on soil enzyme activiey, soil active organic matter and soil microbial respiration. The negative significant relationship was present beween soil temperature and catalase activities ($P<0.05$) , between pH and urease ($p<0.01$), between pH and sucrase ($P<0.05$), and between soil moisture content and soil active organic matter($P<0.05$). and the positive significant relationship was seen between soil moisture content and catalase activities ($P<0.01$).

Conclusion In the end, the variation of soil active organic matter, three enzyme activities were demonstrated by the plant succession, although there were no significant difference among them. And we suggested that soil temperature, pH and soil moisture content were the important factors affecting soil enzyme activiey, soil active organic matter and soil microbial respiration. I suggested that these results are important for further understanding soil carbon cycle, for optimizing ecology of wetland, even for making a basic decision to response the climate warming caused by excessive carbon emissions in the Poyang Lake.

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P 2.7.04

Interactive effects of fire and erosion in controlling the fate of soil organic matter

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Fire, erosion, and soil carbon (C) storage and persistence overlap in space and time. Increased erosion follows fires, and fire-altered or pyrogenic C (PyC, also referred to as black carbon) is redistributed vertically within soil profiles and laterally to lower landform positions along hillslopes, changing its C sequestration trajectory. However, we currently lack sufficient understanding on how and why the interaction of fire and erosional distribution of soil materials control persistence of bulk soil organic matter (SOM) and PyC in dynamic landscapes. Sediments and source soils were collected along a hillslope at the site of the 2013 Rim fire, which burned over 250,000 acres of land in Yosemite National Park and Stanislaus National Forest (California, USA). This work uses a combination of elemental and molecular-scale techniques to determine how fire severity and slope of the landscape interactively determine the nature and rate of SOM and PyC mobilization post-fire varies as a function of burn severiy. Our data show that the amount and nature of OM eroded post-fire (based on stable isotope composition of ^{13}C and ^{15}N, and NMR analysis of OM composition) vary as a function of slope and burn severity. We found higher enrichment of C in eroded sediments (compared to source slopes) in areas impacted by moderate severity burns at high slopes, compared to high severity burns at medium and high slopes. The sediments from high burn intensity areas were enriched in ^{15}N compared with the moderate burn intensity areas, suggesting that some fractionation may have occurred during combustion. We also found evidence for rapid erosion of bulk C and PyC immediately after fire. Findings of this study are critical for better integration of biogeochemical and geomorphological approaches to derive improved representation of mechanisms that regulate SOM persistence in dynamic landscapes that routinely experience more than one perturbation.

P 2.7.05

Tidal marsh soils along the salinity gradient of a temperate estuary are subjected to significant organic carbon losses on a decadal timescale

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Introduction

Tidal marshes are among the most productive ecosystems in the world. The high biomass production, reduced soil conditions and burial of organic matter under tidally deposited sediment results in a natural atmospheric CO_2 sink. Although the potential for tidal marshes to sequester organic carbon (OC) has been quantified for specific cases (Chmura et al. 2003), the difference in carbon storage potential among different marsh types has hitherto not been considered. Different types of marshes are characterized by variations in the sedimentation rate and salinity, among other factors.

Objectives

The objective of this study is to assess the main factors controlling SOC dynamics in tidal marsh soils along the salinity gradient of an estuary. As the estuary under study contains a large variety of tidal marshes, it was possible to assess the effect of (i) sedimentation rate and (ii) salinity (through its effect on biomass production) on SOC dynamics. This approach allows to assess how SOC storage and controlling factors vary through *space* along an estuary and through *time*, as sediment profiles can be dated.

Materials & methods

Study area

The Scheldt river (N-France, Belgium and SW-Netherlands) has a tidal reach of 160 km with mean tidal ranges up to 5.5 m. The estuary has a full saline gradient resulting in the existence of salt, brackish and freshwater tidal marshes. In each of these salinity zones two locations (with different sedimentation rates) on a marsh were sampled.

Methods

At each location 3 replicate soil cores were collected, divided into sections of 0.03 m and analyzed for OC, C:N, $\delta^{15}N$, $\delta^{13}C$, texture, pH and EC in order to construct depth profiles for these variables. In addition, bulk- and root density profiles were constructed. To date the sediment cores, remains from aboveground vegetation and knowledge on the timing of vegetation successions were used, together with ^{137}Cs measurements of bulk soil. SOC profiles were reconstructed for every marsh site using a combination of a calibrated marsh sedimentation model (MARSED, Temmerman et al., 2003) and a model of SOC dynamics in sedimentary systems (ICBM-DE, Wang et al., 2014).

Results

OC input is the highest in the sampled brackish water marshes and smallest in the saltwater marshes. On the other hand, the fraction of the OC stock that has disappeared after burial at a depth of 0.5 m is the largest in brackish water marshes (about 70%) and the lowest in freshwater marshes (no significant losses). Saltwater marshes have the lowest input of OC and lose a considerable amount of OC after burial. As a consequence, the total SOC stock in the upper meter of tidal marsh soils has the following pattern: freshwater > brackish water > saltwater marsh.

Although tidal marshes are widely acknowledged as important carbon sinks, the results show that a significant amount of OC is removed from the soils on a decadal timescale. This is summarized in figure 1, which shows the preservation of organic carbon with depth, relative to a situation in which all OC is preserved in the marsh soil (100%).

The figure shows that (i) all but one marsh profile have significant OC losses with depth (thus through time) and (ii) that losses are largest in brackish water marshes (C-D) and smallest in freshwater marshes (A-B). Site B had larger historic OC inputs than present-day, resulting in a relative gain with depth.

[figure 1: relative preservation of OC with depth, relative to a situation in which all OC is preserved in the soil. (fast (A) and slow (B) accreting freshwater marsh; fast (C) and slow (D) accreting brackish water marsh; fast (E) and slow (F) accreting saltwater marsh)]

Conclusion

This study shows that although tidal marshes are important carbon sinks, a considerable amount of SOC is lost from marsh soils after burial. In addition it is shown that both the SOC stock and the amount of preserved SOC varies (i) along an estuarine gradient and (ii) within a tidal marsh as a consequence of different local sedimentation rates. These results contribute to a better understanding of coastal SOC dynamics, the timeframe in which OC is removed from tidal marshes and help to provide better assessments of the future OC storage in tidal marsh soils under changing environmental conditions.

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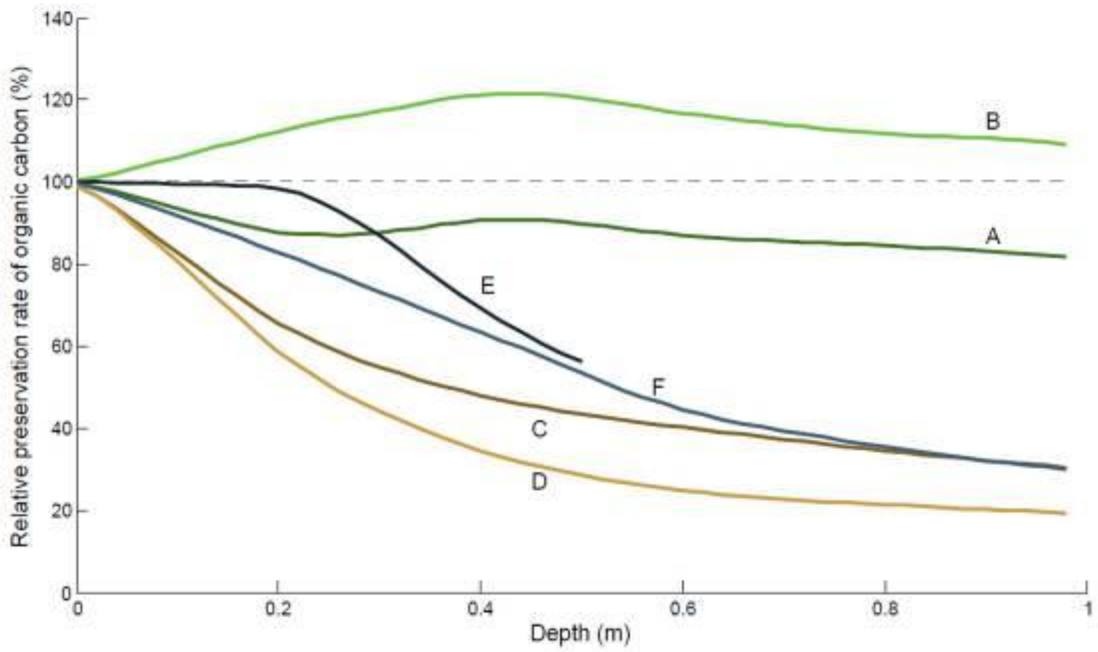
Figure 1



P 2.7.06

Tracking soil sediments to freshwater systems using CSIA of plant wax lipids

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The prediction and/or modeling of sediment pathways to freshwater ecosystems is becoming increasingly important for catchment managers, as sediments remain one of the major ecological threats to aquatic biota and hydrosystem sustainability.

We report about an innovative experimental setup, methodology and obtained results of a first approach of sediment source apportionment in a Swiss river using the compound specific δ^{13}C signatures of plant wax lipids such as the long-chain fatty acids (FA). δ^{13}C signatures of FA of different possible sediment source soils and suspended sediments are measured. Using the FA concentrations, the proportionate contributions of the different source areas to the sediment yield in the river can be calculated. It is unique, that such a CSSI based fingerprinting approach was successful without benefiting from the presence of the shift in d^{13}C signals between C3 and C4 plants.

In addition to the obtained results, we plan to further present the concept of a new study, conducted in the catchment of a hypertrophic Swiss lake. Hypertrophy is due to diffuse pollution originating from agricultural practices and livestock breeding. This environment may serve as an example to explore the potential of the CSSI technique as catchment management tool. We will present sampling strategies and model concepts and would be pleased to discuss these with potential poster visitors.

P 2.7.07

Controls on mineralization of eroded soil organic carbon in terrestrial and aquatic environments

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Question

Better integration of terrestrial and aquatic SOC fluxes is crucial to understand carbon cycling in dynamic, eroding landscapes and advance global carbon budgets. Worldwide, erosion on agricultural land plays an important role in carbon cycling. Deposition of eroded soil organic carbon (SOC) takes place on downslope soils or in adjacent inland waters, i.e. a substantial transfer of SOC from terrestrial to aquatic ecosystems. However, the fate of eroded SOC after deposition and the net effect on C exchange between soils, atmosphere and inland waters is highly uncertain.

Methods

A 4-month incubation study was performed, using a gradient of European agricultural soils to identify and quantify mechanisms that control C turnover in terrestrial and aquatic environments. The soils spanned a wide range of SOC, soil chemical and physical characteristics, and were incubated under conditions reflecting downslope soils and aquatic depositional conditions to determine C turnover. Different additions of ^{13}C labelled cellulose enabled us to assess the impact of labile carbon inputs ('priming') on SOC stability.

Results

Depositional conditions (terrestrial vs. aquatic) were found to be crucial in determining CO_2 emissions, where transitions to inland waters induce a 2 - 3.5 fold increase in C turnover. Trends in C mineralization changed over time, and showed a lag phase for aquatic systems. Labile C inputs resulted in a 1.4 - 3 times higher cumulative CO_2 emission. Analysis of the ^{13}C labelled tracer provided insights in priming effects. Soil microbes had fast adaptation strategies to shifting environmental conditions, as demonstrated by ^{13}C incorporation into PLFAs. ^{13}C CPMAS NMR and FTIR analyses gave an in-depth characterization of SOM quality, and showed large similarities in molecular composition among the sites. C turnover was affected in a complex manner by interactions between soil properties and molecular composition.

Importantly, a novel empirical model was developed to predict CO_2 emissions from SOC deposited on downslope soils, in inland waters, and with labile C inputs. The model improves on linear scaling or simple exponential curves, which underestimate short- but overestimate long-term C turnover for aquatic conditions. This model provides quantitative insights into C turnover, and is supported by a broad data set of agricultural sites.

Conclusion

The fate of eroded SOC will become increasingly important for global C cycling, given that agricultural erosion due to heavy rainfall under climate change is likely to intensify. Our study highlights that C turnover differs for soils vs. inland waters and upon labile C inputs. Incorporation of these quantitative relations in C cycling models is key to improve our understanding of C turnover across soil-water interfaces, particularly in cultivated landscapes. On a larger scale, these quantitative relationships can be used to parameterize global biogeochemical models and they are envisaged to contribute to better estimates of the effect of soil erosion on C budgets and reduce uncertainties in the linkage between terrestrial and aquatic C cycling.

P 2.7.08

Impact of soil aggregate size on the potential dissolved organic matter : isotopic and molecular approaches

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Under temperate climate, the presence of dissolved organic matter (DOM) in stream waters is largely dominated by the transfer of DOM from surrounding catchments. The DOM transfer from soils to stream is controlled by hydro-climatic conditions involved along the year. Indeed, in stream waters, the DOM concentration varies largely according to the water-table dynamics in the catchment, both in downland-wetland zone and upland zone. Based on chemical and isotopic composition of river and soil solutions, it has been suggested that (i) DOM reservoir in the wetland zone dominated the annual DOM budget, and supposed to be an unlimited reservoir, and (ii) DOM reservoir from the upland zone contributed partially during the winter period, with a gradually decreasing influence and supposed to be a limited reservoir.

Two questions may be asked: (i) Is the chemical, molecular and isotopic composition of DOM in stream waters only dependent on a mixture between downland and upland waters? (ii) Is the flow ways (i.e. porosity location) through soils and soil particles controlling the stream DOM composition?

In order to answer these questions, soil samples have been fractionated in size of aggregates, according to the method developed by Elliott (1986) in order to extract potential DOM through a water leaching. Our working hypothesis was that the water flow ways are controlled by macro- and micro-porosities, which are directly linked to soil aggregation. Moreover, it cannot be excluded that the different aggregate size contained organic matter with different origin (microbial, humified, fresh…) traceable by their molecular composition and isotopic signatures. That's why, considering aggregate-size distribution and modification of hydro-climatic conditions along the year, both the production and transfer of DOM may differ in macro- and micro-porosity. The DOM produced may largely differ in isotopic and molecular compositions, and therefore,by mixing in soil solutions may generate variable organic matter composition. This method has been tested and applied on two soils sampled the same day in an agricultural catchment, belonging to the French Critical Zone Observatory AgrHyS: a soil (G3) in a downland zone and a soil (K3) in upland. The two soils are isotopically distinct ($\delta^{13}C$=-26‰ for K3 and $\delta^{13}C$=-28‰ for G3). Briefly, the method consists of a soil sieving at 10 mm, 2 mm, 0.250 mm, and 0.50 mm in order to discriminate between macro- and micro-aggregates, and silt-clay fractions. Samples have been sieved, dried at 40°C and freeze-dried for isotopic ($\delta^{13}C$) and molecular analysis (thermally assisted hydrolysis methylation - gas chromatograph / mass spectrometer).

The results show that the aggregate size does not largely influence both molecular and isotopic composition of each aggregate fraction. This may indicate that, based on the method used in this experiment, aggregate size do not influence the distribution of different soil organic matters from different origin (microbial, humified, fresh,...).

P 2.7.09

Organic and inorganic phosphorus in soils of buffer zones in an intensively used agricultural catchment

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Since several years, phosphorus (P) transport from agricultural soils to waterbodies has become an important non-point pollution source, which may be responsible for toxic algae blooms. Remediation of this source is impeded by the lack of understanding of processes leading to the release of P from the agricultural soils. Up to now erosion was thought to be the main controlling factor of P export occurring mainly bound to soil particles. However, in recent years dissolved P and colloidal P in solution have been identified as major contributors to P export from agricultural watersheds being controlled by microbial activity as well as redox processes. The P release occurring by these processes may be depended on the P forms present in the soil mineral phase. The objective of the present study was to quantify and characterise P forms present in soils characterised by different humidity of an agricultural watershed presenting high risk of P export due to intensive use of organic amendments in form of pig manure. We hypothesised that organic P forms as well as microbial turnover of P could be a main controlling factor of the presence of easily available P forms, ready to be exported from the watershed.

Our conceptual approach included direct determination of inorganic and organic P as well as chemical fractionation of organic and inorganic P forms present in the surface soil and at depth of three adjacent sites characterised by contrasting humidity.

The results indicated changing P content of surface soils with contrasting humidity, while subsoils showed a similar P content. Strong differences were noted for the contribution of organic P depending on the method used. Direct analyses of organic P underestimated its contribution as compared to the Hedley method. These P forms may be more important at depths than the surface soil. Moreover, significantly different microbial biomass content was noted in all samples, which could in non-humid soils be related to P forms. Correlations with easily available organic as well as easily available and bound inorganic P forms supported partly our initial hypothesis. For organic P the strength of correlation decreased with the strength of P bonding, with NaOH extractable organic P, being least related to microbial biomass. This P form being either related to soil organic matter or metal oxides, was the most important P form together with inorganic HCl extractable P.

We conclude that sequential chemical extraction may be well suited to quantify organic P in agricultural soils. Intensive agriculture with high amounts of organic amendments may influence P content and forms mainly in surface soils. Soil humidity may have an impact on the microbial controls of soil P.

P 2.7.10

A Field Investigation on Settling Velocity Specific SOC Distribution along hillslopes

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The net effects of soil erosion by water, as a sink or source of atmospheric CO_2, are decisively affected by the spatial re-distribution and stability of eroded soil organic carbon (SOC). The deposition position of eroded SOC, into terrestrial or aquatic systems, is actually decided by the transport distances of soil fractions where the SOC is stored. In theory, the transport distances of aggregated soil fractions are related to their settling velocities under given layer conditions. Yet, little field investigation has been conducted to examine the actual movement of eroded soil fractions along hillslopes, let alone the re-distribution pattern of functional SOC fractions.

Eroding sandy soils and sediment were sampled after a series of rainfall events from different topographic positions along a slope on a freshly seeded cropland in Jutland, Denmark. All the soil samples from difference topographic positions along the slope were fractionated into five settling classes using a settling tube apparatus. The SOC content, ^{13}C signature, and C:N ratios of all settling fractions were measured. Our results show that: 1) the spatial distribution of soil settling classes along the slope clearly shows a coarsening effect at the deposition area immediately below the eroding slope, followed by a fining trend on the deposition area at the slope tail. This proves the validity of the conceptual model in Starr et al. 2000 on along eroding hillslopes. 2) The isotopically enriched ^{13}C on the slope back suggests greater decomposition rates possibly experienced by eroded SOC during transport, while the pronounced respiration rates at the slope tail indicate a great potential of CO_2 emissions after deposition. Overall, our results illustrate that immediate deposition of fast settling soil fractions, and the thus induced preferential deposition of SOC at foot slope and potential CO_2 emissions during transport, must be appropriately accounted for in current soil carbon balances. Therefore, a SOC erodibility parameter based on the actual settling velocity distribution of eroded fractions (aggregated or not aggregated) is urgently needed to better parameterize soil erosion models.

IT 2.8

Is all mineral stabilized organic matter microbial in origin? - Insights from NMR spectroscopy

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Introduction

The origin and formative pathways of stable SOM has been a contentious topic amongst soil scientists, organic chemists and microbiologists for most of the last century. Early researchers considered stable SOM to be a complex macromolecular entity originating through a series of abiotic and potentially biotic pathways. Molecular level insights from the past two decades have consistently failed to observe humic substances in situ and a new view has emerged where stable SOM is a loose assemblage of diverse but recognizable low molecular weight compounds from biological origin generally associated with mineral surfaces. This view also suggests a prominent role for interactions between dissolved organic matter (DOM) and reactive mineral surfaces. Most recently, there has been a push towards a microbial origin for most stable SOM with supporting evidence coming from molecular level investigations and theoretical simulations. However, there is also evidence that not all OM must pass through a microbe before being found in what would be considered stable SOM.

Objectives

Our objective in this presentation is to assess the chemical nature of mineral-stabilized SOM with a particular focus on whether this material appears to be dominated by microbial necromass and then think a bit about under which environmental conditions favor stabilization of plant-derived SOM.

Materials & Methods

In this presentation, we pull together evidence from several investigations[1, 2, 3] using solid-state ^{13}C NMR spectroscopy to assess the chemical nature of SOM. Solid-state NMR spectroscopy is, in our opinion, a particularly useful tool for addressing this issue since NMR spectroscopy can “see” all or at least most of the OM in a sample.

Results

A leaching-sorption experiment using ^{13}C-labeled plant material as a source of DOM demonstrated that a similar highly aromatic fraction of DOM will bind to minerals of varying reactivity[1]. Whether or not this highly aromatic character of mineral-associated SOM is retained then appears to be dependent upon the degree of microbial activity regulated by environmental suitability, substrate availability and reactivity of mineral surfaces. In an Ultisol and a Mollisol, this highly aromatic character was slowly lost with depth as it undergoes slow but continual processing[2]. However as demonstrated in Figure 1, this highly aromatic OM appears to be retained for millennia in subsurface horizons rich in short-range ordered minerals but not in surface horizons of a tropical Andisol[3].

Conclusions

The evidence presented in these studies demonstrate that soluble partially oxidized plant materials can and do bind strongly with mineral surfaces and that under the right environmental conditions can remain stable for millennia. However, under conditions of favorable microbial activity such as in top soils or in soils with low reactivity minerals, this plant-like chemical composition will be lost in favor of a dominance of microbial necromass as the dominant form of mineral-stabilized SOM.

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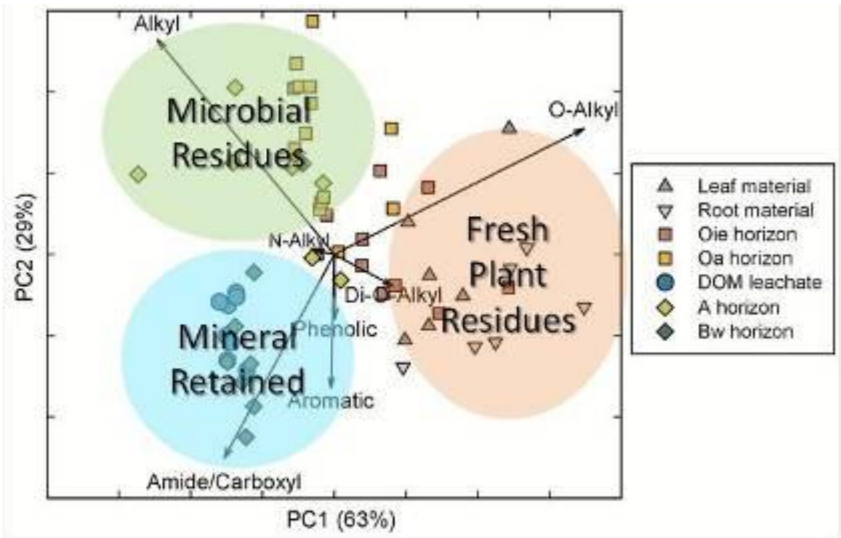
Figure 1. Principle components analysis of the chemical composition of SOM as revealed by solid-state ^{13}C NMR spectroscopy. Fresh residues (leaf, root and Oie horizon material) are dominated by signal from cellulose and lignin. In the Oa and A horizon, chemistry is dominated by aliphatic material likely indicating a strong microbial origin for OM in these horizons. In the Bw horizons with a concentration of reactive minerals, the OM chemistry is nearly identical to that of litter leachate being composed of a large fraction of partially oxidized lignin phenols (modified from ref 3).

Figure 1



O 2.8.01

Carbon Cycling in the Sub-soil: "A Can of Worms".

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1. Introduction

The yearly exchange of carbon between atmosphere and terrestrial biosphere amounts to ca. 110 PgC, of which about half goes into net primary productivity that is subsequently remineralized, mostly on and in the top-soil. Sub-soil carbon cycling has often been neglected. Yet, sub-soils may hold the key to understanding carbon storage in soil organic matter (SOM). Radiocarbon can be used to determine carbon cycling in soils, because the time elapsed since organic carbon atoms were removed from the atmosphere by photosynthesis may, in principle, be measured by the concentration ratio $^{14}C/^{12}C$. Soils are, however, open systems through which organic carbon is transported almost continuously and in which microbial activities both transform and remineralize organic compounds. Thus, ^{14}C concentrations of bulk soil organic matter and soil fractions reflect the heterogeneous mixture present and can be quite different. Yet they can still give insight into soil organic carbon dynamics.

2. Objectives

We use the ^{14}C concentration of different organic soil fractions and compounds in soil profiles to determine carbon cycling and storage in different soil types and climates. Some of the key results will be discussed.

3. Materials & methods

Soil samples were taken from different horizons/depth intervals to about 1 m depth

in Germany under the DFG Special Priority Program 1090 "Soils as source and sink for CO_2" and in Cixi, China, and Jawa, Indonesia, in the DFG Research Unit 995 "Biogeochemistry of paddy soil evolution". Different organic fractions and compounds were isolated in collaboration with project partners and their ^{14}C concentration was determined by accelerator mass spectrometry (AMS). The passage of ^{14}C, produced in atmospheric nuclear weapons testing up to 1963, through the atmosphere provides an almost yearly ^{14}C label for photosynthate since 1954.

4. Results

The combined data of the two projects allow conclusions relevant for our understanding of carbon cycling and sequestration in soils:

- ^{14}C concentrations in agricultural top-soils are generally close to those of the atmosphere, indicating carbon residence times on the order of years to a few decades.
- Fossil carbon, introduced as dust or black carbon, participates in the active soil carbon cycle.
- The customary ^{14}C concentration decrease with increasing depth in an undisturbed profile may fully result from the transport of young organic material, mostly as DOM, down from the surface instead of from sediment deposition over a long time period.
- Such DOM transport may prime sub-soil microbial communities and counter-intuitively, lower bulk organic ^{14}C concentrations.
- Rootlets, root exudates, and bio- and pedoturbation introduce additional young carbon in the (deep) sub-soil.

5. Conclusion

The organic carbon distribution in soils is determined by the dynamic equilibrium between the supply of fresh photosynthate and the loss to remineralization, and leaching by water. This equilibrium depends on soil type and structure, local temperature and rainfall (climate), hydrology, and management on time scales from seasons to decades. Long-term SOM stabilization and storage is likewise subject to these influences and the potential of soils for long-term storage of anthropogenic CO_2 is thus limited.

O 2.8.02

Soil carbon fractions at depth in Eastern Australia

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1. Introduction

Conceptually, SOC is separated into numerous pools with varying turnover rates ranging from hours to millennia, which are linked with the bioavailability of SOC and therefore its degradability. Mechanisms such as mineral-association, aggregation (and associated occlusion of SOC in aggregate interiors) and physico-chemical transformation to recalcitrant carbon forms (e.g. via pyrolysis) can reduce the biological accessibility of organic matter, converting it into more stable forms which are resistant to degradation processes and remain in the soil environment for long time periods. Manipulating the stocks of stable SOC is seen as a means of mitigating anthropogenic climate change, with the potential to provide a long-term carbon sink. Sub-surface soils are seen as potentially attractive stores of additional soil carbon, as they generally contain older carbon than surface soils, which is thought to be (by implication) more stable.

2. Objectives

The aim of the study was to identify the controls on SOC stability down the whole soil profile, in particular relating to climate, site and human influences.

3. Materials & methods

To do this we investigated the stability of whole profile soil organic carbon (SOC) based upon three mid-infrared predicted fractions - particulate organic carbon (POC), humus organic carbon (HOC) and resistant organic carbon (ROC) - at 100 sites across Eastern Australia. We used three data-mining techniques (randomForests, gradient boosting machines and multiplicative adaptive regression splines) to identify and assess the controls on the relative proportions of the three fractions down the soil profile.

4. Results

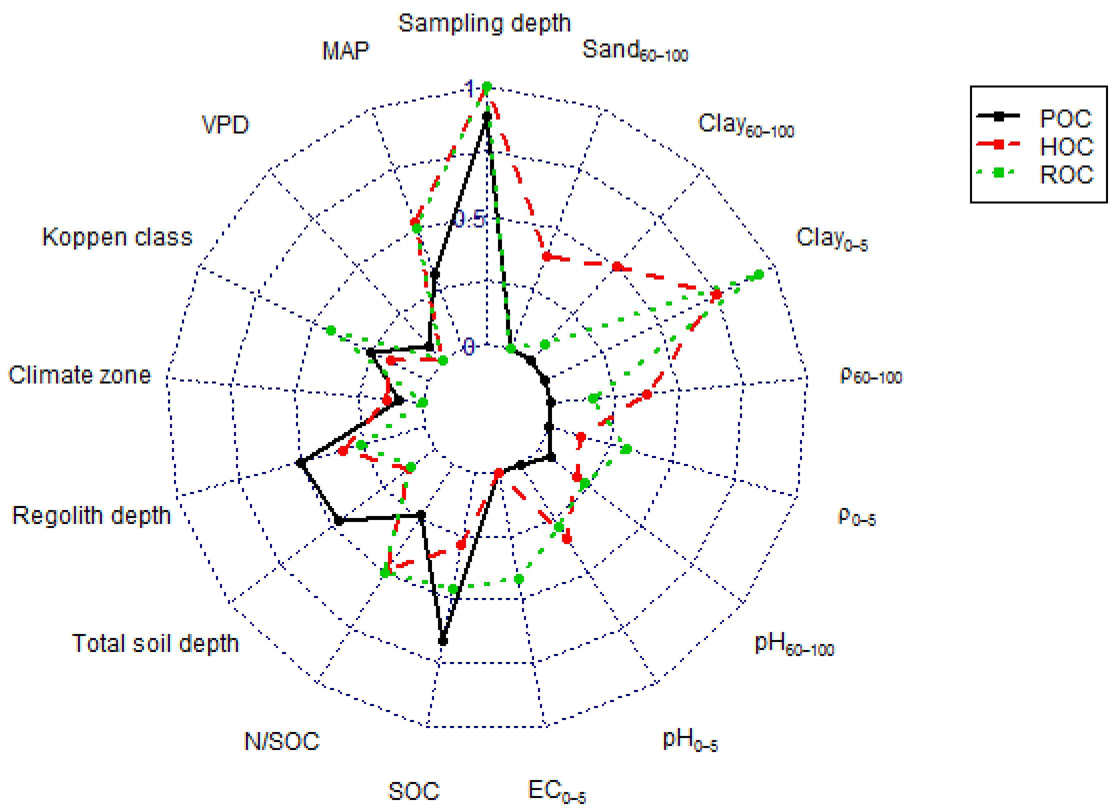
Depth was the key control on all three fractions, with the proportion of POC decreasing, and the proportion of HOC carbon increasing with increasing depth (Figure 1). POC was strongly linked with bulk SOC concentration. HOC and ROC were controlled additionally by climate and soil physico-chemical properties, with SOC being less important to these fractions. Greater proportions of resistant organic carbon (associated with pyrogenic carbon forms) were found in light-textured soils at depth. Human influences (land-use and management) were not important to any of the fractions.

5. Conclusion

The strong link between POC and total SOC suggested that SOC content in the studied soils were input driven. Conversely, the positive association of HOC with depth implies that subsoil organic carbon consists largely of humified soil organic matter translocated from the surface. The enhanced proportion of ROC implies that pyrogenic carbon may be a substantial stock of organic carbon at depth in sandy soils. The lack of importance of land-use and management on the fractions down the entire profile implies that the potential for manipulating carbon stocks by humans with a view to increasing stable carbon forms of high longevity in soils may be limited, as all carbon fractions appeared to respond similarly to human influence.

Figure 1: Variables identified in the multiplicative adaptive regression splines as important to the proportions of the three fractions.

Figure 1



Sampling depth
Sand60–100
Clay60–100
Clay0–5
ρ60–100
ρ0–5
pH60–100
pH0–5
EC0–5
SOC
N/SOC
Total soil depth
Regolith depth
Climate zone
Koppen class
VPD
MAP
1
0.5
0
POC
HOC
ROC

O 2.8.03

Carbon allocation and stocks in African tropical lowland rainforest driven by nutrient availability

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African tropical rain forests are one of the most important hotspots to look for changes in the upcoming decades when it comes to carbon (C) storage and release. In our study on lowland rainforest in the central Congo basin, we combine both an assessment of the aboveground C stock with an assessment of the belowground C stock and analyze the latter in terms of functional pools and controlling factors.

Our study shows that despite similar vegetation, soil and climatic conditions, soil organic carbon stocks in an area with greater tree height (= larger aboveground carbon stock) were only half compared to an area with lower tree height (=smaller aboveground carbon stock). This suggests a substantial variability in the root:shoot C allocation strategy of two similar plant communities for nutrient mining, especially potassium, and has important consequences for the assessment of the total C stock of the system (above and belowground C combined).

We argue that as long as these large differences in C stocks cannot be adequately explained mechanistically, all modeling and estimates of the future response of the C storage of tropical forest ecosystems are subject to large uncertainties and will, hence, introduce additional uncertainty in the response of tropical forest systems to climate change and its contribution to the current terrestrial C budget.

O 2.8.04

Variability of SOC components in relation to other soil parameters in top- and subsoil of a sandy Cambisol under beech forest

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1. Introduction

Subsoils are known to store a high amount of organic carbon (40-60% of the total C-pool) for several millennia, as indicated from ^{14}C-dating. Reactive minerals might be the reason for the stabilization of soil organic matter (SOM) in subsoils while the distribution of SOM and the controlling soil parameters are nearly unknown.

2. Objectives

The aim of this study was i) to estimate the variability of soil organic carbon (SOC) in subsoils by using a grid sampling approach, and ii) to analyze which soil parameters (pH, texture, SOC-content, dithionite and oxalate soluble Fe, root biomass and microbial biomass C) drive SOC distribution in subsoils.

3. Material & Methods

Within the DFG-FOR 1806 the heterogeneity of soil parameters in soil profiles (top and subsoil) of a podzolic Cambisol in a 95 years old beech forest in Lower Saxony, Germany was investigated. Three transects were established with a vertical and horizontal dimension of 2.00m and 3.15m, respectively. In each transect, 64 soil samples were taken out of a grid in 10, 35, 60, 85, 110, 135, 160 and 185m depth with increasing horizontal distance to a main tree. Soil physical (texture) and chemical properties (content of soil organic carbon, dithionite and oxalate soluble Fe, root biomass), and microbial biomass C were detected for all soil samples. The SOC contents of the respective depth were described by linear regression considering the mentioned soil parameters under addition of spatial exponential correlation models.

4. Results

The results show an enhanced variability of soil properties in subsoil (30-185cm) compared to the top soil (10-30cm). The coefficient of variation of SOC and dissolved organic carbon (DOC) increased with increasing depth over all transects by 50 and 90%, respectively. The linear regression model indicated significant relationships between SOC and microbial biomass C ($r=0.52$; $P<0.05$).

5. Conclusion

The results point out so far, that root biomass contributes significantly to the organic matter pool in subsoils, whereas, the texture is regulating its pattern.

O 2.8.05

The contribution of "root carbon" and SOM in soil food webs as reflected in the vertical distribution of soil animals

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The density of soil animals in subsoil is typically low. Nevertheless, animal activity can contribute into dynamics of soil organic matter (SOM) in deep soil layers. Emerging evidence suggests that animal communities in the topsoil are at least partly fuelled by the fresh photosynthate pumped in the soil by plant roots. The importance of this "root carbon" might be even greater in deep soil. On the other hand, certain groups of soil animals (endogeic earthworms, humiphagous termites) use stabilized soil carbon as main energy source. The relative importance of plant roots (and associated microorganisms) versus "dead SOM" (and associated saprotrophic microflora) in the energy budget of soil animals inhabiting deep soil layers remains unknown. We addressed this question by comparing vertical distribution of roots, SOM, and various groups of soil animals in different soil types.

To compare the distribution of different parameters and taxonomic group, a simple log-linear model was used: $\log_{10} \mathbf{y} = -m\mathbf{x} + b$. In this equation, **y** is the abundance of soil animals [ind. × kg of dry soil^{-1}], at the depth **x** [cm]. Thus, the "*m*" (*slope*) reflects the rate of the decline in abundance with depth, whereas the *b/m* ratio estimates the maximum soil depth inhabited by certain taxonomic group. The vertical distribution of soil animals was compared with the distribution of their potential food sources. We hypothesized that comparing *m* and *b/m* values in SOM, roots, and various groups of soil animals allows differentiating animal taxa trophically linked to the "root carbon" from those feeding on saprotrophic soil microorganisms and thus having direct trophic link to SOM. To characterize the fraction of SOM available for soil organisms, active microbial biomass (estimated via substrate-induced respiration) was used instead of the total SOM.

The study was conducted in three forests located on a latitudinal gradient in European Russia: a boreal forest on podzolic soil (Tver region), a broad-leaf deciduous forest on dark-gray forest soil (Kaluga region) and forest-steppe vegetation on typical chernozem (Penza region). At each site, soil samples were taken from soil profiles exposed on the sides of freshly dug pits. Samples were taken from the soil surface (litter) down to the depth of 140-200 cm with 10 cm intervals.

On average, the density of soil animals decreased faster with soil depth than the density of thin roots. The *slope* averaged 0.05±0.01[SE] and 0.03±0.01, respectively. Microbial biomass decreased even slower (on average, *m* = 0.02±0.01). The *m* values of animals, roots or microbial biomass did not differ significantly in different forest types. Macrofauna members Diplopoda (*m* = 0.09±0.03) and Staphylinidae (0.09±0.01) demonstrated the steepest decline in abundance. The decline in the density of smaller animals, collembolans and oribatid mites, was less pronounced, with *m* averaging 0.03±0.01 and 0.04±0.01, respectively.

The *b/m* ratio of roots was significantly higher in the forest steppe compared to deciduous and boreal forests (210±26, 48±20, and 40±3, respectively). The corresponding latitudinal pattern in microbial biomass was much less pronounced. Changes in the *b/m* ratio of oribatid mites (141±6, 77±4, and 58±3 in forest steppe, deciduous and boreal forest, respectively) were similar to those of roots. The *b/m* ratio of enchytraeids (115±7, 74±22, and 21±6) and collembolans (148±7, 107±12, and 57±3 in the forest steppe, deciduous and boreal forest, respectively) also changed with latitude, though the difference between forest steppe and deciduous forest was much less pronounced than in the roots. In contrast, maximum soil depth inhabited by Diptera larvae and Diplopoda did not change with latitude (*b/m* ratio averaged 32±9 and 9±2, respectively).

Our data suggest that the relative importance of the root- and SOM-derived resources differs strongly in different groups of soil animals inhabiting deep soil. Among the animal groups studied, only oribatid mites are likely depending mainly on roots. Other animal taxa may be more dependent on SOM-derived sources, though this question needs further investigation.

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O 2.8.06

Sources of CO_2 production in subsoils

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It is estimated that subsoils store more than 50% of the total global soil organic carbon (SOC). The high mean residence times of subsoil SOC compared to topsoil SOC indicate that SOC in subsoils is more stable than in topsoils. The main C-inputs into subsoils occur through roots, roots exudates, dissolved organic carbon (DOC) and bioturbation. However, it is not clear which are the pathways of SOC into the subsoil and sources of SOC mineralization in subsoils.

The aim of this study was to identify the mineralization of different SOC sources by the analysis of the CO_2 production in subsoils, its ^{14}C content, and changes in ^{13}C after the application of ^{13}C enriched litter.

We installed three subsoil observatories in a 100 yr^{-1} old beech forest on a podzolic cambisol in northern Germany in 2013. In each subsoil observatory CO_2 sensors and gas samplers were installed in 5 depths (10, 30, 50, 90 and 150 cm). Since November 2013 the CO_2 concentration is measured continuously. In order to gain information about the age of the respired CO_2 we collected CO_2 samples in all 5 depth for radiocarbon analysis using molecular sieves. Two observatories were sampled twice in 2014, one during the vegetation period and one during the winter season. To trace the litter-born DOC input and mineralization of DOC in subsoils, ^{13}C-labeled litter have been applied to all three subsoil observatories in January 2015. Before the application of the ^{13}C labeled litter $^{13}CO_2$ gas samples were taken every month from March 2014 to December 2014. After the addition of the litter gas samples were taken on a weekly basis.

The CO_2 concentrations in all depth have a seasonal variation with the highest CO_2 concentrations during the summer (up to 4 Vol. % CO_2) and the lowest concentrations during the winter (0.4 Vol. % CO_2). In two observatories the CO_2 concentration increased with soil depth and were highest in 150 cm depth. The third observatory showed no depth gradient. The radiocarbon results showed no differences in the ^{14}C content of the CO_2 between topsoil and subsoil during and after the vegetation period. The ^{14}C concentrations varied between 1.031 to 1.080 fraction modern ($F^{14}C$). This indicates that CO_2 in the subsoils originates from relatively fresh sources. One week after the application of the labeled litter the CO_2 $^{13}C/^{12}C$ isotope ratios increased up to 50 cm depth. Two weeks after the labeling the CO_2 $^{13}C/^{12}C$ isotope ratios increased in 90 cm depth indicating a rapid transfer of litter-derived DOC into the subsoil. However, DOC in subsoils accounted only for less than 2% of the CO_2. Therefore these results indicate that old/stable SOC and DOC are only a minor source of microbial mineralization in subsoils. We discuss the implications of our result for our understanding of the coupling and decoupling of subsoils from the ecosystem carbon cycle.

O 2.8.07

DOC sorption is influenced more by concentration than retention time and source: An investigation into moorland and grassland soils in UK upland catchments

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Introduction

Increased levels of dissolved organic carbon (DOC) in upland surface waters in Europe and North America have led to a greater need to understand the causes of its occurrence. In the UK, upland catchments are a major source of potable water and increasing DOC is a source of financial and operational concern for water companies. Surface organic rich horizons are a major source of DOC while mineral horizons potentially adsorb and remove DOC from soil solutions. Organo-mineral upland soils range in hydrological properties from free draining podzols to seasonally waterlogged gleysols. Several studies have shown that a reduced contact time between DOC and mineral horizons during storm events leads to greater export of DOC to waters draining the catchment. In waterlogged soils there is an increased contact time between mineral soil and soil solution but few studies have explored whether this influences the amount of DOC adsorbed from solution. Thus further research is needed to investigate the relationship between soil solution retention time and DOC adsorption. UK upland organo-mineral soils typically are vegetated by low shrubs and acid grassland, and occasionally are afforested. Whilst a number of studies have explored the sorptive properties of forest soil DOC, few studies have compared properties of DOC leached from O-horizons dominated by non-forest vegetation. Thus there is a gap in knowledge on the role of non-woody plants in the production of DOC and its retention and release from catchment soils. Variations in vegetation and soil solution retention time at these sites might explain the variation in DOC composition and concentration seen in waters of upland catchments, however further research is needed to investigate if catchment DOC dynamics can be explained by dominant vegetation cover and soil solution retention time.

Objectives

The aim of this research was to answer the following questions:

- Does the retention time of soil solution influence the amount of DOC adsorbed to mineral soil?
- Does the retention time for maximum adsorption of DOC differ for DOC sourced from O-horizons beneath different vegetation types?
- Do variations in DOC input concentrations to mineral soil affect the time required for maximum adsorption?
- How do the chemical properties of soil solution change with increased retention time?

Materials & methods

A column study was carried out using upland soils. We investigated the sorption behavior of DOC extracted from O-horizons beneath moorland dominated by the shrub *Calluna vulgaris* and grassland dominated by *Molinia caerulea* to a common mineral soil. For each DOC, 4 concentration treatments (ranging from 2 to ~ 100 mg C L^{-1}) were applied. Differences in adsorption between DOC source, concentration and at retention times of 24, 48, 96 and 120 hours were investigated using ANOVA. Specific UV absorbance at 254nm ($SUVA_{254}$) was used as an indicator of DOC quality before and after adsorption.

Results

For all DOC sources tested equilibrium was reached within 24 hours and longer retention times had no significant impact on sorption. Desorption was seen at low concentrations of added DOC and adsorption seen at higher concentrations of added DOC for all sources of DOC. The effect of concentration was significant on the amount of DOC adsorbed or desorbed ($p=<0.001$). $SUVA_{254}$ decreased significantly ($p=<0.001$) between pre and post adsorption solutions. Pre adsorption $SUVA_{254}$ ranged 4.4 to 5.1 L mg^{-1} m^{-1} for the different treatments of added carbon while all post adsorption $SUVA_{254}$ was < 1 L mg^{-1} m^{-1}.

Conclusions

The results suggest that in upland organo-mineral soils prone to waterlogging, sorption equilibrium would be reached within 24 hours of DOC being introduced into mineral horizons regardless of source or input concentration. The shift from high $SUVA_{254}$ compounds to low $SUVA_{254}$ compounds whether adsorption or desorption dominated suggests that there is an active exchange of DOC between percolating solutions and the soil matrix. This observation was made for both DOC sources which would indicate that the quality of DOC released from these soils is unaffected by the DOC source. When the concentration of DOC entering the mineral layer is low the net effect will be desorption and when the concentration is high the net effect will be adsorption. Overall these results suggest that it is the concentration of DOC entering the mineral layer and not the retention time that determines the amount of DOC released from these soils.

O 2.8.08

Dissolved organic matter transport into the subsoil varies with the water flow regime

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1. Introduction

Dissolved organic matter (DOM) is the most mobile fraction of carbon in the soil and connects the litter layer as the main carbon source to the subsoil where the translocated OM may get stabilized. The water flux in soil is highly heterogeneous, both temporarily and spatially. Flow conditions range from matrix to preferential flux, which can exert strong effects on the quality and quantity of the transported DOM. During preferential flow, DOM can bypass possible mineral binding sites and microorganisms, while under a matrix flow regime there will be less kinetic restrictions in getting into contact with the soil solid phase and a higher chance of microbial alteration.

2. Objectives

We, therefore, hypothesize that fast transported DOM is less degraded than DOM transported under matrix flow conditions. Further, we assume that preferential flow paths are persistent over time and thus create predictable patterns of water and DOM fluxes.

3. Materials & methods

To address these question, we investigated water and DOM fluxes *in situ* using segmented suction plates (4 x 4 segments on 25 x 25 cm) installed into three soil observatories at three depths (10 cm, 50 cm, and 150 cm) in a Podzolic Cambisol under Beech (*Fagus sylvatica*) near Nienburg, Germany. To follow the transport of carbon from the litter layer through the soil, on one side around the observatories the litter has been replaced by ^{13}C-enriched beech litter in January 2015, leaving the other side as control. Percolates were analyzed weekly for DOC, total nitrogen (TN), and specific $UV_{280\ nm}$ absorbance as a proxy for the aromaticity and monthly for $DO^{13}C$.

4. Results

The amount of transported DOM decreased by ca. 70% from 10 to 50 cm depth and by additionally 15% from 50 to 150 cm depth. The DOM transport was significantly higher at higher water fluxes in all three depths. The specific $UV_{280\ nm}$ absorbance of DOM decreased with increasing soil depth. The mean spatial heterogeneity of water fluxes within each suction plate increases with depth from 34 ± 13% in 10 cm depth to 61 ± 12% in 150 cm depth. Moreover, preferential flow paths, as indicated by fluxes through individual segments, remained stable over the observation period. The mean spatial heterogeneity of DOC fluxes ranges from 21 ± 17% in 10 cm depth to 35 ± 20% in 150 cm depth.

5. Conclusion

The decreasing specific $UV_{280\ nm}$ absorbance of DOM over depth indicates a selective loss of aromatic compounds. The influence of different flow regimes on the DOM quality became apparent in the subsoil samples (>50 cm depth) showing a correlation of increasing $UV_{280\ nm}$ absorbance and increasing water flux, and suggesting that preferentially sorbed DOM contains a larger fraction of aromatic components and that this preferential sorption is less pronounced under kinetically restrained conditions. Finally, the ^{13}C labeling experiment will then provide further insights into the origin of soil DOM within different depths and along the different transport paths, and will also help to decipher the importance of exchange processes with *in situ* soil organic matter.

O 2.8.09

Stabilization and vertical mobility of dissolved organic carbon and its potential contribution to microaggregate formation in sandy soils

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Introduction:

The role of dissolved organic carbon (DOC) in soil organic carbon (SOC) stabilization through adsorption and aggregation leading to SOC accumulation in sandy textured soils are unclear.

Objective:

On the basis of a long-term field experiment in Northeast Thailand in which biochemically contrasting organic residues have been applied for 13 years, we investigated: i) characteristics of the generated DOC pertaining to microbial decomposition, ii) its potential role in SOC stabilization in microaggregates, and iii) its vertical mobility in a soil profile of a tropical sandy Ultisol.

Materials and methods:

This work employed DOC samples extracted from soil samples taken in year 13 (2007-2008) of the Khon Kaen long-term field experiment that was initiated in 1995 to study the potential of biochemically contrasting organic residues (g kg^{-1}) (rice straw (RS, 5 nitrogen (N), 29 lignin (L), 7 polyphenols (PP), 507 cellulose (CL)), groundnut stover (GN, 23 N, 68 L, 13 PP, 178 CL), dipterocarp (DP, 6 N, 176 L, 65 PP, 306 CL) and tamarind (TM, 14 N, 88 L, 32 PP, 143 CL) to restore SOC in a degraded tropical sandy Ultisol. Dynamics of whole and molecular weight fractions (<1 kDa, >1 kDa, >10 kDa) of DOC were determined in topsoil samples (0-15 cm) taken at defined time points within the course of 52 weeks. To study the vertical distribution of whole and molecular weight fractions of DOC, we considered samples (week 2 and 8 after residue application) from two soil layers of each soil (Ap horizon (0-15 cm) vs. Bt1 horizon (60-80 cm)) treated individually with the respective organic residues.

Results:

TM, GN and DP with higher contents of N and recalcitrant substances (L, PP) but lower content of CL than RS produced large amounts of high molecular weight (HMW) (>10 kDa) DOC. A mechanism was put forward that this HMW fraction of DOC, having a high affinity for adsorption to fine soil particles, was probably the result of microaggregate formation in topsoil (0-15 cm) where it was stabilized. Accordingly, higher SOC accumulation in topsoil in these treatments than under RS was observed. Meanwhile, RS with higher content of CL but lower contents of recalcitrant substances produced high amounts of low MW (LMW) (<1 kDa) fraction DOC during the initial stage of decomposition. The LMW fraction DOC having low affinity for adsorption was easily leached, leading to its depletion in the topsoil. Nonetheless, it was sequestered at lower soil depths (60-80 cm) where higher clay contents were found.

Conclusion:

More in-depth investigation on the mechanism which renders the very likely DOC influence on microaggregate formation and its vertical mobility is mandatory. This will have important implications for increasing the C sink size for soil C sequestration in sandy soils.

O 2.8.10

Release, transport and transformation of organic matter from topsoil to subsoil and beyond: A combined lab- and field study to elucidate the fate of mobile organic matter in soils

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The fate of organic carbon in soils is strongly linked to the (trans-)formation, release and transport of its mobile fraction. Commonly, mobile organic carbon is considerd as the dissolved organic carbon, an operationally defined fraction that passes a 0.45µm filter. Yet, under certain and favourable conditions even particles up to a size of some tenths of micrometers can be translocated in soils. Thus, a considerable amount of mobile organic matter that includes biocolloids, mobile genetic elements and microorganisms is vastly ignored. Mobile organic matter is formed and released at biogeochemical interfaces, the "hot spots" of microbial activity and turnover in soils. Release, composition, transport and transformation of mobile organic matter is studied with a combined theoretical and experimental approach, the latter comprises field lysimeter and laboratory column studies. New to the field approach was a specific design of the tension-controlled lysimeters that allowed collection of particles up to 10µm. The column studies were run at variable initial and boundary conditions, yet a specific feature was to mimick the topsoil-subsoil situation by using columns packed with an organic rich source layer (top-soil) and a mineral rich reception layer (subsoil). By doing so, the combined effects of release, transformation and reactive transport under conditions relevant for natural systems can be studied. The lysimeters used in this study were not packed or refilled, but installed below both topsoil and subsoil without disturbing the natural soil bedding. Release of mobile organic matter was in general controlled non-equilibrium processes with strong "biological" and "colloidal" control. The released material comprised a vast variety of organic materials of biotic origin and organo-mineral associations. Besides the operationally defined dissolved and colloidal fraction, at certain conditions also larger particles including competent cells and microorganisms are translocated. Retardation and redistribution does not exclusively on the presence of reactive surfaces. Yet, it is strongly linked to the dynamics of the soil solution (aqueous phase). Immobilization and transformation in the subsoil is thus controlled by physical (hydraulics; entraprment), physicochemical (sorption; colloidal interactions) and biological mechanisms.

P 2.8.01

Soil Organic Carbon Distribution in Deep Soil Layers under different Land uses in a Reclaimed Sodic Soil of Semiarid north-west India

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Soil carbon pools change rapidly in response to land use change. In-depth understanding of C-dynamics is needed with respect to eco-systems variability. Suitable land use systems can help sequestering C and reduce green house gases (GHG's) adverse effect. We selected six land use systems namely Guava (*Psidium guajava*), Litchi (*Litchi chinensis*), Mango (*Mangifera indica*), Jamun (*Syzygium cumini*), Eucalyptus (*Eucalyptus tereticornis*), and Prosopis (*Prosopis alba*) to study their impact on distribution of soil organic carbon (SOC) in deep soil layers in a reclaimed sodic soil of north west India. Soil samples were collected upto a depth of 2 m i.e. 0-0.2, 0.2-0.4, 0.4-0.6, 0.6-0.8, 0.8-1.0, 1.0-1.5 and 1.5-2.0 m. Results showed that oxidizable organic carbon content and total organic carbon (TOC) stock under all the land uses decreased significantly ($P<0.05$) with depth increment. Highest and lowest oxidizable organic C (33.5 and 15.1 Mg C ha^{-1}) and TOC stock (37 and 18.7 Mg C ha^{-1}) at 0-0.2 m depth was observed under Eucalyptus and Prosopis plantation, respectively. Among the horticultural land uses, Guava recorded highest oxidizable organic C (26 Mg C ha^{-1}) and TOC stock (29 Mg C ha^{-1}) at 0-0.2 m depth of soil. Oxidizable OC content at 1.0-1.5 m soil depth varied from 6.3 (Jamun) to 17.0 Mg C ha^{-1} (Litchi). At 1.0-1.5 m depth, highest TOC stock was observed under Guava (27.5 Mg C ha^{-1}) followed by Eucalyptus (20.7 Mg C ha^{-1}) and Litchi (19.7 Mg C ha^{-1}) land uses. In all the land uses, with depth increment carbon content in passive pool along with its recalcitrant nature was increased whereas active pool carbon decreased. Overall highest SOC storage (133 Mg C ha^{-1}) as well as maximum passive pool C (76 Mg C ha^{-1}) was maintained in Guava plantation. Depth-wise maximum decreasing tendency of lability index in Jamun plantation (0.44 at 1.0 to 1.5 m and 0.72 at 1.5 to 2.0 m soil depth) reiterated more recalcitrant nature of SOC.

P 2.8.02

Soil organic matter composition in sub-soils along an erosion-affected arable slope

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Soil particles can be transported with surface runoff along hillslopes forming truncated profiles at hilltop and slope positions and colluvial soils in topographic depressions. Erosion modifies not only the mineral components but also the organic matter (OM) distribution. Unclear was especially the effect of erosion on the composition of differently stable OM fractions for investigations of soil carbon storage in arable landscapes. Here, we compared OM content and composition of subsoils from eroded, colluvic, and non-eroded slope positions along a hillslope including a Luvisol (LV), an eroded Luvisol (eLV), a Calcaric Regosol (caRG), and a Colluvic Regosol (coCR) with that of corresponding topsoils. After separation of larger organic particles, a sequential extraction procedure was used to obtain water soluble (OM-W) and pyrophosphate soluble (OM-PY) fractions. Entire soil samples, OM fractions, and extraction residues were analyzed with transmission Fourier transform infrared (FTIR) spectroscopy. The OC contents of entire soil and soluble fractions, OM-W (3% of OC) and OM-PY (15% of OC), were found to in-crease along the hillslope from the eroded hilltop and slope towards the foothill (coRG) position for the cultivated topsoil (about 2-times) and subsoil horizons. The highest intensities of C=O (carboxyl groups) absorption band were found in FTIR spectra of OM-W and OM-PY from colluvium (coRG). Higher intensities of C-H (alkyl groups) absorption bands were in the OM-PY of Ap from eroded hilltop (caRG). The OM composition in terms of the C-H/C=O ratio decreased along the slope with in-creasing contents of Fe and Al oxides. The erosion induced increase in relatively stable OM-PY fraction in the colluvium at the foot hill position could support the hypothesis that erosion resulted in a larger overall C-storage in the arable soil landscape.

P 2.8.03

Loss of labile organic carbon from subsoil due to land-use changes in subtropical China

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Question: Topsoil carbon (C) stocks are known to decrease as a consequence of the conversion of natural ecosystems to plantations or croplands; however, the effect of land use change on subsoil C remains unknown. Here, we hypothesized that the effect of land use change on labile subsoil organic C may be even stronger than for topsoil due to upward concentration of plantations and crops root systems.

Methods: We evaluated soil labile organic C fractions, including particulate organic carbon (POC) and its components [coarse POC and fine POC], light fraction organic carbon (LFOC), readily oxidizable organic carbon, dissolved organic carbon (DOC) and microbial biomass down to 100 cm soil depth from four typical land use systems in subtropical China.

Results: Decrease in fine root biomass was more pronounced below 20 cm than in the overlying topsoil (70% vs. 56% for plantation and 62% vs. 37% for orchard. respectively) driving a reduction in subsoil labile organic C stocks. Land use changes from natural forest to Chinese fir plantation, Chinese chestnut orchard, or sloping tillage reduced soil organic C stocks and that of its labile fractions both in top and subsoil (20 to 100 cm). POC reduction was mainly driven by a decrease in fine POC in topsoil, while DOC was mainly reduced in subsoil. Fine POC, LFOC and microbial biomass can be useful early indicators of changes in topsoil organic C. In contrast, LFOC and DOC are useful indicators for subsoil. Reduced proportions of fine POC, LFOC, DOC and microbial biomass to soil organic C reflected the decline in soil organic C quality caused by land use changes.

Conclusions: We conclude that land use changes decrease C sequestration both in topsoil and subsoil, which is initially indicated by the labile soil organic C fractions.

P 2.8.04

Factors controlling carbon mineralization in subsoils of arable land - A long term incubation experiment

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Subsoil is important for soil organic carbon (SOC) storage in terrestrial ecosystems. Currently different factors are discussed, which control carbon dynamics in subsoil. Three of these factors are: the physical separation of microorganisms and substrate, the lack of readily degradable plant substrate, which enables microorganisms to degrade recalcitrant SOC, and the inhibition of the microbial community due to elevated CO_2 and reduced O_2 concentrations.

The aim of our study was to investigate the importance of these factors in relation to naturally different SOC contents in subsoil.

Therefore we sampled one Colluvic Cambisol covering the original soil surface of a Chernozem and one Haplic Luvisol at 5-10 cm and 75-85 cm depth in August 2014. The SOC content in the subsoil of the Cambisol (12 mg g^{-1} soil) was four times higher than in the Luvisol (4 mg g^{-1} soil). Within the incubation experiment we used disturbed (sieved < 2 mm) and undisturbed samples to test whether mixing of soil results in higher mineralisation rates. To investigate the influence of fresh substrate amendment 2 % of amaranthus (*Amaranthus hypochondriacus L.*) were added to the disturbed samples. Gas samples for CO_2 and O_2 were analysed every week for 6 months. In order to investigate the influence of subsoil gas conditions, we first measured the natural gas concentrations in subsoil. Average concentrations were 4 Vol.-% CO_2 and 17 Vol.-% O_2 but extreme values reached concentrations of 8 Vol.-% CO_2 und 13 Vol.-%-O_2. We then used these two different concentrations in our incubation experiment. All samples types were subjected to all treatments and incubated for 6 months at 22°C. Pre- and post-incubation analyses are supposed to show whether the treatments have an influence on the development of SOC, microbial biomass C and ergosterol as a marker for saprotrophic fungi.

Respiration rates did not differ between disturbed and undisturbed subsoil samples from both sites. However, the disturbed topsoil showed higher respiration rates than the undisturbed topsoil. Substrate application increased respiration rates in topsoil and subsoil. The increase in subsoil respiration rates even exceeded those of the topsoil with the highest increase in the Cambisol subsoil. Regarding the gas conditions there was a slight tendency towards an increase of fungal biomass with increasing CO_2-concentrations.

P 2.8.05

Deep ploughing can increase soil organic carbon stocks

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1. Introduction

Deep ploughing has been promoted in Germany until the 1970s as a measure to break hardpan, improve soil structure and increase infiltration, and thus enhance yields. Soil organic carbon (SOC) burial as a consequence of deep ploughing so far has not been addressed as an SOC sequestration option. Deep ploughed croplands represent unique long-term experiments on in-situ incubation of topsoil material in subsoils which contributes to elucidate the question if subsoil carbon is more stable than topsoil SOC.

2. Objectives

This study investigates if deep ploughing can increase SOC stocks in loamy and sandy agricultural soils on the long-term. The hypothesis was tested, if topsoil carbon reached steady state conditions more than 40 years after deep ploughing following an initial carbon depletion due to mixing with subsoil. Finally we evaluated if the buried topsoil carbon is more stabile compared to the reference topsoil.

3. Materials & methods

We sampled five cropland loamy (Luvisols) and sandy (Cambisols and Podzols) soils, respectively, in Lower Saxony, which were deep ploughed (60 to 90 cm depth) 35 to 50 years ago. Adjacent equally managed, but conventionally ploughed plots were sampled as a reference. On each plot we retrieved five composite samples of randomly distributed cores down to 1 meter depth. Moreover, we collected samples from defined depths from a soil pit down to 1.5 meter depth. Soil bulk density, stone content and SOC were determined to derive SOC stocks. Moreover, we conducted incubation experiments to determine short term CO_2 production and microbial biomass via substrate-induced respiration in order to elucidate the stability of the SOC in the buried ploughing horizons.

4. Results

The deep ploughed soils show on average 33% higher SOC stocks compared to the reference plots. After almos 50 years, the SOC content of the topsoil of the deep ploughed plot (new Ap) is still 15% lower compared t the reference topsoil. The buried SOC in the deep ploughed sandy soils on average show a 69% lower respiration per unit C compared to the non buried SOC of the reference topsoils. This indicates a considerably higher SOC stability. In contrast, this effect could not be observed in all loamy soils. The CO_2 production per unit C in the buried material on average of the 5 studied sites is 36% higher compared to the reference topsoil.

5. Conclusion

The burial of SOC rich topsoil by deep ploughing prooved to be a feasible carbon sequestration option over the long term. The new Ap horizon offers additional potential for SOC storage. In the sandy soils, buried SOM is highly stable.

P 2.8.06

Determination of microbial community structure in subsoil biopores of different genesis

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Question

Macropores created by earthworms or roots, so called biopores, are generally a key factor for root growth, nutrient mobilisation and acquisition from the subsoil [1,2]. Contents of total N, total P, Corg, microbial biomass and enzyme activities related to N and P mineralization are considerably higher in biopore coatings compared to bulk soil[1,4]. How does the microbial community structure actually differ between three different biopore types (i.e.old root channels, earthworm-derived pores, mixed pores)? This study was carried out on an agricultural field trial, where Cichorium intybus was grown from 2009-2012 followed by fallow from 2012-2014.

Methods

24 samples of biopore inner wall coatings of the three aforementioned origins and 8 bulk soil samples were taken from two soil depths (45 - 75 cm; 75 - 105 cm) and extracted twice by a solution of methanol, chloroform and citrate/KOH buffer (pH 4, v:v:v = 1:2:0.8). Following separation of phospholipids, derivatisation was by hydrolysation using NaOH in MeOH and methylation by adding BF3 in MeOH and heating at 80°C. After further purification, samples were measured by gas chromatography - mass spectrometry (GC-MS).

Results

Total PLFA per g SOC was significantly higher in pores (45-75 cm) featuring earthworm activity compared to old root channels and was lowest in bulk soil samples. Generally, the total amount of PLFA per g SOC differed only slightly between the upper and lower soil depth, however in two treatments (root pores, mixed pores) there was a trend towards higher total amounts in the deeper 75-105 cm horizon. Statistically significant differences were mainly found between treatments in the 45 - 75 cm horizon. Gram negative bacteria (16:1w7c, 18:1w7c and Cy17:0) were the most abundant microbial group in both soil depths and show clear enrichment in earthworm and mixed biopores (45-75 cm), likely because there is recent input of SOM by earthworms. Gram positive bacteria on the other hand (a15:0, i15:0, i17:0 and a17:0) are significantly enriched in root channels and enriched in bulk soil, i.e. compartments featuring low SOM input and this is indicative for general decomposers of old soil organic matter. A similiar pattern was observed for actinobacteria (10Me16:0 and 10Me18:0), which are known to be consumers of old complex SOM and show the highest enrichment in root-derived pores. Fungi (18:2w6,9) showed a more complex picture with significantly higher amounts in mixed pores compared to root channels, and possibly a shift towards lower fungi abundance in the lower soil depth.

Conclusions

Old root pores appear to attract decomposers of old SOM as gram positive bacteria and actinobacteria, whereas the pores featuring earthworm activity and thus input of recent SOM seem to attract gram negative bacteria and generally feature higher total amounts of PLFA per g SOC. This is also linked to improved nutrient turnover and mobilisation.
PLFA analysis was shown to be a valuable tool to characterise the microbial community of these habitats and it allows deep insight into the ecological roles of different microbial groups.

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P 2.8.07

Dissolved Organic Carbon within Soil Profiles

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Background

In tropical forest, the C flux of litter fall and soil respiration generally are greater than those in temperate forests (Bond-Lamberty *et al*., 2004). Similarly DOC also appear to be larger in tropical forest soils than in temperate forest soils because of the greater precipitation, substantial substrate supply, and related rapid decomposition (Kalbitz *et al*., 2000). The DOC (Dissolved Organic Carbon) in the tropics is important thing because its contribution to the soil organic matter formation. The DOC leached will decrease the soil fertility and contaminate the water bodies. The DOC leached by water percolation in the soil profile will be affected by the soil properties and the position in transect. The relationship beetween soil properties with DOC is not fully understood and specific location. Therefore it is very important to explore the effect of position in transect and soil properties to the DOC.

The objectives of this research was to evaluate the DOC in soil horizons within soil profile and relationship between soil properties and the DOC.

Materials and Methods

We made six soil profiles with different position in transect. The soil profiles were two soil profiles in the top, two soil profiles in the middle slope and two soil profiles in the foot slope (near river) of Bukit Dua Belas National Park. Before the lysimeters installation, soil samples in A horizon, AB horizon and B horizon were collected. The lysimeters were installed horizontally in small soil pits by inserting the plates (200 cm^2) into precut openings and connecting them with Tygon tubing to the collecting bottles.

The soil samples were air-dried and crushed to pass through 2-mm sieve, and then analyzed by the following method: soil pH was measured using a soil to solution (H_2O or 1 M KCl) ratio of 1:5 (w/v) after shaking for 1 h. Total C was determined using Walkley and Black. Total N was determined using Kjeldahl method. Particle size distribution was determined by a pippete method. The CEC was determined using the ammonium acetate (1 M and pH 7.0) method. The contents of dithionite-citrate-bicarbonate-extractable iron (Fe) and aluminum (Al) (Fe_d and Al_d) were determined according to the method of Mehra and Jackson (1960). The contents of oxalate-extractable Fe and Al (Fe_o and Al_o) were obtained by extraction with 0.3 mol L^{-1} ammonium oxalate, at pH 3 for 4 hours in a dark room (McKeague and Day, 1966). Extracted Fe and Al of Fe_d and Al_d and of Al_o and Fe_o were filtered through a syringe filter with a 0.45 µm pore size (Minisart RC 15, sartorius, Hannover, Germany), while those of Fe_p and Al_p were filtered through a millipore filter with a 0.025 µm pore size (Millipore Corporation, Bedford, USA). Contents of extracted Fe and Al were then determined by inductively coupled plasma-atomic emission spectroscopy (SPS1500, SEIKO).

Results and Discussions

The concentration of DOC toposequently and is presented in Figure 1. Figure 1 shows that toposequently the concentration of DOC was higher in bottom than that of top and middle position. As for soil horizon, Figure 1 shows that A horizon had concentration of DOC higher than that of AB and Bt horizon. The results suggested that the position and the horizon of soil profile affected the concentration of DOC.

Figure 1. DOC in transect and soil profile

Correlation between soil properties and DOC is presented in Table 1. Table 1 shows that DOC was negatively correlated with soil pH, Fe_d, Fe_o and Al_o. DOC was positively correlated with CEC, organic C andtotal N.

Table 1. Correlation between soil peoperties and DOC

	pH	CEC	Organic C	Total N	Fe_d	Al_d	Fe_o	Al_o	Cla
DOC	-0.56*	0.76**	0.79**	0.73**	-0.63**	0.04	-0.37	-0.43	-0.40

* P

** P

The subscripts,o, d denote selective extractions with oxalate, and dithionite-citrate-bicarbonate, respectively

Conclusions

Toposequently the concentration of DOC was higher in bottom than that of top and middle position. Within soil profile, DOC was high in A horizon than that of AB and Bt horizons. DOC was significantly negatively correlated with soil pH and Fe_d. DOC was significantly possitvely correlated with CEC, organic C and total N.

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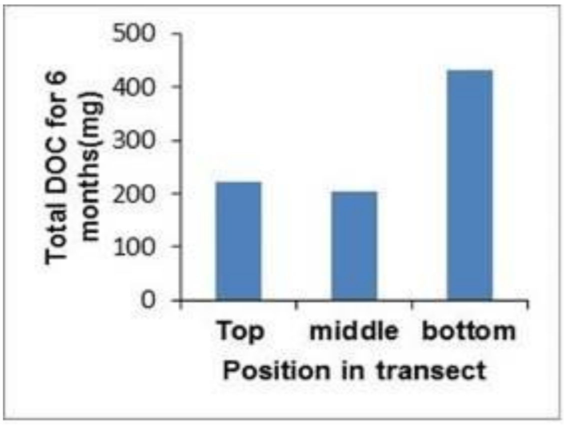
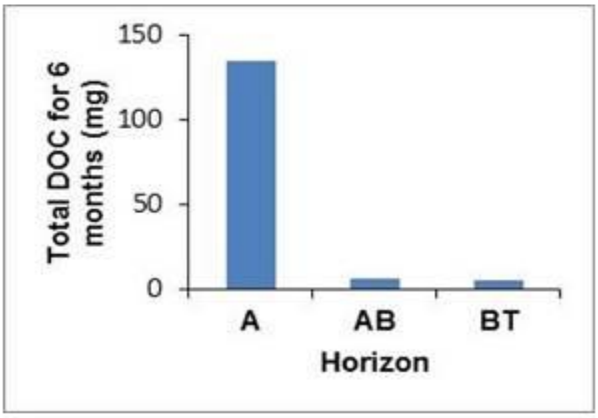
Figure 1



Total DOC for 6 months(mg)
500
400
300
200
100
0
Top
middle
bottom
Position in transect



Total DOC for 6 months (mg)
150
100
50
0
A
AB
BT
Horizon

P 2.8.08

Determinant Factors of Carbon Accumulation in Superficial and Deep Soil Layers under Long Term No Till

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In the context of the global C cycle and climate change, it is important to understand what drive the accumulation of large amounts of C in the surface horizon and below into the underground. It is recognized that these processes are highly dependent on climate, soil, topography and vegetation types. However, few studies were completed on this issue in subtropical soils. The present study aims to assess the factors that drive the accumulation of C in the surface (0-15 cm) and deep (0.60 to 1.0 m) layers of pioneer areas in the adoption of no-till in Rio Grande do Sul state (Brazil), and nearby native vegetation (NV). Six sampling sites with no till adoption ranging from 1978 to 1990, with different textural and mineralogical characteristics were considered. The soil layers were considered: a) surface layer (0-15 cm) and b) sub-superficial layer (60-100 cm). The C content in the soil was determined by dry combustion using a C/N analyzer. The soil C stock has been calculated based on the equivalent mass of soil. Using a data matrix with 24 variables (attributes of climate, topography and soil surface and subsurface layer) a principal component analysis (PCA) was performed with the Statistica software version 7 . A multiple regression with the selection methods of "Stepwise" and “Forward” was also performed to model the C stock in the layer 0-15 and 60-100 cm depth, . The regression analyzes was performed using the JMP software version 3.2.1, (Sall et al. 2005), the F test at 5 % was used to verify the models significance. Factors that drive the C accumulation were different in the subsurface layer (60-100 cm) in relation to the surface layer (0-15 cm). At the surface layer (0-15 cm), the saturation of calcium, magnesium, cation exchange capacity (CEC) and soil organic matter (SOM) were the factors with higher positive correlation with the C stock in both no-till and NV. In the subsurface layer (60-100 cm) the attributes that showed the higher positive correlation with the C stock were altitude and SOM in the no-till, and clay, SOM and iron oxides in NV. The highest altitude (801 m) and lower mean annual temperature (16.7°C) favored the accumulation of C in surface (0-15 cm) and subsurface (60-100 cm) in no till. This can be due to the most altered C mineralization in this environment. The C accumulation allied with the increase of Ca saturation in the surface layer (0-15 cm) are important practices that promote soil fertility and reduce the environmental impact of the agronomic activities by promoting the C sequestration in soil.

P 2.8.09

The role of sampling depth in the evaluation of management induced changes of soil organic matter

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Introduction

For a sustainable agriculture it is indispensable to develop management practices most appropriate for the specific site were crop production takes place. Sustainability of crop production includes the maintenance of sufficient soil organic matter (SOM) levels. Yet, the assessment of management impact on SOM is limited to the topsoil in most studies. On the other hand, the subsoil contributes to a remarkable extend to plant nutrition (Kautz *et al*., 2013), and therefore must be included in the evaluation of cropping effects. The aim of this study is to analyze the relevance of the subsoil in the assessment of management-induced changes of soil organic matter stocks based on the OAFEG long-term field experiment (Schulz *et al.*, 2014). Details of the survey will be presented soon.

Objectives

The upcoming question is the relevance of subsoil in the assessment of long-term effects of different tillage treatments. Focus of the investigation is the soil organic matter (SOM) in 0-30cm, 30-60cm and 60-90cm soil depth as affected by different tillage treatments. Aim was to verify whether SOM changes in deeper soil layers (>30cm) will influence the evaluation of tillage treatments, compared to the evaluation based on changes in 0-30cm soil depth.

Material and methods

The OAFEG has been carried out at the experimental station Gladbacherhof. The station is located at Villmar in the Taunus hill landscape in Hesse (altitude 170 masl., mean annual temperature 9.5°C, mean annual precip. 649mm, orthic luvisol, silt with high clay content). The experiment includes three different crop rotations/fertilizations and four tillage treatments in a two-factorial design (Schulz *et al.,* 2014). Crop rotations correspond to mixed farming, stockless cashcrop farming and stockless cashcrop farming with rotational ley. The different tillage treatments comprise, full inversion tillage at 30 cm (FIT), two layer plow at 15/30cm (TLP), reduced inversion tillage at 15 cm (RIT), and non-inversion tillage at 15cm (NIT). The experimental setup is a split plot design with four replications. The investigation period covers 11 years (1998-2009) of the current experiment. Soil samples were taken in 0-30cm, 30-60cm and 60- 90cm soil depth prior to sowing and after the harvest in four replications per field plot. Additionally the bulk density of each depth layer was determined and crop yields of each plot were noted. Amounts of SOC and STN were analyzed by dry combustion with. Statistical analysis was performed using ANOVA and LSD-test.

Results

The tillage treatments do not differ in their effect on SOM mass in 0-30cm soil depth. Yet, significant differences occur layers >30cm: FIT led to a significant increase in STN, mainly in a soil depth of 30-60cm. SOC and STN changes in the 60-90cm are negligible under all treatments. Due to the negative effect of the farm type "cashcrop farming" in a reference depth of 0-90cm SOM overall decreased under RIT, TLP and NIT whereas no significant effect but an apparent increase can be observed under FIT. The statistical analysis states a significant difference between FIT and the lesser intense tillage treatments.

Conclusions

It can be stated, that the consideration of subsoil SOM changes can alter the evaluation of management induced SOM changes in arable soils to some extent. Effects of tillage treatments on SOM may need to be reevaluated. In the context of long term field experiments on SOM dynamics, it is suggested to choose a minimum sampling depth of 0-60cm in order to assess SOC and STN changes.

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P 2.8.10

Effects of the distribution, amount, and size of beech fine roots on the C-turnover in the topsoil and subsoil of a sandy Cambisol

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1. Introduction

The function of soil to act as a sink for CO_2 is affected by the decomposition intensity of plant roots entering the mineral soil at different depths. Dead fine roots are assumed to be an important source for the organic C stored in subsoils. Environmental conditions change with soil depth and presumably become less beneficial for the microbial decomposition of the plant residues. Differences between topsoil and subsoil regarding the concentration, distribution and particle size of roots might also affect the mineralization kinetics. However, only little is known about the key factors governing the mineralization kinetics of beech fine roots in topsoils compared to subsoils.

2. Objectives

The aim of the study was to analyze the effects of the concentration, distribution, and size of beech fine roots on their decomposition rates in sieved composite samples and intact columns from the top- and subsoil of a sandy Cambisol.

3. Material and methods

Undisturbed soil columns and composite soil samples from topsoil (2 - 10 cm) and subsoil (145 - 152 cm) were taken from three profiles of a sandy Cambisol under beech located near Hanover (Germany). Additionally beech fine roots (Ø ≤2 mm) from the tangle of beech roots were sampled. An incubation experiment was carried out using an automated microcosm system for 365 days at 10°C and at soil water contents of 50% of the water-holding capacity to determine the CO_2 emission. The studied treatments included control soils (homogenized and sieved <2 mm or as intact soil column) and soil material with applications of dried beech fine roots varying in size (<2 mm and 1-2 cm), application rate (2 and 8 g kg^{-1}), and distribution (homogenously mixed with sieved soil or added in form of hot spots). At the end of the incubation experiment subsamples of the undisturbed (hot spots and the surrounding material) and composite soil columns were taken and the concentrations of total C and N, microbial biomass C and N, macro nutrients and mineral N were determined. First order models were used to evaluate the cumulative C mineralization data. Calibration of a one-pool model was carried out for the C mineralization of the control topsoil and of a two-pool model for the C mineralization data of the treatment with root application to subsoil at the rate of 2 g kg^{-1}. Models were validated in the treatments using topsoil and root application at the rate of 2 g kg^{-1} (using the three pools obtained in the calibration) and at the rate of 8 g kg^{-1} (using the three pools obtained in the calibration and multiplying the maximum mineralizable root amounts by 4).

4. Results

For the treatments containing 2 g <2 mm roots per kg soil, the C mineralization data were well described (calibration) or estimated (validation) by the modelling approach indicating less importance of the root distribution for the mineralization kinetics. In contrast, for the samples containing 1-2 cm roots the measured C mineralization rates could not be satisfactorily estimated by the pool model approach. For the subsoil samples with root concentrations of 8 g kg^{-1}, the CO_2 emission rates were distinctly larger for the samples that received the 1-2 cm roots compared to those containing the <2 mm roots. Only for the subsoil receiving 8 g <2 mm roots per kg soil, we detected a small effect of the root distribution on the CO_2 emissions (hot spot > homogenized). The content of microbial biomass C for both topsoil and subsoil was in general higher in the hot spot than in the surrounding material and in the homogenized samples. This effect was more pronounced for the subsoils and in the treatments with the higher root application rate (8 g root kg^{-1} soil) and corresponds only with the content of available Ca among the analyzed macro nutrients.

5. Conclusion

The modelled and measured CO_2 emissions suggest only a minor effect of the root distribution on the mineralization kinetics of beech fine roots in the top- and in the subsoil. The CO_2 data indicate pronounced effects of the root concentration and size on the C turnover whereby the magnitude of these effects seems to be influenced by the soil depth, which has to be taken into account for the elucidation of the C turnover in the top- and in the subsoil. The biological and chemical characteristics of the hot spots differ more strongly from the surrounding material and the homogenized samples in the subsoil than in the topsoil. The data indicate a larger importance of hot spots for the microbially mediated C and nutrient dynamics in the subsoil than in topsoil.

P 2.8.11

C and N stocks and ^{13}C isotopic signature of humic and histic horizons in a southern Brazilian topossequence

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Introduction. The subtropical Humic and Histic soils play an important role in soil C and N stocks and water retention, and therefore act as environmental filters. However, in Brazil there are few studies about the role of SOM in highlands natural ecosystems.

Objective. The aim of this study was to investigate SOM stabilization mechanisms and dynamics in profiles with Humic and Hístic horizons from a toposequence by means of C and N stocks and ^{13}C isotopic signature determinations.

Materials & methods. Soil sampling was performed in triplicate in a topossequence under Araucaria forest in the sedimentary basin of Curitiba, Brazil, located in the environmental protected area of Iraí (EPA-Iraí). The soils were classified as Oxisol (LBa), Gleysol (GMvd) and Histosol (OXs). Undisturbed samples were collected in triplicate from different depths (0-180 cm). Soil C and N contents and ^{13}C isotopic signature were determined by an elemental analyzer coupled to a mass spectrometer.

Results. The C and N stocks decreased in the order GMvd > OXs > LBa, and the estimated value of 4.2 x 10^6 Mg C for the whole EPA-Iraí, was greater than those observed for other Brazilian subtropical highland soils. The δ^{13}C value was different between the litter (-30 ‰) and the soil samples (-19 ‰) in the GMvd (middle position and semi-hydromorphic) and OXs (hydromorphic alluvial plain) profiles. In the surface layer of GMvd profile, δ^{13}C values of microaggregates < 0,25mm were similar to those of the soil roots and litter. However, the δ^{13}C values of the macroaggregates > 4 mm were similar to that of the soil samples, which were typical for C4 plants. In agreement with these data, the C/N ratio of microaggregates was comparable to that of the nearest litter and roots, while in largest aggregates, C/N ratio was similar to that of the soil samples. Possibly, the contribution from forest litter to the SOM is being partially stabilized by the physical occlusion in microaggregates, whilst the older SOM is stabilized in the largest aggregate class.

Conclusion. The soils from the middle and lowest position of the topossequence represent a higher capacity to sequester C. In these two soils, which are frequently under saturated conditions, the SOM originated from a previous vegetation (C4 plants) is stabilized within macroaggregates.

Figure 1

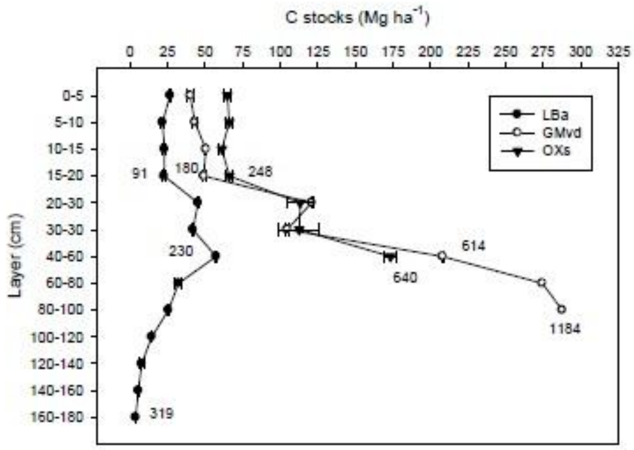

Figure 1. Stocks of C of the studied profiles.

Figure 2

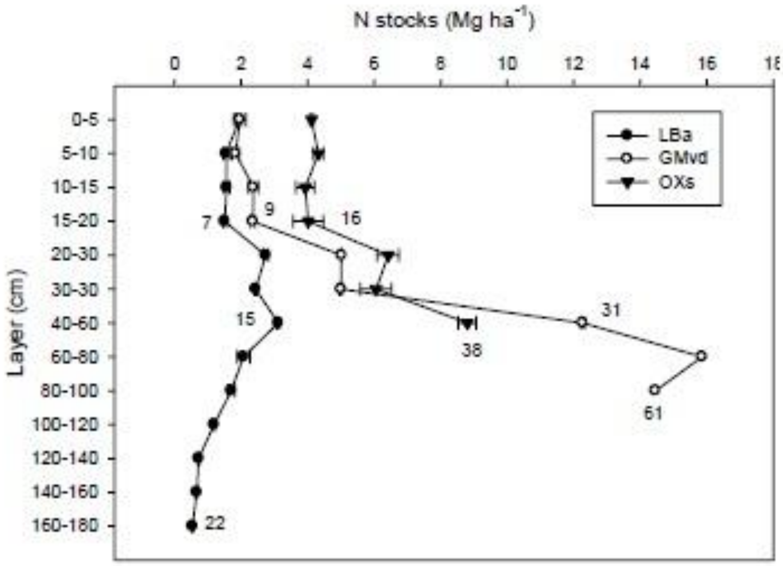

Figure 2. Stocks of N of the studied profiles.

P 2.8.12

Functional and structural responses of bacterial and fungal communities to 700-year rice cultivation in different soil depths

*Yalong Liu[1]
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Question: Rice paddy soils under prolonged cultivation can accumulate organic matter, which can result in a stratification of soil nutrients and organic matter due to the retention of crop residues on the soil surface, potentially affecting microbial communities. Our aims were to investigate the dynamics of soil properties and elucidate the changes in bacterial and fungal community functions and compositions with soil depth under long-term rice cultivation.

Methods: Soils of different cultivation time (a chronosequence of 0-700 years of rice cropping in the Bay of Hangzhou, China) at three soil depths (surface: 0-5 cm; middle layer: 5-10 cm; deep layer: 10-20 cm) were assayed. Soil organic carbon, total nitrogen, dissolved organic carbon, microbial biomass carbon/nitrogen and soil enzymatic activities (acid phosphatase, invertase and urease) were determined, and the abundance and composition of the bacterial and fungal communities were characterized.

Results: With increased rice cultivation duration, soil organic carbon and total nitrogen from the three depth soils significantly increased, while pH decreased. Soil microbial abundance, invertase activity and urease activity significantly increased with prolonged rice cultivation, especially at the surface soil. In addition, fungal abundance and acid phosphatase activity clearly declined with depth, but bacterial abundance was highest at the middle layer. Notably, repeated measures ANOVA revealed significant interactions between cultivation time and soil depth on fungal abundance and acid phosphatase activity. Molecular analysis of PCR-DGGE indicated that the composition of fungal communities changes significantly with soil depth. Moreover, based on cluster analysis results, we found that long-term rice cultivation had less effect on soil bacterial community at deep layer.

Conclusions: Thus, it was concluded that soil bioactivity (microbial abundance and soil enzymes) gradual increased with organic carbon and total nitrogen accumulation under prolonged rice cultivation. The soil bioactivity from the surface soil was higher than the deep soil, and soil microbial communities were stratified with soil depth. Moreover, fungal community was more sensitive than bacterial community with cultivation time and soil depth. However, the mechanism of fungal community succession with rice cultivation need further research.

P 2.8.13

Subtropical mountain meadow soil nutrient distribution characteristics in different altitude

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[2]*Jiangxi agricultural university, Foreign language institute, Nanchang, China*

Question:

Based the mountain meadow landscape on the typical subtropical area Wugong mountain scenic area 1600 meters (meadow distribution starting point) to 1900 meters (the top of the mountain area) of soil sampling investigation in southern China.

Methods:

Using the Soil Nutrient Systematic Approach (ASI), to study the effect of elevation of factors on the mountainous soil nutrients by Determination of soil nutrient content of different altitude.

Results and Conclusions:

The results showed that:

(1) the altitude has significant impact on soil nutrient content. (a) Along with the altitude increases the soil pH value range between 4.43 to 4.67showed a trend of gradually reduce, the soil is strongly acidic reaction in the whole areas. (b) The Soil organic matter content increased with higher altitude, but the peak value appeared in the 1750 meters in the middle of the terrains. (c) The Soil nitrate nitrogen, ammonium nitrogen almost have the same distribution trend, which shows inverted U-shaped except the value of the highest and the lowest altitude. (d) The curve of Soil available phosphorus content express in partial inverted U-shaped, and Soil available potassium content express in rules of the inverted u-shaped along with altitude change.

(2) The human disturbance has much effect on the mountain meadow soil nutrient content. It may be because the highest and the lowest areas of meadow range is the meeting-place of tourists, so appeared irregular nutrient content value.

Key words: Disturbance; Meadows; Nitrogen; Phosphorus; Potassium

Acknowledgement：

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P 2.8.14

Soil organic carbon stocks in arid soils: case of desert and coastal oases of South Tunisia.

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Arid regions cover 41% of total global land area and host 37% of world population. Soils in these regions can play an important role in the global C cycle by enhancing carbon sequestration in their horizons. Furthermore Batjes (1996) referred to soil organic matter as a key component of terrestrial ecosystem, whose abundance and composition has important effects on processes that occur within the system. This study was conducted to assess the impact of different arid soil properties and arid climate on soil organic carbon (SOC) content and stocks under oases in southern regions of Tunisia. Soil samples were collected from soils of three coastal oases and three desert oases. Soil samples were taken from 0 to 5 cm and 0 to 30 cm depths. Soils were characterized by basic pH, high E.C and important content of gypsum. According to FAO classification Soils are lithosols, regosols, gleysols and canbisols.

Results showed that in desert oases organic carbon content reached 2.11 % and 1.96 % respectively in 0-5 and 0-30cm depth. However in coastal oases organic carbon content did not exceed 1.94 % in 0-5cm and 1.47 in 0-30cm. Particulate organic carbon showed high percentage of SOC in the case of two types of oases. Consequently, Organic carbon stocks exceed 0.7 kg $C.m^{-2}$ and 4.3 kg $C.m^{-2}$ respectively in 0-5 cm and 0-30 cm in these regions. Furthermore more than 30% of SOC was localized in 5cm from surface. Soil of arid regions of Tunisia showed important capacity to organic carbon sequestration under oases. If we are to optimize this fact, actions to maintain and improve soil quality must be taken through maximizing the retention and recycling of OM and plant nutrients, and minimizing the losses of these soil components caused by water scarcity, leaching, runoff and erosion. Furthermore, future studies on terrestrial C cycle under oases agrosystem should also focus on assessing the SOM accumulation potential with particular emphasis on influencing factors such as land use patterns, soil salinity and environmental changes (Khalil Mlih, 2015).

Key words : Soil organic carbon - Soil organic stocks - arid lands - oases - Tunisia

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P 2.8.15

Depth dependent SOM gradients: interactions of age and climate

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Introduction.

Quantification of soil feedbacks to climate change requires a mechanistic understanding of the processes contributing to soil organic matter (SOM) stabilization. Such an understanding can help prioritize conservation decisions and may enhance management of our carbon resources. For instance, characterization of the mechanisms linking soil water and organic matter cycling over timescales of soil development will provide a more quantitative framework for assessing the influence of sustained drought on SOM stocks. This is particularly important in deep soils (below 20 cm), where previously stable SOM may be sensitive to changes in water content.

Objectives.

The overarching objective of our work is to determine how soil forming factors including climate, age, ecology, geomorphology, and parent material interact to control the depth distribution and mean residence time of soil organic matter. In this study, we focus primarily on the influence of soil age and water flux on soil carbon (C) storage and stability, but other factors of soil development cannot be ignored.

Materials & Methods.

We compared SOM depth gradients of soils from two different marine terrace chronosequences in northern California, USA. The Santa Cruz (SC) and the Mattole River (MT) chronosequences both include grassland soils ranging in age from at least 60 to 225 kyr but the MT soils receive greater mean annual precipitation (MAP). We measured soil C and nitrogen (N) content and C isotopic composition ($\Delta^{14}C$ and $\delta^{13}C$) to a depth of 2 m and evaluated patterns in the context of soil mineralogy (including Fe and Al oxyhydroxides and crystalline/short-range order clays), elemental chemistry, organo-metal complexes, and surface area. Additionally, we compared soil SOM dynamics of the SC and MT chronosequences with a database of ~35 other long age gradient soil sequences (spanning at least 5 kyrs of development).

Results.

We found significantly greater SOM accumulation in the wetter MT soils in both shallow and deep soil environments but the $\Delta^{14}C$ of bulk soil suggests C stored in the SC soils is older. Variations in SOM between chronosequences were larger than variations within each chronosequence, indicating the strong influence of soil water. In the context of other soil chronosequences, the CA marine terrace soils represent two different trajectories of SOM accumulation during soil development: relatively dry ecosystems with 1000 mm MAP (MT). Soils developed in wetter moisture regimes exhibit faster and greater SOM accumulation.

Conclusions.

Climate, specifically precipitation, is likely the dominant factor controlling the differences in C accumulation between the MT and SC soils. There are several pathways through which enhanced precipitation may result in greater accumulation of SOM. Across the marine terrace soils, hydro-ecological controls on the formation of secondary weathering products, including organo-metal complexes and short-range order minerals, appeared to regulate C storage and stability across the climate gradient. Depth and age dependent mineral gradients influence SOM cycling in all soils but climate driven thresholds of mineral transformations may be one of the most important controls on long-term SOM accumulation and stability.

P 2.8.16

Catalytic properties of enzymes hydrolyzing soil organic matter in the rhizosphere and detritusphere at pedon scale

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Extracellular enzymes in soils catalyze important transformations in the C-, N- and P cycles. Thus, the decomposition of soil organics is strongly dependent on its availability for microbes and hydrolytic extracellular enzymes. Rhizosphere and detritusphere are hotspots of very high C availability, leading to high abundance, specific composition and contrasting functions of microbial communities. Resource availability decreases with depth and consequently increases microbial competition for C and nutrients. Microorganisms may decrease the competition by production of efficient enzyme systems able for fast and complete resource mobilization.

We established a field experiment to determine the effects of contrasting substrate quality, namely, soil organic matter, maize shoot litter and rhizodeposits on microorganisms and their extracellular enzymes in an arable soil. Additionally, enzyme kinetics (β-cellobiohydrolase, β-glucosidase, acid phosphatase, β-xylosidase, tyrosine-, and leucine-aminopeptidase) were measured in 0-50 and 60-70 cm to elucidate the effects of substrate amount on substrate affinity and catalytic efficiency of extracellular enzymes hydrolyzed soil organics. Additionally, substrate-induced respiration was used to determine respired CO_2 and N_2O of microorganisms. Salt-extractable organic carbon and salt-extractable nitrogen was quantified throughout the soil profile.

The objective was to analyze kinetic parameters (V_{max} and K_m) of hydrolytic enzymes involved in C-, N-, and P cycles and their changes with depth as affected by input of contrasting substrates: root exudates, maize-litter, and soil organic matter.

Glucose addition significantly increased microbial respiration in rooted soil. Easily available substrates (e.g. rhizodeposits) increase enzyme activities (V_{max}) in rooted surface-soil. Strong correlation between the sum of catalytic efficiencies of all enzymes and the extractable N with depth, suggests that N availability strongly regulates enzymatic systems with depth. Low N availability led to strong microbial competition for N throughout the plough horizon, especially in the rhizosphere.

Figure 1

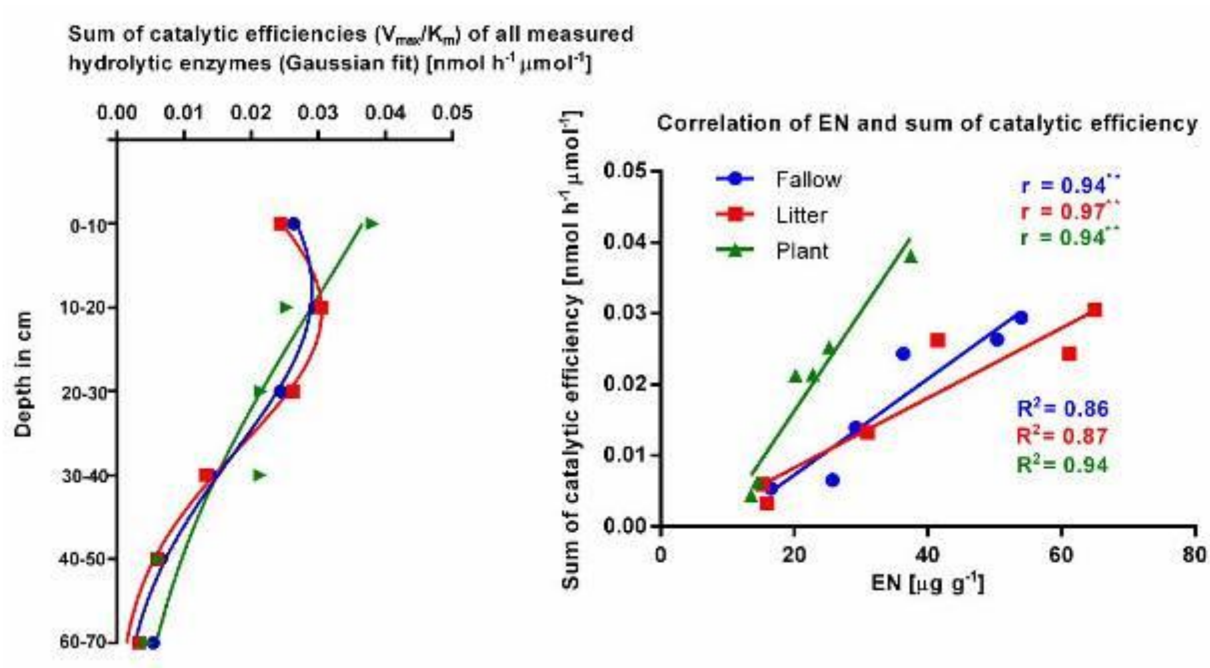
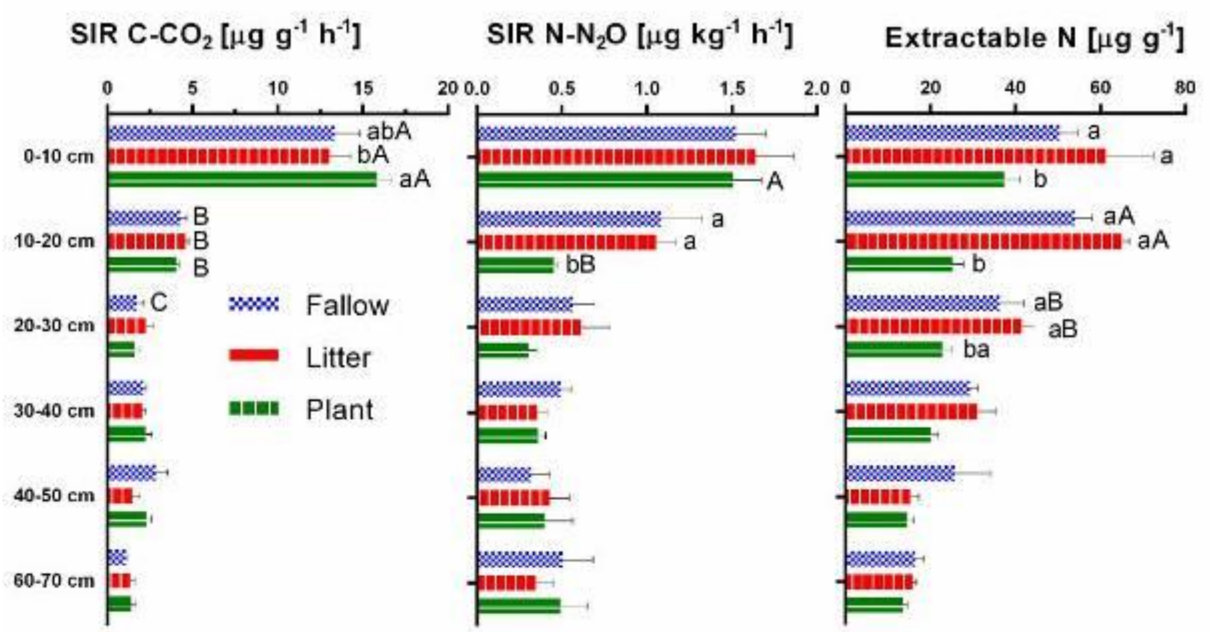


Figure 2


SIR C-CO$_2$ [μg g^{-1} h^{-1}]
SIR N-N$_2$O [μg kg^{-1} h^{-1}]
Extractable N [μg g^{-1}]
0
5
10
15
20
0.0
0.5
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1.5
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0
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40
60
80
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abA
bA
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B
B
B
C
A
a
a
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ba
Fallow
Litter
Plant

P 2.8.17

Organic matter composition at intact biopore and crack surfaces of Luvisol B-horizons analyzed by FTIR spectroscopy and Pyrolysis-Field Ionization Mass Spectrometry

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In the Bt-horizons of Luvisols, surfaces of biopores and aggregates can be enriched in clay and organic matter (OM), relative to the bulk of the soil matrix. The OM composition of these coatings determines their bio-physico-chemical properties and is relevant for transport and transformation processes but is largely unknown at the molecular scale. The objective of this study was an extended characterization of the OM composition at intact biopore and aggregate surfaces. Specifically, we aimed to improve the interpretation of data obtained with Fourier transform infrared spectroscopy in diffuse reflectance mode (DRIFT) by combining the signals from DRIFT spectra with data from pyrolysis-field ionization mass spectrometry (Py-FIMS) as a more detailed molecular-scale analysis. Samples were manually separated from the outermost surfaces of earthworm burrows, coated and uncoated cracks, root channels, and pinhole fillings of the B-horizons of Luvisols developed from loess and glacial till. The OM at earthworm burrow walls was characterized by a mix of chemically labile aliphatic C-rich and more stable lignin and alkylaromatic compounds whereas the OM of coated cracks and pinholes was dominated by relatively stable heterocylic N and nitriles, and high-molecular aromatic compounds (benzonitrile and naphthalene). This more recalcitrant OM likely originated from the combustion of biomass and, in case of the till-derived Luvisol, from diesel exhausts. The OM composition of pore walls reflected the differences between biopores (i.e., topsoil and plant residual, worm activity) and cracks (i.e., solutes and colloids, rapid percolation). The information of Py-FI mass spectra enabled the assignment of OM functional groups also from spectral regions of overlapping DRIFT signal intensities to specific OM compound classes. In particular, bands from C=O and C=C bonds in the infrared range of wave number 1688 … 1565 cm-1 were related to highly stable, chemically recalcitrant OM components such as heterocyclic N-compounds, benzonitrile and naphthalene. Based on such relations, the OM composition at intact soil structural surfaces relevant for sorption and wettability could be characterized in more detail even by using DRIFT spectroscopy.

P 2.8.18

Variability of Microbial Activity in Top- and Subsoils on Different Parent Material under European Beech

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1. Question

The role of subsoils in the global carbon cycle is poorly understood and probably underestimated. This is due to an incomplete understanding of processes and mechanisms that influence carbon storage and decomposition in deeper soil horizons. Microbial communities play an important role in these processes, as their presence, structure and function are crucial for the decomposition and/or stabilization of organic compounds. This study aims at providing a deeper insight into abilities and limitations of microbial decomposition in top- and especially in subsoils.

2. Methods

Therefore, we analyzed different microbial activity parameters of a total of 312 samples from top- and subsoils at five sites near Goettingen, all under beech forest (*Fagus sylvatica*), each on different parent material (loess, tertiary sands, red sandstone, basalt and shell lime). At each site three profile walls (length: 180 cm, depth: 75-185 cm) were sampled in a regular 25*45 cm grid. These samples were analyzed for the activities of 9 extracellular enzymes of the C-, N-, P- and S-cycle using a multisubstrate enzyme assay, for microbial respiration after addition of glucose, alanine and citric acid using the MicroResp™ -system, as well as for the activities of dehydrogenase and peroxidase. Correlations with soil properties as e.g. soil organic carbon (SOC) or texture were calculated for some of these parameters.

3. Results

The results showed that microbial activity was greatly influenced by both site and depth. Basal respiration was similar for all sites in topsoil but variation was highest between 35 and 60 cm depth. Mean values of specific respirations rates, related to SOC content, increased with depth, as also did their variation. Specific enzyme activities varied greatly between depths and sites. The patterns of these correlations differed between top- and subsoils, as well as between different sites. On all sites microbial activity was to some part clearly linked to the occurrence of SOC, but on some sites there was no clear correlation found for parameters like substrate-induced respiration. Enzyme activities were partly linked to SOC and/or texture, but there were different patterns of correlations found for enzyme activities related to substrates with different degrees of degradability.

4. Conclusion

The relatively high increase of specific respiration after substrate addition in the subsoils can lead to the assumption that, in these depths, microbial activity is limited mostly by substrate availability. Different sites, i.e. different physico-chemical properties of the soils seemed to influence the correlation of e.g. SOC content and texture with microbial parameters which might indicate that different stabilisation or decomposition processes dominate at different sites.

P 2.8.19

The importance of chemolithoautotrophic microorganisms for carbon sequestration in tropical rainforest soils

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The land surface has acted as a strong global carbon sink during the past decades, as indicated by atmospheric carbon dioxide records. A substantial fraction of this sink is probably located in the tropics, particularly in the Amazon, whereas there is evidence for a decrease of the tropical carbon sink.

Soil organic matter (SOM) is a major compartment of the tropical carbon cycle with up to 26 % of global carbon stocks stored in the deeply weathered tropical soils. Understanding factors and processes driving SOM dynamics under changing climate conditions is crucial for predicting the role of tropical forest ecosystems to act as a carbon sink or source.

Soil microorganisms are major drivers of the belowground carbon cycle by releasing CO_2 by soil respiration but also by stabilizing and storing SOM, as indicated by recent research. Our investigations focus on chemolithoautotrophic microorganisms, a group that relies on CO_2 as their carbon source. Chemolithoautotrophic microorganisms have been shown to be highly abundant in soils, whereas their role in SOM sequestration is still poorly understood.

In tropical soils, the activity of chemolithoautotropic microbes might be important for generating and stabilizing carbon, especially in the deeper soil, which is rich in CO_2 and reduced energy sources like Fe^{2+}.

In order to study the activity of chemolithoautotropic microbes and their importance for SOM, we conducted isotope and isotope-labelling studies, gas measurements as well as molecular analyses at soils from the Atto site from 0 to 1 meter depth. These soils are classified as Ferralsols and Alisol and represent two of the most abundant soil types in the Amazon.

With this we will be able to gain knowledge about the function and identity of an important group of microorganisms and their contribution to crucial biogeochemical cycles in the world`s most important ecosystem.

P 2.8.20

Short term changes in soil carbon, nitrogen and acidity under *Quercus ilex* stands along its distribution area in Spain

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Introduction

This study examined the variation of four soil chemical variables between two forest soil surveys conducted in an average time span of 12 years in 91 holm oak plots spread along its distribution area in mainland Spain. The first Forest Soil Monitoring at European level was carried out in the middle of the 1990s with the objective of assessing changes in soil condition at spatial and temporal scales (ICP-Forests programme), over a georeferentiated grid called Level 1. A second soil monitoring was conducted more than 10 years later in the same sampling locations under the European BIOSOIL Demonstration Project implemented from 2006 to 2009.

Objectives

In Spain, the first Forest Soil Monitoring survey was carried out between the years 1993-95 over 464 points. The plots where Quercus ilex is the predominant forest species represented 21 % of the total. In the implementation of the BIOSOIL Project at national level (2006-08), a second forest soil survey was conducted in 620 plots. 91 locations with *Quercus ilex* stands were sampled and analyzed in both monitoring programs. The goal of this study is to compare the changes in soil carbon and other chemical variables in the 15 year period between the two soil surveys in the topsoil mineral layers.

Materials & methods

The 91 sampling locations were spread along the *Quercus ilex* distribution area in mainland Spain over an altitudinal range of 150-1500 m asl and a tree density gradient starting from the woodland grasslands dehesas in the Western regions until dense stands in the north. The acidic topsoils are predominant (60%) in contrast to the 40 % basic topsoils. Basic topsoils appear only in the open and dense forest stands. Soils were sampled by depth until 20 cm in four (first survey) or in five (BIOSOIL survey) representative locations at each sampling plot and a composite sample per layer was generated in the field for chemical analyses. Soil analyses were carried out according to the ICP-Forests guidelines.

Results

Soil total and organic carbon in the holm oak stands increased with tree density and soil pH. In the upper 0-10 cm layer, the median values were significant greater in the dense forest (5.0 % SOC, 6.8 % TOC), than the open stands (3.1 % SOC, 4.5 % TOC) and the dehesas sites (2.1 % SOC, 2.1 % TOC) (α

Differences between the median values of the two soil surveys (Kruskal-Wallis test) in pH, TOC, SOC and nitrogen were only statistically significant for the layer 10-20 cm for SOC and nitrogen contents. Although differences in pH median values were not significant in both layers considering all holm oak sites together, median and mean pH values in the second survey were slightly lower. In the superficial 0-10 cm layer, plotwise paired mean differences in soil pH between the second and first survey in the acid soils were significantly lower than in soils with basic character (α

A clear trend in the variation of SOC between the two monitoring programs in the upper 10 cm was not observed being the dispersion of SOC higher in the basic soils. In the acid soils, absolute differences between the second and first survey were always below 2.7% C and 0.8% C in the upper and deeper layer respectively, while in the basic soils in both layers the maximum absolute differences reached 4.7% C.

An opposite trend could be observed in the pairwise regression between the two surveys in the soil nitrogen contents by soil pH especially in the upper 0-10 cm layer.

There is an upward trend in the basic soils of the BIOSOIL survey in relation to the first survey (1.21 slope) and a downward trend in the acid soils (0.74 slope). In upper layer, differences between the second and the first survey had a positive average value of 0.28 g/kg Nt in the basic soils, significantly different (α

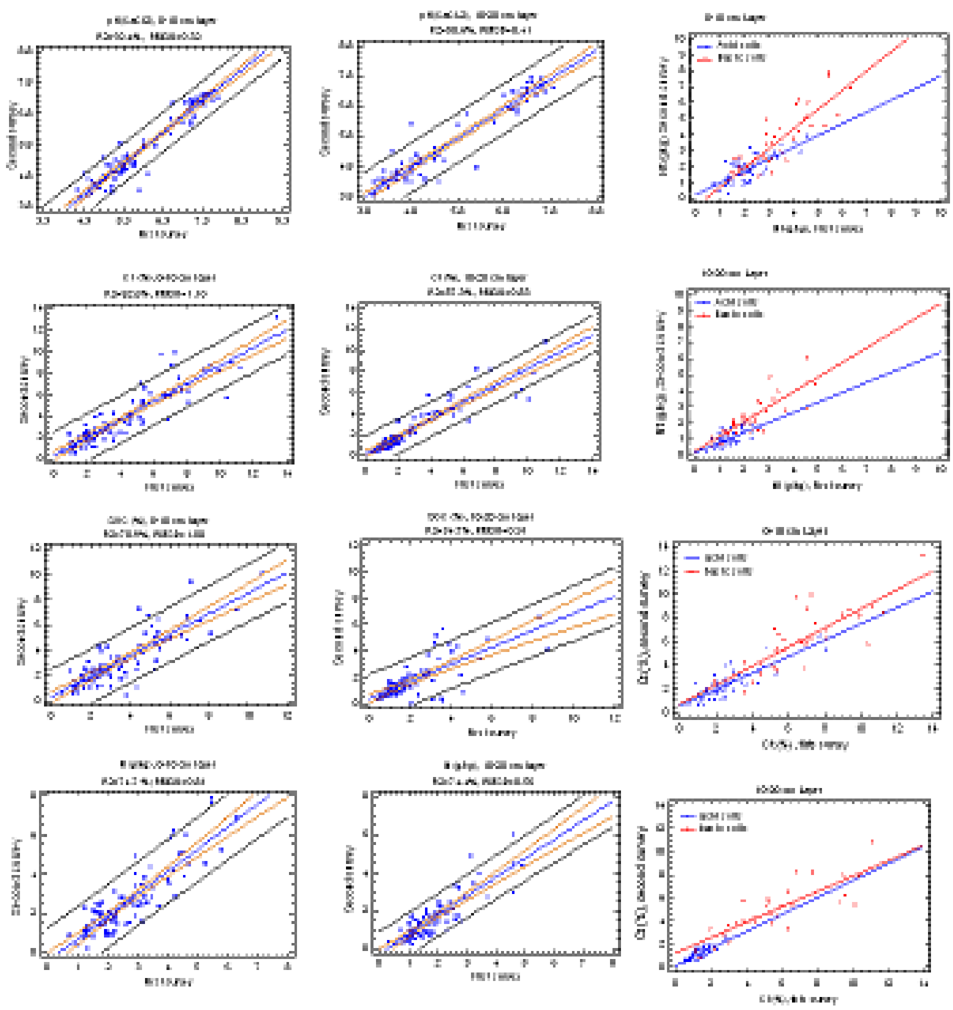
Conclusions

A clear trend in the soil carbon contents was not found through the two soil monitoring programs considering all sites together although soil organic carbon in acid soils and less dense stands presented a decreasing tendency. An average slight drop in pH in the 0-10 cm layer of the acid topsoils was detected as well. In the basic soils, the presence of carbonates made difficult the assessment of changes in the soil. However total nitrogen seems to be a better indicator of temporal changes as trends in both layers according to soil reaction were more consistent. The level of uncertainty associated to the field sampling and analysis methodologies should be quantified in order to improve the interpretation of the results.

This work has been carried out in the framework of the CGL-2012 34383 project (Ministry of Economy and Competitiveness)

Figure 1

Figure 1. Linear regressions for the plotwise variables: pH($CaCl_2$), total carbon (Ct), SOC and soil nitrogen (N) in the two soil surveys for the two mineral layers



P 2.8.21

Subsoil C dynamics in a Vertisol profile under different crop management on Jawa, Indonesia : Accelerator Mass Spectrometry (AMS) ^{14}C study

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Introduction

Organic carbon (OC) in the subsoil is a key in anthropogenic CO_2 discussions considering its relation to the potential of carbon stabilization and sequestration in soils. Data suggest 60% of OC stocks are stored at ca. 0.3 to 1 m of 1-m depth profile. ^{14}C offers a proxy to decipher subsoil OC dynamics based on age-heterogeneity of organic matter fractions throughout a profile.

Objectives

We studied subsoil organic carbon dynamics using the natural ^{13}C and ^{14}C signal together with SOC measurement, and compared physically and chemically different organic matter fractions (bulk, humic and humin, macrofossils) under different crop management regimes and linking with existing soil processes that influence those dynamics.

Material and Methods

Research was done at Ploso Lor, Karangjati, Ngawi, East Jawa, Indonesia on two neighbouring fields with different land use namely growing lowland rice (*Oryza sativa*) and sugarcane (*Saccharum officinarum*). The area is situated high on the Bengawan Solo River floodplain and associated with Quaternary and Tertiary alluvium at ca. 80 m a.s.l. The soil consists mainly of smectite clays derived from a mixture of marine sediments and basaltic materials (Bemmelen, 1949; Kögel-Knabner, 2011). The climate of the area is wet-dry tropical with annual rainfall ranging from 2500 to 4860 mm. Consecutive dry months with < 60 mm precipitation occur annually from June to September.

Results

Long-term cultivation of sugarcane (>100 years) in the non-paddy site may have triggered more TOC accumulation than rice cultivation. Higher TOC concentrations in the non-paddy site correspond with abundant plant remains (roots, leaves, seeds).

A mixture of C_3 and C_4 derived organic materials at ca. 25-50 cm depth is indicated by $\delta\ ^{13}$C values of -25 to -20 ‰, confirming the mix of OC moving from the top and/or laterally with groundwater together with insitu OC. Observed C_3 derived organic materials at about 1 m depth in the sugarcane (C_4) field also indicate carbon mixing into the deeper subsoil. Plant remains from the surface of soil supposed to be weed remains may have been introduced deeply into the subsoil through soil cracks during the dry season.

AMS measurement showed a decreasing value of ^{14}C with increasing depth that indicates accumulation of young organic carbon on the top soils with concentration ~100 pMC, close to the atmosphere. Evidence of soil carbon mixing appears at about 20-30 cm and ca. 100 cm depth with older carbon overlying young carbon. Introduction of young carbon materials into the subsoil through cracks, irrigation water and root growth, as well as of older carbon from ground water below ca. 1 m depth may have created the OC distribution in the profile. At the same depth, the proportion of ^{14}C was higher in the non-paddy site implying more rapid exchange between OC and atmospheric CO_2 under non-paddy than under paddy cultivation. We separated soil carbon chemically into, humic acids, alkali-soluble high-molecular-weight fraction, and, insoluble humins, mostly physically bound to the mineral fraction. Lower subsoil humic and humin-^{14}C values throughout the profile in the rice paddies than in the non-paddy revealed a dominance of older carbon and suggest slower turnover of organic matter.

Conclusion

Plant remains in the subsoil profile indicate soil processes providing a pathway for young carbon into the deeper subsoil. Using ^{14}C as a tracer, shows a cycling of OC in the subsoil profile not only attributable to soil processes but also to hydrology. Our results suggest more rapid terrestrial-atmosphere carbon cycling under non-paddy (sugarcane C_4) than paddy (rice, C_3) cultivation.

O 3.1.01

Temperature sensitivity of soil organic carbon mineralization and enzyme kinetics at different altitudes in three temperate forests

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It is necessary to understand how carbon (C) related microbial enzyme kinetics responses to temperature for better predicting SOM decomposition to global warming.

We studied the changes in the kinetics of carbon related hydrolase (β-1, 4- glucosidase (βG) and N-acetyl glucosaminidase (NAG)), soil organic carbon mineralization rates (Cmin), their temperature sensitivity (Q10), as well as their driving factors along the southern slope of Laotuding Mountain in temperate forest soils in northeast of China. The three typical forests were as follows: Ermans birch (EB, altitude 1233 m), dark-coniferous mixed broad-leaved forest (DB, altitude 1060 m, and korean pine (KP, altitude 825 m).

The results showed that the Cmin increased with temperature increase and was the highest at the EB. The temperature sensitivity of Cmin (Q10(Cmin)) varied as EB> KP >DB. Both Vmax and Km for βG and NAG responded positively to temperature for the three forest soils. The temperature sensitivity of Vmax (Q10(Vmax)) ranged from 1.37-1.90 and temperature sensitivity of Km (Q10(Km)) ranged from 1.59-2.0 for βG and NAG, respectively. The temperature sensitivity of enzyme efficiency (Q10(Vmax)/Q10(Km)) varied as EB>KP>DB for βG and KP>EB> DB for NAG, respectively. Soil water content (SWC), altitude, soil pH, total nitrogen (TN) content, ratio of soil organic C to TN (C/N) were main driving factors for the Cmin and enzyme kinetics.

The results suggest that βG enzyme kinetics are sensitive indicators for C decomposition and the impacts of the global warming on soil C dynamics will be sensitive at the higher altitude forest soils.

Figure 1

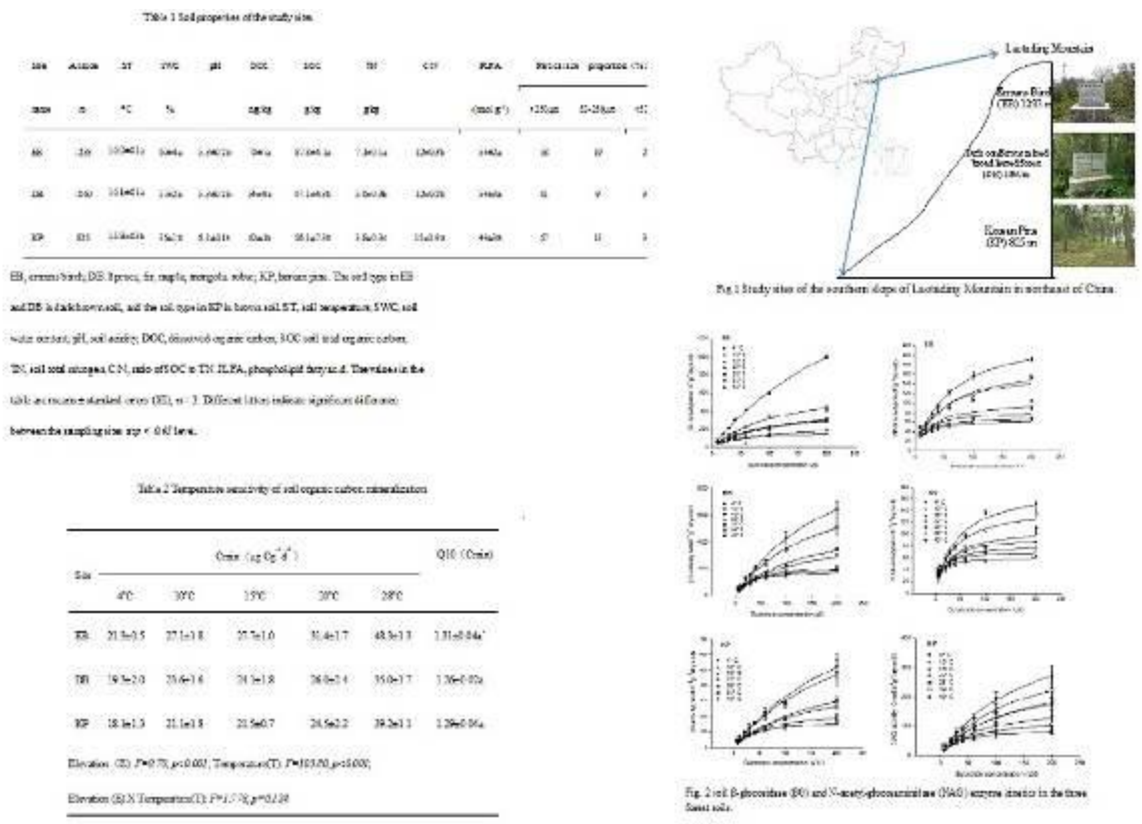

Figure 2

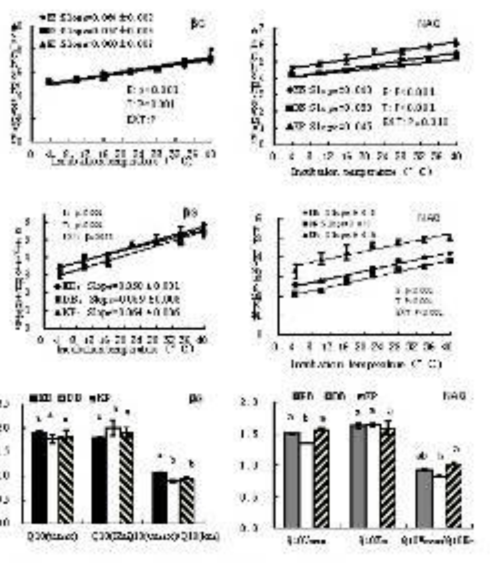

Fig. 3 Temperature sensitivity of soil βG and NAG enzyme kinetics

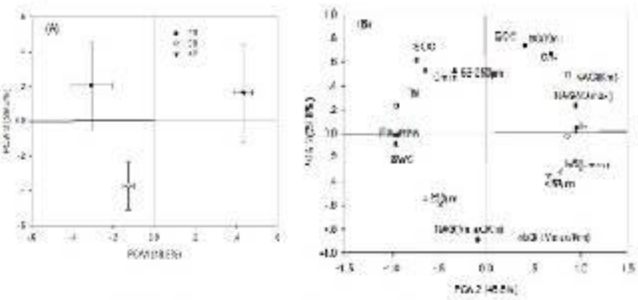

Fig. 4 PCA analysis of soil organic carbon mineralization, βG and NAG kinetics and soil environmental factors

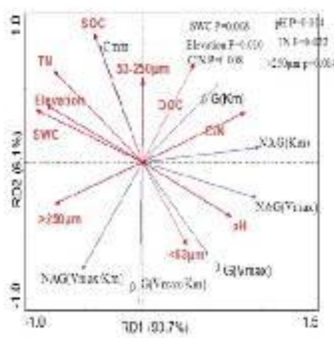

Fig. 5 RDA analysis of soil organic carbon mineralization, βG and NAG kinetics and soil environmental factors

O 3.1.02

Land use and management practices have little influence on agricultural soil organic carbon stocks in Eastern Australia

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Australia's "Direct Action" climate change policy relies on purchase of greenhouse gas abatement from projects undertaking approved abatement activities. Management of carbon in agricultural soils is an approved activity, based on the expectation that significant change in soil carbon is possible and practical via land use change, such as converting cropland to pastures. However, there is considerable doubt as to whether substantial change in soil carbon stocks is possible, due to the influence of other factors such as climate and soil texture. The aim of this work was to identify key drivers of soil organic carbon stock across the major agricultural regions of Eastern Australia, and to determine the relative strength of association of land use and other drivers (climate, soil and topographic factors), with current soil carbon stocks. Applying structural equation modelling and conditional inference tree analysis to data from a unique large (1482 sites) survey, we show that aridity and soil texture strongly regulate the amount of carbon present in soil under different land uses. Variation in land use explained only 1.4% of the total variation in carbon stock. Despite the overriding effect of climate, the greatest potential for increasing soil carbon stocks in Eastern Australian agricultural soils may lie in converting from cropping to pasture on heavy textured soils within the approximate rainfall range of 460-1000 mm per annum.

O 3.1.03

Coupling erosion into a biogeochemical model to evaluate the effect of Good Agricultural and Environmental Conditions on soil organic carbon changes in Italy

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Introduction

Since the Common Agricultural Policies (CAP) reform in 2003, many efforts have been made at the European level to promote a more environmental friendly agriculture. The Good Agricultural and Environmental Conditions (GAEC) were introduced as part of the Cross Compliance mechanism in order to increase the land sustainably, as well preventing soil erosion and preserving the soil organic carbon (SOC) content.

Objective

There is a substantial lack of knowledge about the effects of this policy on erosion prevention and SOC change, we tried to quantify by a modelling approach in Italian arable lands.

Material and methods

We coupled a high resolution erosion model based on RUSLE with the CENTURY biogeochemical model, with the aim of incorporating the lateral carbon fluxes occurring with the sediment transportation in the overall SOC balance.

Three scenarios were simulated on the whole arable land in Italy: i) a baseline without the GAEC implementation; ii) a current scenario considering a set of management related to GAEC application derived from land use and agricultural management statistics and iii) a technical potential where GAEC standards are applied to the entire surface.

Results

The results showed a 10.8% decrease, from 8.33 Mg ha^{-1} yr^{-1} to 7.43 Mg ha^{-1} yr^{-1}, in soil loss potential due to the adoption of the GAEC conservation practices. The technical potential scenario showed a 50.1% decrease in the soil loss potential (soil loss 4.1 Mg ha^{-1} yr^{-1}). The GAEC application resulted in overall SOC gains, with different rates depending on the hectares covered and the agroecosystem conditions. About 17% of the SOC change was attributable to avoided SOC transport by sediment erosion in the current scenario, while a total potential gain up to 23.3 Mt of C by 2020 was predicted under the full GAEC application.

Conclusion

These estimates provide a useful starting point to help the decision-makers in both ex-ante and ex-post policy evaluation while, scientifically, the way forward relies on linking biogeochemical and geomorphological processes occurring at landscape level and scaling those up to continental and global scales.

O 3.1.04

Linking organic matter chemistry to stability in organic soil amendments

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Introduction

Organic soil amendments (OSAs) are produced from a variety of sources, including composts, biosolids, biochars, manures, and plant residues. There is high variability in the chemistry of the organic C (OC) within many of these classes. While these amendments may be applied to agricultural soils to improve productivity, there is also strong interest in their use to sequester C in soils. However, the highly variable nature of the OC within OSAs likely results in significant differences in their stability once applied to soil. Consequently methods of predicting the stability of OC in OSAs are required. Predictions of OSA OC stability would lead to a better understanding of OSAs in soil, and would pave the way to better modelling of OSA OC from a C accounting perspective.

Objectives

This work had three objectives:

- To quantify the chemical variability of OC in OSAs using a variety of spectral techniques including nuclear magnetic resonance (NMR) and mid infra-red (MIR)
- To measure the stability of OSAs through incubation and to relate this to the spectroscopic measurements to allow predictions of OC loss
- To asses the effect of soil type on the stability of OSAs, and to understand how this affects relationships established in (2)

In meeting these objectives, we attempted to provide a proof of concept that rapid spectrometric measurements could be used to predict stability of OSA OC, which in turn would lead to more robust modelling of these inputs.

Materials and methods

Eighty-five OSAs comprising manures, plant residues, composts and biosolids were analysed by NMR, MIR, and a variety of other techniques. Multivariate statistical techniques including principal components analysis (PCA) and analysis of similarity (ANOSIM) were used to describe differences and similarities between the OSA types. The OSAs were then incubated for 18 months in a sand mixture containing a microbial inoculum derived from a diverse range of 200 Australian agricultural soils. Regular measurements of headspace CO_2 were performed by infra-red gas analysis, and the resultant cumulative respiration was fitted to a two-pool exponential model. Partial least squares regression (PLSR) was then used to predict the exponential parameters derived from the modelling of the cumulative CO_2 data.

A second 18 month incubation experiment was conducted on six contrasting soils with a subset of 25 OSAs comprising five biochars, eight biosolids, and 12 composts. Respiration was measured and modelled in the same way as for the sand incubation above, and several chemical and biological measurements were carried out on separate destructively harvested samples over the course of the experiment to quantify changes.

Results

The OSAs were highly varied in chemical composition as quantified by NMR, MIR, and other techniques. The NMR analysis revealed a strong gradient in alkyl/o-alkyl ratio across all amendments apart from the biochars, with the biochars being separated along a gradient of aryl-C, reflecting their highly aromatic nature.

In the sand incubations, respiration of OSA-C varied from 68 to 516 mg CO_2-C g^{-1} OSA-C, with the composts and biosolids emitting less than the manures and plant residues.

After fitting a two component model to the cumulative respiration data, it was apparent that the majority (>70%) of the OSA-C was partitioned to the slower pool, with decay constants in the range of $3.5x10^{-6}$ to $7.8x10^{-4}$ $days^{-1}$.

The relationship between the four parameters of the fitted model and chemistry as measured by NMR and MIR was explored using PLSR. Here, while there was generally good agreement between PLSR predictions from the NMR spectra and measured allocation of OSA-C to the fast and slow pools, we were unable to reliably predict the rate constants for those pools. A similar though marginally poorer story was found for the more rapid MIR analysis.

The soil incubations yielded complementary information to the sand incubations. While the amount of CO_2 respired was affected by soil type, the majority of OSA-C was allocated to the slow pool. Further, the rate constant for this pool appeared to be strongly related to soil properties, particularly clay content.

Conclusions

We found that OSAs contain a wide diversity in OC chemistry, and this diversity allowed us to predict partitioning of OSA-C to fast and slow pools using rapid spectrometric techniques. Further, edaphic properties such as clay content were strongly related to the turnover of the larger slow pool. Together, these findings indicate that using a combination of analyses of both the OSA and the target soil, it may be possible to more accurately predict their stability and thus potential to sequester C.

O 3.1.05

Land use controls soil organic carbon dynamics in both topsoil and subsoil horizons

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1. Introduction

Land use is an important controlling factor on soil organic carbon (SOC) dynamics through the whole soil profile. In England and Wales, we estimated a total SOC stock in the upper 1.5 m of 812, 1154 and 1315 Tg (168, 187 and 370 Mg ha^{-1} on an area basis) under arable, grass and other (e.g. woodland and semi-natural) land uses, respectively. Importantly, 40-60% of such SOC is found below 0.30 m in the subsoil (Gregory *et al.*, 2014). The need to consider the dynamics of SOC in the full soil profile of managed agricultural systems has been highlighted by recent propositions to mitigate climate change by increasing the SOC stored in the subsoil (Kell, 2011). Historically the subsoil was assumed to be a comparatively stable environment largely influenced by soil type (i.e. mineralogy and texture) alone, but recent work has suggested that all SOC is inherently unstable thermodynamically and controlled by its availability to decomposition agents (Dungait *et al.*, 2012), regardless of where it is found in the profile.

2. Objectives

Our objective was to test the hypothesis that land use in agricultural systems affects SOC dynamics in both the topsoil and subsoil.

3. Materials & methods

We present new results from bulk, isotope and geochemical biomarker analyses of soils from established field experiments at Rothamsted Research (UK) where long- and short-term land use changes have been imposed. The range of land uses include conventional arable, bare fallow, managed grassland, naturally regenerated woodland, and perennial woody and herbaceous bioenergy crops. Being sited on the same soil type (stagnogleyic paleo-argillic brown earth, or Chromic Luvisol) under the same climatic conditions, we were able to investigate hypotheses about SOC input, stabilisation and loss.

4. Results

The Highfield ley-arable experiment has treatments where the existing managed grassland was converted to conventional arable (1949-) and bare fallow (1959-) management. In 2008, we determined that SOC losses in the topsoil had been substantial (65% and 78% under arable and bare fallow, respectively) compared to managed grassland, and that SOC was significantly greater under managed grassland compared to bare fallow down to 0.60 m depth. Comparing the impacts of the grass-to-arable change at Highfield with the arable-to-grass change at the complementary Fosters ley-arable experiment (1949-) confirmed that SOC was lost more rapidly than gained following opposing land use changes. Novel inputs of fresh plant inputs and decomposition of existing SOC down the soil profile to 0.75 m were investigated using the treatments at Highfield using bulk ^{13}C stable isotope and long-chain *n*-alkane analyses, which revealed the turnover of old SOC at depth under the cultivated treatments.

The use of perennial bioenergy crops (short rotation coppice willow (*Salix* spp.) and *Miscanthus*) to both provide fibre and increase SOC has also been explored in more recently established experiments at Rothamsted. We measured greater SOC contents in the upper 0.30 m under a 4-year stand of *Miscanthus*, and a spatial effect related to proximity to the centre of the plant, compared to that under willow, although a reduced bulk density did not translate this gravimetric difference into a difference in SOC areal stock. By contrast, comparison of *Miscanthus* stands of 4 and 16 years revealed that significantly more SOC accumulated with time, for example a doubling of SOC (2 to 4%) in the topsoil beneath one genotype was found. Novel input of new C from *Miscanthus* in both topsoil and subsoil horizons was confirmed by bulk ^{13}C stable isotope analyses (Richter *et al.*, 2015).

5. Conclusion

There is a clear need to monitor and predict changes in SOC in the long term down the whole soil profile if soils are to be managed sustainably to deliver both food security and other ecosystem services, especially climate change mitigation through C sequestration.

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O 3.1.06

The impact of forest age, climate, and soil properties on soil carbon stocks in Swiss forests

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Land use and climate changes can strongly affect soil organic matter cycling. As soils store the most carbon of all terrestrial ecosystems, even very small variations in land use and climate could substantially impact ecosystem carbon balance. Our current knowledge on the impact of climate and land-use changes on soil C storage is primarily based on case studies and an extrapolation to a larger scale is limited due to the lack of historic soil samples, an unknown land-use history, and the difficulty to disentangle various factors.

In Switzerland, where the climatic gradient spans from Arctic to Mediterranean conditions, forest cover has increased by more than 20% in the past century. Thus, the objective of this study was to examine the influence of forest age, climate, tree species composition, and soil properties on carbon stocks stored in the organic layer and the mineral soil of Swiss forest soils.

For the analysis, we evaluated our extensive soil database, containing information on over 1000 soil profiles from forest sites across Switzerland, and covering a large heterogeneity in climate, soil properties and tree species composition. We began the analysis by estimating the minimal forest age for all presently forested sites using historical maps from 1850, 1900 and 1950. Then, using statistical analysis, we evaluated the effect forest age, climate, soil properties, and forest species composition have on current SOC-stocks.

Our preliminary results indicate no influence of forest age on C-stocks in the organic layer. However, carbon in the organic layer is influenced strongly by tree species and mean annual temperature. Furthermore, pH (measured at 0-30cm soil depth) and soil type have an impact. For the C- stocks in the mineral soil (0-120cm), we found a slight effect of forest age, but a strong control by mean annual precipitation, as well as, soil type, pH and clay content (both measured at 0-120cm depth).

We conclude that forest age has only a limited effect on carbon stocks and that climate combined with soil physico-chemical properties demonstrate a strong influence on SOC-stocks stored in Swiss forest soils.

O 3.1.07

Soil acidification drives carbon stabilisation in soils grazed for millenia

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Human activity affects properties and development of ecosystems across the globe to such a degree that it is challenging to get baseline values for undisturbed ecosystems. This is especially true for soils, which are affected by land-use history and hold a legacy of past human interventions. Therefore, it is still largely unknown how soil would have developed "naturally" and if processes of organic matter stabilisation would be different in comparison to managed soils. Here, we show undisturbed soil development, i.e., the processes of weathering and accumulation of soil organic carbon (SOC), by comparing pristine with grazed sites in the high Andes (4500 m) of southern Peru. We located study plots on a large ledge (0.2 km^2) that is only accessible with mountaineering equipment. Plots with pristine vegetation were compared to rangeland plots that were constantly under grazing management for at least four millennia. All "state factors"; climate, potential biota, topography, parent material and time; besides "land-use" were, therefore, identical.

Vegetation change, induced by grazing management, led to lower vegetation cover of the soil, thereby increasing soil surface temperatures and soil acidification. Both factors increased weathering in rangeland soils, as indicated by the presence of pedogenic oxides, especially amorphous Al-(oxy)hydroxides (oxalate-extractable Al). Higher losses of base cations (K, Na, Ca) and lower pH-values were related to a low base saturation of exchange sites in rangelands. All profiles were rich in SOC (100 to 126 g kg^{-1}) with no significant differences in concentrations or stocks. SOC of rangeland soils was, however, less available for microorganisms (proportion of microbial C on SOC: 1.8 vs. 0.6% in pristine and rangeland soils, respectively) and showed higher stability against thermal degradation. Reasons for these findings were a high proportion of complexed SOC in rangeland soils (25 to 36 vs. 59% of SOC were extractable with Na-pyrophosphate in pristine and rangeland soils, respectively). Moreover, less C was associated with the light fraction (< 1.6 g cm-3), but more with the silt fraction (< 1.6 g cm^{-3} and size between 63 and 2µm). Differences of the $\delta^{13}C$ signatures of vegetation and soil ($\Delta\delta^{13}C$ plant-soil) were lower in all density-size fractions and even negative in the light fraction of rangeland soils, meaning that these were more depleted or less enriched with ^{13}C. This indicated stabilisation of old C (lower ^{14}C concentrations) derived from former pristine vegetation (having a lower ^{13}C signature), as evidenced by vegetation-specific biomarkers.

Overall, our the approach of using large, inaccessible sites as reference for continuously used sites revealed that grazing management had tremendous effects on the partitioning of SOC among different fractions, but not on the total stocks. Since SOC in rangeland soils was more effectively stabilised, reactions against environmental changes should be slower and SOC in pristine soils is likely to react more sensitive.

O 3.1.08

Decay kinetics of ^{13}C-labelled residue at ten sites across Canada

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The rate of plant litter decay affects the functioning of ecosystems in several fundamental ways: it governs the amount of carbon stored in the soil, it reflects the rate of solar energy transfer to soil organisms, and it controls the rate of nutrient release. Understanding the factors that dictate residue decay is especially important in light of impending global changes, including those related to climate. We established a long-term experiment to measure the decay of plant residues at sites across the agricultural regions of Canada. Barley was grown to maturity in a greenhouse and labelled with ^{13}C to an abundance of about 11 atom%. This residue was applied, in the fall of 2007, to microcosms at ten sites, selected to span a range of representative climates and soil types. After about 0, 0.5, 1, 2, 3, and 5 years, four replicates of microcosms were destructively sampled at each site, and analyzed for recovery of remaining residue-derived ^{13}C. The results showed rapid initial decay of the residue - about 50 to 70% was lost after 1 year - followed by gradually-diminishing rates of loss, so that about 10 to 20% remained after 5 years. Temporal patterns of decay varied among sites, but a single two-pool exponential model effectively described the kinetics of decay for all sites when time was adjusted for temperature, using the concept of 'thermal time', defined as cumulative degree-years (calculated from measured soil or air temperature above a baseline of 0 degrees C). Soil properties, such as clay or sand content had minimal discernible influence on decay kinetics. These findings demonstrate that temperature is the primary driving variable for residue decay in cool climates like those in the agricultural regions of Canada. They show, further, that projected increases in temperature under various climate change scenarios may exert a strong and lasting influence on residue decay, microbial activity, and storage of carbon in soil. Our experiment is intended to continue for at least another decade, to measure the fate and stabilization of the remaining ^{13}C applied in the residue. Findings from the Canadian sites will be melded with those from similarly-established experiments in other countries to extend the range of climate and soil types.

O 3.1.09

Effects of land-use change on soil organic matter in Siberian steppe soils under different climatic conditions

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1. Introduction: The Kulunda steppe is part of the greatest conversion areas of the world where 420.000 km² grassland have been converted into cropland between 1954-1963. However, little is known about the impact of land-use change (LUC) on soil organic carbon (SOC) dynamics in Siberian steppe soils under various climatic conditions.

2. Objectives: By relying on a climatic gradient enclosing sites in the dry, typical, and forest steppe biomes, our study aimed to (i) quantify the change of SOC stocks after conversion from grassland to cropland and its link to changes in aggregate stability, (ii) elucidate the role of different functional soil organic matter (SOM) fractions (particulate *vs*. mineral-bound SOM) with respect to SOC stabilization under different management regimes, and (iii) assess the accompanied changes of the microbial community composition.

3. Material & Methods: We investigated the effect of LUC in a paired plot design, in which one reference plot under native steppe vegetation or extensive pasture represented the soil conditions before LUC. Functional SOM fractions were isolated by density fractionation, using a cut-off density of 1.6 g cm^{-3}, and subsequently analyzed for SOC and ^{14}C activities. Phospholipid fatty acid (PLFA) profiles were examined to estimate the amount of microbial biomass and distinguish between six different microbial groups. Aggregate stability was determined by a combined dry- and wet-sieving method. The SOM-protecting effect of aggregates was quantified in an incubation experiment using intact (250-2000 µm) and pestled (<250 µm) macro-aggregates.

4. Results: Our results show that independent from climate, agricultural management of grasslands has caused SOC losses in 0-25 cm depth of 28 ± 5% with the majority of SOC being lost within the first years after LUC. The largest part of SOM (>90% of total SOC) was associated with minerals. Even topsoil mineral-bound SOM had high ^{14}C ages (500-3,000 yrs B.P.), thus providing evidence for the relevance of mineral-organic associations in SOM stabilization. Clay content, pH, and bulk density were the primary environmental determinants for SOC abundance. Unlike reported for soils of the Great Plains in Northern America, in the studied soils aggregation has a minor importance for SOM stabilization. The microbial community composition of the differently managed soils was more affected by changes in soil properties along the climatic gradient than by the effect of LUC. Fungi-to-bacteria ratios decreased after LUC only in forest and typical steppe sites but not in dry steppe soils. In contrast, the ratio between gram-positive and gram-negative bacteria increased with increasing dryness.

5. Conclusion: On biome level, SOC stocks followed a typical precipitation gradient. High precipitation caused higher net primary productivity, thus higher biomass input into the soil and subsequently higher SOC stocks. For all steppe types, protection by minerals rather than aggregation was the primary SOM stabilization mechanism. The SOM quantity in steppe soils, however, was negatively affected by LUC irrespective of the climatic conditions. Land-use changes affected the quality of SOM more under wet than under dry conditions, which is possibly related to the initially poor state of SOM in the dry steppe.

O 3.1.10

Effect of grassland management on soil organic matter storage and greenhouse gas emissions

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In the common agricultural policy, establishment of temporary grassland into cropping cycles is encouraged because of its beneficial effects on carbon storage and possibly the reduction of greenhouse gases emissions. Up to now, little is known about the long-term impact of different grassland management practices on soil organic matter location, composition and reactivity. The objective of this study is to take advantage of a 9 year field experiment to quantify the legacy effects of differently managed temporary grasslands after crop phases on soil organic matter as well as greenhouserai gas emissions.

We sampled soils after three years cropping, which was preceded by grassland subjected to different management such as grassland duration (3 and 6 years) and presence or absence of N fertilization. We characterized the biochemical nature of soil organic matter (C, N, Nmin and sugars), the microbial biomass of soil, the potential mineralization of soil carbon and nitrogen and field CO_2 and N_2O emissions.

Our results showed legacy effects of grassland management on soil organic matter parameters. N fertilization during the grassland phase is necessary to maintain soil C and N contents as compared to continuous arable land. While absence of N fertilisation also affected SOM biochemical composition, it had no effect on greenhouse gases emissions. Grassland duration influenced the soils' biogeochemical parameters as well as their nitrate content, potential N mineralization and N_2O emissions. These results suggest that grassland management influences in particular the N cycle. There seems to be a trade-off between fertilizer use, carbon storage and greenhouse gas emissions, which should be taken into account when introducing grasslands into cropping cycles.

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O 3.1.11

Impact of climate change on carbon cycling and soil microorganisms in an arable ecosystem

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Introduction

Carbon cycling in terrestrial ecosystems provides a feedback mechanism to climate change by releasing or sequestering additional atmospheric CO_2. However, the role of soil microorganisms as key players in this feedback mechanism is still unclear. Most of previous studies focused on the effects of climate change on forest or grassland ecosystems, whereas much less is known about the response of arable ecosystems to a changing climate. Arable ecosystems considerably differ from more natural ecosystems in terms of e.g. soil management, nutrient availability and input of organic matter.

Objective

The objective of this study was to link SOC turnover under conditions of climate change to microbial abundance and activity. Specifically, we hypothesized that 1) a modified temperature and precipitation regime will change microbial abundance and activity and 2) modifications in microbial abundance and activity will be accompanied by a season specific change in SOC turnover rates.

Material & Methods

The Hohenheim Climate Change (HoCC) experiment was established in summer 2008 to manipulate soil temperature and precipitation on an arable field. Soil temperature is increased by 2.5°C in 4 cm and is combined in a factorial design with the following precipitation manipulation treatments: a) ambient, b) precipitation amount decreased by 25% during summer, c) reduced precipitation frequency by 50% during summer, d) combination of b and c. The experimental plots were planted with spring wheat (*Triticum aestivum*, 2009), spring barley (*Hordeum vulgare*, 2010, 2013), oilseed rape (*Brassica napus*, 2011, 2014), and winter wheat (*Triticum aestivum*, 2012). Soil samples (0-5 cm, 5-15 cm and 15-30 cm depth) were taken at four occasions in 2009 and 2010, at three occasions in 2011, and two times in 2012, 2013 and 2014, respectively. Data of aboveground biomass, soil organic carbon, soil microbial biomass, ergosterol content, hydrolytic enzyme activities and CO_2 fluxes (closed chambers, weekly measurements) will be presented.

Results

Results from 2009 and 2010 indicated that changes in soil temperature and precipitation differently affected aboveground biomass and that these effects depended on the crop. Effects of elevated soil temperature on microbial biomass and CO_2 fluxes were related to moisture conditions during the different seasons of the year in 2009 but not in the following years [Poll et al., 2013]. In the years 2010-2012, warming increased soil respiration across the seasons. Effects of reduced summer precipitation on soil respiration increased across the years with a significant reduction in summer 2011 and 2012. This effect could be explained by the yearly weather conditions as a boundary condition for the response of soil respiration to climate change; specifically, we found a linear relationship between the precipitation amount in May and the reduction in CO_2 emission by reduced summer precipitation for the years 2009-2013. First evaluation of ergosterol contents and enzyme activities from 2009 to 2012 indicate that soil warming continuously stimulate fungal biomass and microbial activity depending on the time of sampling.

Conclusion

Overall, soil warming was the most effective factor of climate change simulations in the HoCC experiment showing a continuous enhancement of microbial activity and CO_2 emission. Weather conditions of specific years seem to be an important boundary condition for estimating the effect of climate change on C cycling in arable ecosystems. The presentation will give insight into the complex interactions between climate change, soil moisture and soil microorganisms as key players of carbon cycling.

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O 3.1.12

Are temperature-induced differences in substrate use efficiency related to microbial community composition?

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Introduction

Soil organic matter is the largest carbon pool in terrestrial ecosystems. Consequently, even small changes of soil organic carbon dynamics may have significant impacts on feedbacks to global climate. The fate of soil organic carbon in ecosystems is determined during its decomposition by microbial metabolic activity. Specifically, the microbial substrate use efficiency controls whether carbon remains stored in soils or if it is respired and lost as CO_2 into the atmosphere. Alterations in substrate use efficiency may thus be important for global carbon balances. Recent research suggests that substrate use efficiencies of microorganisms are temperature and substrate dependent, but are often neglected in soil organic matter models used for climate change projections. However, it is unclear if the temperature dependency of microbial substrate use efficiencies are due to changes in composition of active microbial communities or physiological adaptations of the same community.

Objectives

Our objective was to advance understanding about the temperature dependence of microbial substrate use efficiency and how this is related to microbial community composition and land use managements.

Material & Methods

We sampled soils from long-term research sites with different land use managements comprising forest, arable, grassland and ley farming systems. The sites were located in northern Sweden and Scotland and from boreal and temporal climatic areas, respectively. In the laboratory, we amended the samples with natural abundance and ^{13}C enriched substrates differing in complexity and incubated them at constant temperatures in the range of 5 to 20 °C. We determined heat flows and respiration after amendments via isothermal calorimetry and CO_2 production. In addition, we analyzed composition of active microbial communities using the ^{13}C-phospolipid fatty acid approach.

Microbial substrates use efficiencies were calculated using the two following indices:

(i) thermodynamic substrate use efficiency = $1 - (Q_{Metabolism} / \Delta H_c)$

(ii) calorespirometric ratio = $Q_{Metabolism} / CO_2$

where $Q_{Metabolism}$ is the heat dissipated from metabolic activity after substrate addition, ΔH_C is the standard molar enthalpy of combustion of the utilized substrate and CO_2 is the CO_2 production after substrate addition.

Results

We hypothesized that microbial substrate use efficiencies decreases with increasing temperatures and that this decrease is linked to shifts in active microbial community composition: there is a shift from higher relative abundance of fungi in cooler soils to lower relative fungal abundance in warmer soils. Furthermore, we assumed that more complex substrates are metabolized with lower substrate use efficiency than simple substrates. We found differences in microbial community composition among different land use management systems and these differences were reflected in varying substrate use efficiencies. Moreover, substrate use efficiencies were lower at higher temperatures when comparing samples from the same land use type confirming our first hypothesis. The extent of decrease in efficiency depended on the substrate metabolized. Surprisingly, the composition of active microbial communities did not change, when samples from the same sites were incubated at different temperatures.

Thus, short term alterations in substrate use efficiency due to temperature shifts are more likely to be caused by changes in microbial community physiology rather than composition.

Conclusions

Our results indicate that microbial substrate use efficiency is linked to the composition of the active microbial community and that communities differ among land use management systems. Still, short term changes in substrate use efficiency as a result of temperature alteration seems more likely to be caused by shifts in microbial physiology. As a consequence for climate change prediction, it may be necessary to (i) consider decreasing substrate use efficiencies with increasing temperatures and (ii) differences in substrate use efficiency depending in land use and microbial community composition. Effects of long term temperature changes on microbial substrate use efficiency require further investigation.

O 3.1.13

Field-Scale Changes in Soil Organic C Storage and GHG Balances upon Irrigation Adoption in Mediterreanean Semi-Arid Land

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INTRODUCTION

In a context of global change and increasing food demand, agriculture faces the challenge of ensuring food security making a sustainable use of resources, especially arable land and water. This implies in many areas a transition towards agricultural systems with increased and stable productivity and a more efficient use of inputs. The introduction of irrigation is, within this framework, a widespread strategy. It implies significant changes in soil and crop management. As a consequence, the C cycle in irrigated agroecosystems change, as it does their impact in greenhouse gases (GHG) emissions. The net effect on global change needs to be quantified also from this perspective.

In the region of Navarra (NE Spain), the construction of a regional-scale irrigation infrastructure in the last decade includes the transformation of 53,000 ha from dryland to irrigation, 22,300 of which have already been converted. This transformation is having significant consequences in the agri-food sector in the region. In this framework the project Life+ Regadiox (LIFE12 ENV/ES/000426, http://life-regadiox.es/) has the objective of evaluating the net GHG balances and atmospheric CO_2 fixation rates of different management strategies in irrigated agriculture in the region, with the aim of developing guidelines for a sustainable soil and crops management in Navarra.

The project involved the identification of areas representative of the different pedocllimatic condictions in the region, in which irrigation has been adopted in the last decades. This required soil and climate characterizations, and the design of a network of agricultural fields representative of the most common dryland and irrigation managements in these areas. This

OBJECTIVES

In a second step, the objective of this work was to quantify net SOC variations and GHG balances corresponding to the different managements identified in the previous step. These quantifications will allow for evaluating the most suitable strategies for developing sustainable irrigation agrosystems in the region.

MATERIALS & METHODS

The selection of fields to be included in the reference network required the characterization and identification of soil and climate data. The most widespread agrosystems were also characterized. This was done using available public datasets on climate and soil data, and from soil pits especially sampled for this study. Two areas were then delimitied, mostly based on their degree of aridity. Within each of those areas, fields were selected to allow for comparisons at three levels: (i) dryland vs irrigation, (ii) soil and crop management systems for non-permanent crops, and (iii) soil management strategies for permanent crops (namely olive orchards and vineyards).

The quantification of SOC stocks in the selected fields was done within equivalent soil units in each area, and for each level of comparison (I, ii and ii above). SOC were quantified using the area-frame randomized soil sampling protocole (Stolbovoy et al., 2007), in the tilled layer (0-30 cm).

GHG balances were calculated from inputs information obtained from farmers, using tools developed by the regional agricultural research institute (INTIA), adapted to the local characteristics of agriculture.

RESULTS

The results corresponding to the comparison between dryland and irrigated agrosystems showed differences both in terms of SOC storage and GHG balances in the two studied areas. Irrigated fields had significantly greater stocks of SOC, and this especially clear in the most arid area, in which irrigation has been applied for more than 10 years. Also, strategies of organic fertilization in dryland resulted in significantly more SOC stored in the soil.

Within irrigated fields, SOC stocks differed among areas. In the most recently transformed area, no differences were observed among managements, whereas in fields transformed to irrigation for more than 20 years, fields under permanent fodder crops stored almost twice the amount of SOC than in the annual crops fields. Net GHG balances were greatly affected by the type of crops and their management, in particular fertilization strategies. As a result, net balances in terms of GHG emissions and mitigation varied greatly among irrigated systems.

CONCLUSIONS

The transformation of dryland to irrigation has significant effects in terms of SOC storage and GHG balances, as shown in this regional-scale field study. This needs to be accounted for when evaluating the development of sustainable agricultural systems in arid and semi-arid land.

O 3.1.14

Tracing the fate of arctic carbon: Understanding litter input controls on soil organic matter turnover and formation

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The arctic is undergoing unprecedented rates of climate change that are projected to continue in the future. Additionally, vegetation shifts and increased plant inputs may disrupt ecosystem carbon dynamics and potentially destabilize native soil organic matter. The arctic stores nearly half of the global carbon belowground, serving a vital role in the regulation of the earth's climate. Therefore, future changes to this ecosystem that disrupt this soil carbon vault by releasing carbon dioxide back into the atmosphere can serve as a positive feedback to climate change. Understanding litter input controls on soil organic turnover and formation are essential for improving carbon-climate feedback predictions for arctic, tundra ecosystems. Through the utilization of scanning electron microscopy and nanoscale secondary ion mass spectrometry, we have observed a close interaction of microbe, organic matter, and mineral surfaces. Thus, our research objective is to elucidate the biotic and abiotic mechanisms controlling the stabilization of soil organic matter in order to improve our ability to predict the fate of arctic carbon. In a laboratory incubation we added isotopically enriched (^{13}C and ^{15}N) *Eriophorum vaginatum* plant litter to arctic soils in order to track litter carbon and nitrogen into the soil. We used soils that were collected at two different sites in northern Alaska. We separated soils into two depths (0-10cm, 10-20cm) and measured $^{13}CO_2$ efflux following litter additions for approximately 6 months. Litter additions did not stimulate the loss of native soil organic matter at any time throughout the laboratory incubation. Total respiration was highest in the upper soils that had higher soil carbon concentrations and microbial biomass, however the proportion of respired CO_2 coming from the isotopically enriched litter additions was highest in deeper soils. Overall, respiration rates were positively correlated with the amount of microbial biomass carbon and nitrogen and soil carbon and nitrogen concentrations. Ongoing analyses will quantify litter and soil chemistry changes with decomposition. Additionally, we will be able to quantify the amount of added litter carbon and nitrogen incorporated into the microbial biomass and different soil fractions. Through these types of experiments, we hope to gain a better understanding of the mechanisms controlling decomposition in arctic soils in order to reduce our uncertainty in predicting how climate change will affect this large terrestrial carbon sink.

O 3.1.15

Stoichiometric constrains on soil C sequestration: a continental-scale analysis

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In a continuously changing environment, where the need to sequester C and stabilize reactive N in soil is an ever more pressing issue, understanding the factors controlling soil C:N stoichiometry and its implications for soil C storage and stabilization at the larger scale and under different land covers becomes a foundational step to inform earth-system modeling and management.

We used the Land Use/Land Cover Area Frame Survey (LUCAS) database and coupled it to data on tree species cover and mycorrhizal associations from other databases (e.g., BioSol, TRY) to analyze the bio-physical factors controlling the top mineral soil (0-20 cm depth) C:N stoichiometry in European forests and grasslands, on over 8,500 geo-referenced points. Additionally, we estimated at all sites the fine SOC fraction (< 50 mm) from percent silt and clay, using published regressions. From this estimates we assessed levels and controls on SOC saturation and deficit in European forests and grasslands.

Top mineral soils C:N stoichiometry appeared to be a feature of the system: Coniferous and mixed forests had consistently higher C:N ratios than broadleaved and grassland soils, and their C:N ratio decreased with increasing pH, clay content, and temperature. Broadleaved forests and grasslands had lower and more constrained C:N ratios, largely independent of physical controls. While ectomycorrhizal systems had a significant higher C:N ratio than arbuscular mycorrhizal systems, this seemed to be a feature of the plant rather than the fungus component of the association, with significant C:N stoichiometric differences among vegetation types within the same mycorrhizal type, and no differences among mycorrhizal types within the same vegetation type.

Even if coniferous and mixed forest systems appeared more efficient at sequestering C per unit N, when we partitioned SOC stocks in a fine and coarse fraction, we clearly identified a higher proportion of coarse non mineral-stabilized SOC in these systems, pointing to a higher vulnerability of the SOC accumulated in these systems.

Across all systems, fine and coarse fraction followed C saturation theory, with the fine fraction saturating at higher soil C, while the coarse fraction increasing linearly with it. Since the same relationships were also observed with soil N, despite the lower C:N stoichiometry of the fine fraction, we conclude that N controls C sequestration by stimulating C inputs rather than by promoting formation of mineral-stabilized SOC with low C:N.

Finally, through our analyses we identified many areas in Europe where soils are below C saturation, in particular in Southern-European grasslands with sparse vegetation, pointing to a management opportunity to realize this C sequestration potential.

O 3.1.16

Effect of land use on preservation of lignin phenols in aggregate fractions

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Perennial systems, such as grassland or alternation of grassland and cropland have been indicated as more efficient in term of C sequestration and ecosystem services than permanent cropping systems. These systems were shown to promote storage of plant-derived compounds in soil through their incorporation into aggregates. However, information on management impact on storage or degradation of such compounds within the hierarchical framework of soil is scarce. The aim of this study was to unveil the effects of different practices on the dynamics of soil organic matter (SOM) and lignin monomers in different soil aggregate fractions. To respond to this aim, we took advantage of a long-term field experiment in Western France(http://www.soere-acbb.com/). This site was kept for 9 years under cropland, grassland, or an alternation of both treatments (6 years grassland followed by 3 years cropland), as well as bare fallow. To evaluate the incorporation rates of new SOM, maize was cultivated on the cropland soil to produce a natural enrichment of ^{13}C. We analysed bulk soil (0-30 cm) and water stable aggregates fractions of different size for elemental contents and determined lignin content as well as composition. Moreover, we used stable carbon isotope measurements to determine the contribution of C incorporated during the cropland phase.

Our results indicated similar carbon contents of bulk soil and all aggregate fractions ranging between 10 and 15 gkg^{-1}. Soil subjected to temporary and permanent grassland and cropland showed higher organic carbon, nitrogen and lignin contents compared to bare fallow plots. Whereas for bulk soil only trends to higher C, N, and lignin concentrations with increasing years of grassland installation on cropland soils could be noticed, significant differences were found in larger aggregate size fractions. Our results suggest that introduction of 6 years grassland into the cropping cycle led to persistent higher carbon contents in larger fractions with regards to agricultural and bare soils. This may indicate amelioration of soil physical properties. Plots managed under permanent or temporary grassland contained less degraded lignin phenols than the other treatments, as indicated by their lower acid to aldehyde ratios, and more root-derived lignin as assessed by the lignin to N ratios.

However, lignin contents decreased, but not significantly, after three years of cropping in all fractions, suggesting that the persistent organic matter is composed of more stabilized compounds and may thus have a considerable potential for long-term carbon storage.

Significant increases of ^{13}C signature were detected for plots subjected to 3 and 9 years maize cropping. Major differences were registered for larger aggregate fractions, which demonstrated a faster turnover of organic matter.

The hierarchical approach proposed by this study, with sequential fractionation of water stable aggregates, and analyses of lignin phenols, allows the detection of management related impacts on organic matter, which could provide some indication towards the resulting soil properties.

O 3.1.17

Is Cover Cropping Effective on Reducing Global Warming Impact in Temperate Rice Paddy?

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Winter cover crop cultivation has been strongly recommended in mono-rice paddy soil to improve soil quality, but its application as green manure stimulates greenhouse gas emissions like CH_4, N_2O and CO_2 during rice cultivation. It could offset the advantages of cover cropping system. However, the impacts of cover cropping on the global warming potential (GWP) are generally analyzed during rice cultivation without consideration of the fallow season and CO_2 uptake by cover cropping. To compare the overall impact of different cover cropping system on the annual GWP in a mono-rice cultivation system, the emission characteristics of CH_4, N_2O and CO_2 were investigated under four different fertilization system (control, barley (B), hairy vetch (HV) and mixture (B+HV)). In cover cropping treatments, barley (180 kg ha^{-1}), hairy vetch (90 kg ha^{-1}), and mixture of barley and hairy vetch (75 % and 25 % of recommended dose) were cultivated during the fallow season and then, the total above-ground biomasses as a green manure were incorporated one week before rice transplanting. In control plot, no cover crop was cultivated during fallow season, and the recommended amounts of chemical fertilizers were applied during rice cultivation. The emission rates of three gases were simultaneously monitored once a week using the closed-chamber method. In particular, the net ecosystem carbon budget (NECB), which refers net exchanges of CO_2, was defined as the difference between total organic C input and output. The net GWPs were calculated as CO_2 equivalents by multiplying the seasonal CH_4 and N_2O fluxes by 25 and 298 respectively, minus soil organic carbon (SOC) changes derived from the NECB. The NECBs were significantly affected by the cover cropping and seasons. In control treatment, annual NECB was -0.5 Mg C ha^{-1}, which was composed with -1.9 and 0.5 Mg C ha^{-1} during fallow and rice growing season, respectively. However, cover cropping increased annual NECB by -0.1 to 0.5 Mg C ha^{-1}. Annual net GWP was 7.9 Mg CO_2 ha^{-1}, which was composed in the control treatment, with 2.7 and 5.2 Mg CO_2 ha^{-1} during fallow and rice cropping season, respectively. However, cover cropping significantly increased annual net GWP by 2-7 times over the control, mainly due to highly increased CH_4 emission during rice cultivation. However, the increased SOC stock by green manuring did not affect net GWP decrease. In conclusion, the soil management technology which can suppress CH4 emission during rice cropping season, should be combined with cover cropping in paddy soil.

key words: fallow season, net global warming potential, net ecosystem carbon budget

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O 3.1.18

Nitrogen availability manipulating allocation and sequestration of photosynthetic carbon in soil under elevated CO_2

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Increasing atmospheric CO_2 concentration has been one of the most pronounced global changes for the past 100 years. Determining whether terrestrial ecosystems will buffer or exacerbate elevated CO_2 over the next century requires knowledge of long term carbon storage in soil and vegetation, which is influenced by the balance among ecosystems' net primary productivity, the rate of delivery of new organic matter to soil pools and the subsequent stabilization, and the decomposition of soil organic matter. Plants increase their productivity with elevated CO_2, but this response could be constrained by nitrogen (N) availability. For agricultural ecosystem, anthropogenic N application possibly altered the interaction of carbon (C) and N by altering crop growth and the residue decomposition as well as the response of the mineralization of indigenous SOM. Therefore, application of N fertilizer at different levels could possibly alter the allocation of photosynthetic C in soil-plant system and the eventual sequestration of C in soil, but great uncertainty remains in their direction and magnitude. Therefore, spring wheat pot cultivations were conducted in sealed chambers and fumigated by ^{13}C-CO_2 for a growing season. The CO_2 concentrations were 370 (ambient) and 650 ppm (elevated), respectively. Nitrogen fertilizer was applied at the rate of 80 (low rate), 120 (moderate rate) and 180 kg N ha^{-1} (high rate), respectively, before CO_2 fumigation. The wheat was sown in the early April, and the plant and soil samples were collected after the wheat harvest in late June. The ^{13}C enrichment in wheat tissues and soil was determined by elemental analyzer-isotope ratio mass spectrometer. Portion of the sampled soil was fractionated into three particle size fractions for estimating the stability of the fixed C. The mineralization potential of photosynthetic C was determined by measuring ^{13}C enrichment in soil respiration along with 100-day laboratory incubation. Consistent with the results previously reported, elevated CO_2 significantly increased the biomass of the wheat. This increment was significantly influenced by N level and it was higher in the moderate and high rate than low rate N application, suggesting the positive feedback of elevated CO_2 to fertilizer N utilization. Elevated CO_2 enhanced the enrichment of photosynthetic C in wheat (indicated by $\delta^{13}C$) but this gas exchange-controlled isotope discrimination in C3 plant was not significantly influenced by N availability. As a result, both N availability and elevated CO_2 favored the accumulation of photosynthetic C in the root, but N availability was only related to the stimulated biomass. After a growing season of three months, elevated CO_2 did not alter the content of soil organic C regardless of N application level. However, the incorporation of ^{13}C into soil was influenced by both CO_2 concentration and N availability. Moderate rate of N application favored photosynthetic C accumulation in soil at both CO_2 concentrations because high rate N application retarded the root decomposition during the reproductive growth of the wheat. Elevated CO_2 furthermore enhanced photosynthetic C fixation in soil at all N levels due to the treatment interaction. As a whole, the moderate and high rate N application increased the recovery of ^{13}C-CO_2 in plant-soil system under elevated CO_2, suggesting that increasing atmospheric CO_2 could be substantially buffered by enhanced crop growth in an agroecosystem through fertilization management while the input of photosynthetic C was balanced by the decomposition of the older C. Although the capacity to store soil C at elevated CO_2 was not affected by N availability in short term, the soil respiration rate by utilizing the fixed photosynthetic C was significantly higher at the low and high level N application than that at the moderate rate N application. This finding suggested that N availability is an essential factor to influence the function of arable soil as C source or sink in long term, and both limited and excessive N supply would decline the stability of the fixed atmospheric CO_2 in soil. The underlying manipulation mechanisms were possibly attributed to the altered formation of labile and recalcitrant components as well as the accelerated translocation of photosynthetic C to finer fractions at the moderate rate N application.

O 3.1.19

Additional storage of soil organic carbon in an agroforestry system under Mediterranean climate

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Introduction Agroforestry systems, i.e., agroecosystems combining trees with farming practices, are of particular interest as they combine the potential to increase biomass and soil carbon (C) storage whilst maintaining an agricultural production. However, most present knowledge on the impact of agroforestry systems on soil organic carbon (SOC) storage comes from tropical systems.

Materials and Methods This study was conducted in southern France, in an 18-year-old agroforestry plot, where hybrid walnuts (110 trees ha^{-1}) are intercropped with durum wheat, and in an adjacent agricultural control plot, where durum wheat is the sole crop. We quantified SOC stocks and their spatial variability as influenced by the distance to the trees and to the tree rows to 2.0 m soil depth, in order to quantify SOC storage between the agroforestry and the agricultural plots. We also quantified the main C inputs to soil (crop residues, leaf litter, fine roots, natural vegetation under the tree rows).

Results SOC accumulation rates were estimated at 248 ± 31 kg C ha^{-1} yr^{-1} at 0-30 cm and at 350 ± 41 kg C ha^{-1} yr^{-1} at 0-100 cm. SOC stocks were higher in the tree rows where herbaceous vegetation grew and where the soil was not tilled, but no effect of the distance to the trees (0 to 10 m) on SOC stocks was observed. C inputs to soil increased by 30% in the agroforestry plot, which may explain the additional storage of C in soil.

Conclusion All together our study demonstrated the potential of alley cropping agroforestry systems under Mediterranean conditions to store SOC.

O 3.1.20

Soil CO_2 flux and soil C storage in dry tropics: Impact of Landuse Change

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Land-use change plays an important role in C dynamics by changing both C output in terms of soil CO_2 flux and also soil C input in terms of soil C storage. Anthropogenic activities have overridden the natural variability in C storage and flux, leading to global efforts to reduce anthropogenic emissions or removing atmospheric CO_2 through sequestration in the biosphere. Carbon storage in the soil represents the balance between accumulation and loss of carbon from soil. Soil is referred to as a 'sink' as well as 'source' of C, and changes in the role of soil from 'source' to 'sink' or *vice-versa* depends mainly on the land-use. The assessment of soil CO_2 flux has attracted interest worldwide as it is a major factor of carbon dynamics in the terrestrial ecosystem, and can be taken as the indicator of carbon availability in soil for decomposition, and the transformation of soil organic carbon to atmospheric CO_2. Soil structure plays important role in the storage of carbon. Degradation of soil due to land-use change is reported to be strongly related to changes in soil structure. Soil structure is often represented through the aggregate size fraction of soil. Soil aggregates protect the soil organic matter from decomposition by trapping and minimizing the direct contact of soil organic matter to soil microorganisms, and provide stability to soil structure. Distribution of aggregate size fraction in dry soil, therefore, can be used as an index of soil disturbance and is helpful to identify sustainable soil management.

A study was conducted to evaluate the impact of land-use change in the dry tropics from natural forest, to degraded forest and then to an agroecosystem or a bioenergy crop plantation of *Jatropha curcas* on soil CO_2-C flux and soil carbon storage, along with the major factors controlling them i.e. soil microbial biomass (SMB), belowground net productivity (BNP), and soil aggregate size fractions.

Four adjacent land-use types selected for study were: natural forest, degraded forest, agroecosystem and bioenergy crop plantation in the form of *J. curcas* plantation. The degraded forest, agroecosystem and bioenergy crop plantation which had initially been natural forest, were situated at Rajeev Gandhi South Campus, Banaras Hindu University, Barakachha Mirzapur, Uttar Pradesh, India, while the natural forest was in the Marihan range, about 7-8 km away from Barakachha Mirzapur. The study was conducted during September 2011 to June 2012. The sites are at 25.15"N latitude, 82.58"E longitude, and about 81 m above mean sea level. The climate of the study region is dry tropical monsoonic with marked seasonality. . The annual average rainfall was about 1876 mm (1700 to 2052 mm), 95% of which fall during the rainy season. Mean monthly minimum and maximum temperature ranged from 14.2 to 32.5ºC and 25.5 to 42.8ºC, respectively. The reddish to reddish-brown soil of the region was categorized as residual ultisol. Soil CO2 flux, soil microbial biomass and soil below ground net productivity were estimated from all the sites during rainy, winter and summer season by alkali absorption method, fumigation- extraction method and root biomass method respectively. Dry aggregate size distribution, soil organic C and bulk density were determined only during summer. Soil C storage was represented as product of soil organic C, bulk density and depth. Three dry aggregate size classes were represented in this study as macroaggregate (> 1000µm), mesoaggregate (212-1000 µm) and microaggregate (<53-212).

The flux of soil CO_2-C was highest in the agroecosystem followed in decreasing order by degraded forest, bioenergy crop plantation and smallest in the natural forest. The inverse trend was found in case of soil organic carbon (SOC) storage, SMB and BNP. The proportion of macroaggregate in the soil follows the trend of SOC storage, whereas mesoaggregate follows the trend of soil CO_2-C flux across all land-use types. The CO_2-C flux showed significant negative correlation with BNP, SMB, macroaggregate size fraction, and SOC. Our study suggests that the flux of soil CO_2-C was regulated directly by the soil aggregate fraction and not by SMB or BNP. However, soil aggregate formation was, in turn, related to the SMB and/or below BNP. Macroaggregates appear to protect the SOC, which results in lower soil CO_2-C flux and higher C storage in soil. It can be concluded that the plantation of bioenergy crops on degraded forest lands in the dry tropics, may increase C storage in soil and reduce soil CO_2-C flux, thereby helping in the mitigation of global climate change in addition to providing feed stocks for fossil fuel substitution.

O 3.1.21

The fate of plant- and microbial-derived organic matter in a forest ecosystem under elevated CO_2 concentrations and increased nitrogen deposition

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1. Introduction

Atmospheric CO_2 concentrations and nitrogen (N) deposition are increasing due to human activities. These changes affect global biogeochemical cycles and the climate system. Forest ecosystems are strongly affected resulting in changes in plant growth and litter decomposition. Soils play a key role in the storage of carbon (C) in terrestrial ecosystems, but it is still not clear how soil organic matter (OM) reacts to combinations of increased CO_2 concentration and N deposition.

2. Objectives

Here, we analyzed biomarkers for plant- and microbial-derived OM and investigated the effects of elevated atmospheric CO_2 concentrations and increased N deposition on their molecular and isotopic ($\delta^{13}C$) composition in above- and belowground tree biomass and soil density fractions. Furthermore, we tested the hypotheses that OM is preferentially stabilized in mineral soil fractions and that increased N deposition retards the decomposition of "old" OM in mineral soil fractions.

3. Materials & methods

We used archived samples from a free air carbon dioxide enrichment (FACE) experiment, where model forest ecosystems were established in open-top chambers and treated for 4 years with two levels of atmospheric CO_2 concentrations in combination with two levels of N deposition. Ecosystems were isotopically labeled with ^{13}C-depleted CO_2 allowing to trace the flow of C through the ecosystem and to distinguish between "new" (experimental-derived) and "old" (pre-experimental) OM. After 4 years of treatment, above- and belowground biomass of beech and spruce trees as well as top soil was sampled. Bulk soil was further separated into distinct soil fractions by a combination of density and particle-size fractionation. Plant (long-chain fatty acids, *n*-alkanes) and microbial (amino sugars) biomarkers were extracted from plant biomass and soil fractions and analyzed for their molecular and isotope ($\delta^{13}C$) composition using gas- and liquid-chromatography coupled to isotope-ratio-mass-spectrometry (GC-, LC-IRMS).

4. Results

We found that microbial biomarkers (fungal and bacterial amino sugars) were mainly stabilized in soil mineral fractions and that bacterial biomarkers were relatively enriched at soil minerals compared to fungal biomarkers. In contrast, plant biomarkers (long-chain fatty acids) did not accumulate at soil minerals, suggesting that they are not as effectively stabilized by association with soil minerals than microbial biomarkers. Plant and fungal biomarkers showed similar fractions of new C compared to total organic C, while slightly lower fractions of new C were found for bacterial biomarkers. However, differences were not large and it seems that the chemical structure of a compound is not a major factor that determines its turnover in soil. Instead, soil OM turnover seems to be controlled by processes like aggregation and interaction with soil minerals that protect soil OM from microbial degradation. N deposition had only minor effects on "new" (experimental-derived) biomarkers. However, the production of "new" fungal biomarkers increased in bulk soil by 108% under high N deposition. A retarded decomposition of "old" (pre-experimental) biomarkers in fine mineral soil fractions was observed for fungal biomarkers (+25%) and plant biomarkers (+15%) and supports previous observations for total soil OM.

5. Conclusion

Our results indicate that stable OM in soils is mainly of microbial origin and preferentially stabilized at soil minerals. Furthermore, interactions with soil minerals seem to be a more important factor for OM stabilization in soil than the chemical structure of OM. Finally, a retarded decomposition of "old" OM in soil mineral fractions was observed under high N deposition for both plant and microbial OM. This might be attributed to reduced mining of native soil OM by microorganisms, if they receive additional inorganic N. This mechanism seems to be especially important in fine mineral soil fractions, where OM is effectively protected from microbial degradation by association with soil minerals.

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O 3.1.22

Drivers of soil organic matter vulnerability to climate change: the effect of plants

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Introduction

The effect of future multifactorial climate change on plant-soil C fluxes and thus on the current C stocks is still largely unknown (Kreyling and Beier, 2013). The overall goal of this project, which is part of the Swiss National Research Program 68, is to estimate the drivers of the vulnerability of Swiss soil organic carbon (SOC) to climate change. The vulnerability is defined as the likelihood of a soil to loose its organic carbon due to the influence of external factors.

Objectives

The objective of the experiment presented here was to study the effect of plants on the soil CO_2 efflux under current and future climate in order to identify potential feedback mechanism between climate and the plant-soil C cycle.

Material and methods

The vulnerability of soil organic matter was quantified as the ratio between the soil respiration rate and its C content, whereby a high ratio indicates a high potential vulnerability. We grew poplar plants in two soils with similar SOC content, but different CO_2 efflux rates for five weeks in two climate chambers (described in Studer et al., 2014). We used stable isotope techniques to distinguish the plant-derived from the SOC-derived CO_2 efflux. The plant shoots, which were hermetically sealed from the roots and the soil, were continuously labelled with 10.6 at.% ^{13}C-CO_2. The plant soil system were acclimatised at current conditions (22 °C air and soil temperature, 400 ppm CO_2, 34 mm week^{-1} precipitation, 60 % relative air humidity) for 11 days before we started to simulate in one of the chambers the climate predicted for Switzerland for the period 2070-2100 (+4 °C temperature, +550 ppm CO_2 concentration, -18 % precipitation and -9 % relative air humidity).

Results

The initial results indicate that the total respiration rate was increased under future climate conditions by 62 and 43 % (+1.1 and +1.4 µmol CO_2 m^{-2} s^{-1}), while the plant-derived respiration was increased by 95 and 76 % (+0.4 µmol CO_2 m^{-2} s^{-1} in both soils) in the soils with low and high potential vulnerability, respectively. Thus 37 and 29 % of the change in total soil respiration was due to a change in plant-C respiration. This indicates that the plant-soil C fluxes in the soil classified as less vulnerable (low CO_2 efflux/C content ratio) were affected more strongly by climate change, but that the overall quantitative change in the SOM mineralization was still larger in the more vulnerable soil (1.0 vs. 0.7 µmol CO_2 m^{-2} s^{-1}) that is characterized by a high mineralization rate compared to the C content under the current climate conditions.

Conclusions

The preliminary conclusions of this experiment are that future climate will have a massive effect on the plant-soil C fluxes and thus endanger the current Swiss SOC stocks. Upcoming sample and data analysis will focus on the question if the plant is a major driver of the soil organic matter vulnerability due to rhizosphere priming effect.

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O 3.1.23

Effects of extreme climate events on biochemical composition of plants and their impact on soil carbon storage

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Introduction

Climatic changes, such as increasing global temperatures as well as infrequency of rainfall events and occurrence of drought periods may have direct and indirect consequences on soil carbon storage. These Climatic changes may alter the quantity and quality of plant litter input and also organic matter decomposition in soil.

Objectives

We combined field and laboratory experiments to assess the effects of future warming and drought on the biochemical composition of aboveground litter of two common grassland species (*Festuca arundinacea* and *Dactylis glomerata*) adapted to moderate water deficits. The conceptual approach included to investigate the effects of future warming and drought on (1) the biochemical composition of above-ground biomass of forage plants, (2) the potential mineralization of this material in soil, and (3) its priming effect on native soil organic matter.

Material and methods

We sampled aboveground plant material from spring regrowth and summer regrowth of a climate change experiment. While in spring, the plants were well watered, the summer regrowth was exposed to drought and elevated temperature (+3 °C) by infrared heating of the canopy during 3 weeks. We assessed the elemental and isotopic composition, lignin and non-cellulosic carbohydrate content and composition of plant material grown under all three conditions. Its mineralization potential in soil and priming effects were evaluated during laboratory incubation.

Results

Warming had no significant effect on elemental and stable isotope composition of both plant materials. In contrast, it resulted in reduction of lignin content for both plant species and decrease of the lignin-to-N ratio for *F. arundinacea* and increased non-cellulosic carbohydrate content for *D. glomerata*. Summer regrowth was characterized by increase of $\delta^{13}C$ values, which is consistent with variations in stomatal conductance due to water shortage. Moreover, summer drought induced an increase in N content leading to decrease of the C/N ratio and increase of lignin-to-N ratio of summer regrowth compared to spring regrowth. Regardless the treatments, the additions of foliage to soil caused net positive priming effects, which was significantly higher for *D. glomerata* having higher non-cellulosic carbohydrates. Differences in decomposition were small, while priming effects were more strongly altered by the different exposure to environment.

Conclusions

Our results provide direct experimental evidence that extreme climatic events (high temperature and precipitation deficit) have an influence on soil carbon storage particularly through their effect on priming of native soil organic matter induced by altered plant litter. These effects seem to be governed by alterations of stoichiometry and to a smaller extent by alterations of plant chemical composition.

P 3.1.01

Comparison of net global warming potential and greenhouse gas intensity affected by management practices in two dryland cropping sites

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Little is known about the effect of management practices on net global warming potential (GWP) and greenhouse gas intensity (GHGI) that account for all sources and sinks of greenhouse gas (GHG) emissions in dryland cropping systems. The objective of this study was to compare the effect of a combination of tillage, cropping system, and N fertilization on GWP and GHGI under dryland cropping systems with various soil and climatic conditions from 2008 to 2011 in western North Dakota and eastern Montana, USA. Treatments in western North Dakota with sandy loam soil and 373 mm annual precipitation were conventional till malt barley (*Hordeum vulgarie* L.) with 67 kg N ha^{-1} (CTB/N1), conventional till malt barley with 0 kg N ha^{-1} (CTB/N0), no-till malt barley-pea (*Pisum sativum* L.) with 67 kg N ha^{-1} (NTB-P/N1), no-till malt barley with 67 kg N ha^{-1} (NTB/N1), and no-till malt barley with 0 kg N ha^{-1} (NTB/N0). In eastern Montana with loam soil and 350 mm annual precipitation, treatments were conventional till malt barley-fallow with 80 kg N ha^{-1} (CTB-F/N1), conventional till malt barley-fallow with 0 kg N ha^{-1} (CTB-F/N0), no-till malt barley-pea with 80 kg N ha^{-1} (NTB-P/N1), no-till malt barley with 80 kg N ha^{-1} (NTB/N1), and no-till malt barley with 0 kg N ha^{-1} (NTB/N0). Carbon dioxide sink as soil C sequestration rate at the 0-10 cm depth was greater in NTB-P/N1 and NTB/N1 than the other treatments at both sites and greater in eastern Montana than western North Dakota. Carbon dioxide sources were greater with N fertilization than without and greater with conventional till than no-till. Soil total annual N_2O and CH_4 fluxes varied among treatments, years, and locations. Net GWP and GHGI were lower in NTB-P/N1 than the other treatments in western North Dakota and lower in NTB-P/N1 and NTB/N1 than the other treatments in eastern Montana. Net GWP across similar treatments was lower in eastern Montana than western North Dakota, but GHGI was similar. Annualized crop yield was greater in the treatments with N fertilization than without. Because of greater grain yield but lower GWP and GHGI, no-till malt barley-pea rotation with adequate N fertilization can be used as a robust management practice to mitigate net GHG emissions while sustaining dryland crop yields, regardless of soil and climatic conditions. Loam soil reduced GWP and crop yields compared with sandy loam soil.

Figure 1

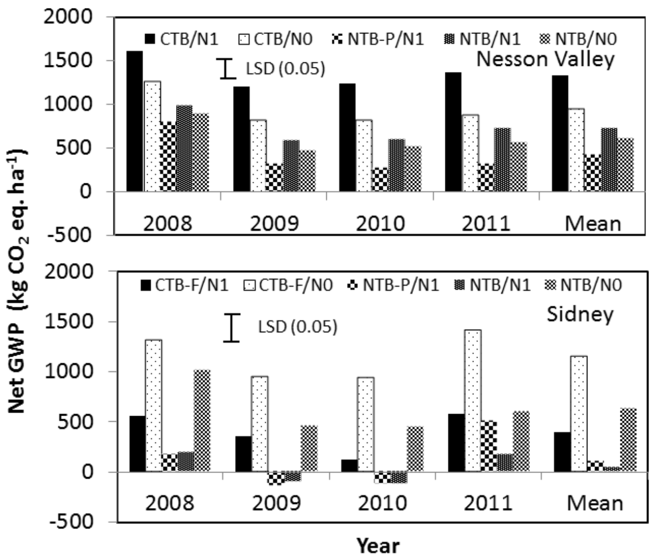

Fig. 4

Figure 2

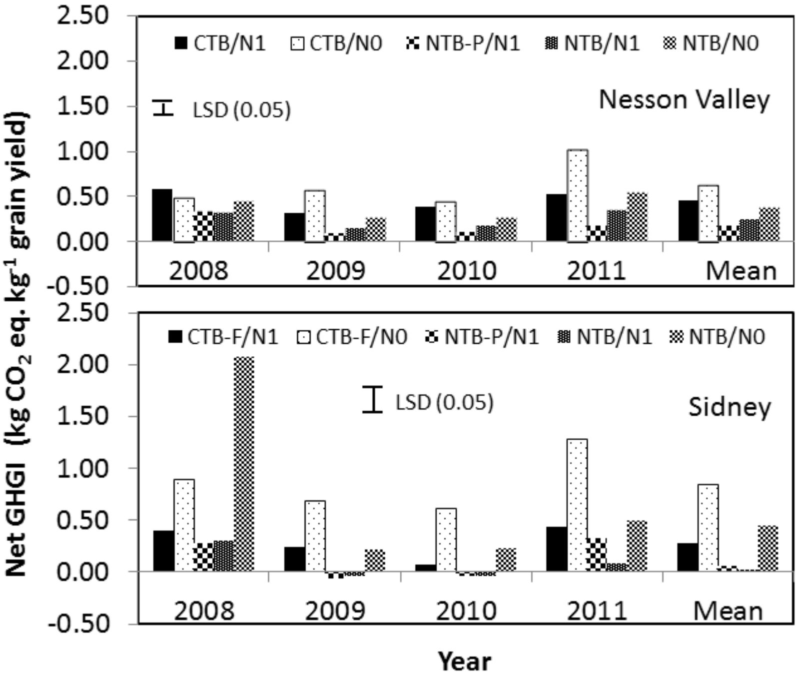

Fig. 6

P 3.1.02

The effect of inorganic fertilizer application on compost and crop litter decomposition in sandy soil

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Inorganic fertilizer applications are common practice in commercial agriculture, yet not much is known regarding their interaction with applied organic residues and soil biota. The main aim of this research was to determine the effect of inorganic fertilizer applications on the decomposition of selected organic matter sources commonly used in South African agriculture. Decomposition studies were conducted at 20-25 C at FWC over a 3-month period, on composts and plant litters, in a local, sandy soil. Two commercial composts, Compost A (C:N 17.7) and Compost B (C:N 4.9) were treated with 3 commercial fertilizer rates. The fertilizers were: tomato fertilizer (100 kg N, 20 kg P, 150 kg K per ha), cabbage fertilizer (250 kg N, 100 kg P, 200 kg K per ha), and pasture fertilizer (150 kg N and 150 kg P per ha). Five contrasting plant litters (kikuyu grass, lucerne residues, pine needles, sugar cane trash and wheat straw) were treated with the cabbage and tomato fertilizers. Dissolved organic carbon (DOC), CO2 emissions, β-glucosidase and polyphenol oxidase (PPO) activities were monitored. At the start and end, soil pH and LOI was measured. The compost study showed that only the high N (250 kg N ha-1) cabbage fertilizer promoted OM decomposition, by significantly increasing DOC, while slightly supressing CO2 production. However, the addition of both cabbage and tomato fertilizers enhanced respiration and DOC production from all the non-legume crop litters (wheat, pine needles, kikuyu, sugar cane), especially the low N residues. In contrast, both fertilizers suppressed CO2 respiration from the lucerne litter while enhancing DOC production. The pine needles showed the least increase in DOC production due to the fertilizers, possibly due to its high polyphenol content which supressed PPO activity. Thus the addition of the fertilizers enhanced CO2 and DOC production from non-legume type of crop residues, as long as the inherent polyphenol concentration is low. However, for legume litter and composts the addition of high N fertilizer suppressed CO2 mineralisation and promoted DOC production. The suppression of CO2 production and stimulation of DOC can be seen as a positive effect for promoting humification if DOC is intercepted by stabilizing clay minerals. The insights obtained can applied to better manage OM in agricultural soils.

P 3.1.03

The effect of nitrogen addition on microbial properties and soil organic matter density fractions in a *Larix gmelinii* plantation in China

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Sustained inputs of nitrogen (N) via atmospheric deposition or N fertilizers, important global change drivers, are likely to change soil microbial properties and ultimately affect soil C storage. Although many fertilization studies have focused on plant growth, the response of soil organic matter to increased N availability remains unclear. In order to understand the influence of N addition on microbial properties and soil organic matter fractions in the larch (*Larix gmelinii*) plantation, a continuous nine-year N addition in the larch plantation was conducted in northeast China. Soil samples from 0-10 cm and 10-20 cm depths were collected in N addition plots and control (no N addition) plots. Results showed that soil C concentration increased 5.7% in the 0-10 cm soil depth in N fertilized plots compared to control plots, and this increased soil C concentration was mainly in heavy fraction C, suggesting stabilization of soil C compounds in heavier associated fraction in the N fertilized plots. In contrast, soil microbial biomass C and N, phenol oxidase activity decreased in response to N fertilization and corresponded to declines in soil $\delta^{15}N$. It appeared that N addition decreased microbially-mediated processes in the larch plantation. This was supported by Fourier transform infrared spectroscopy analysis because aliphatic and carboxylic compounds were less abundant in the N fertilized plots. Overall, long-term N addition in the larch plantation may increase C storage in soil. However, our results indicated that N addition leads to a decline in soil C cycling rate in the larch plantation.

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Figure 1

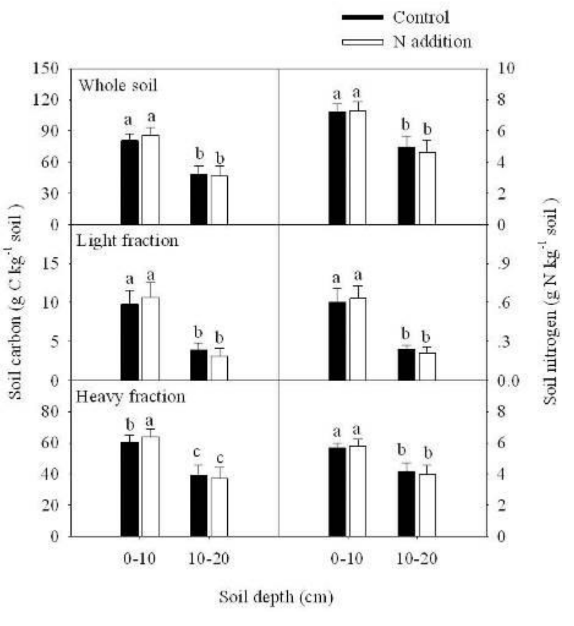
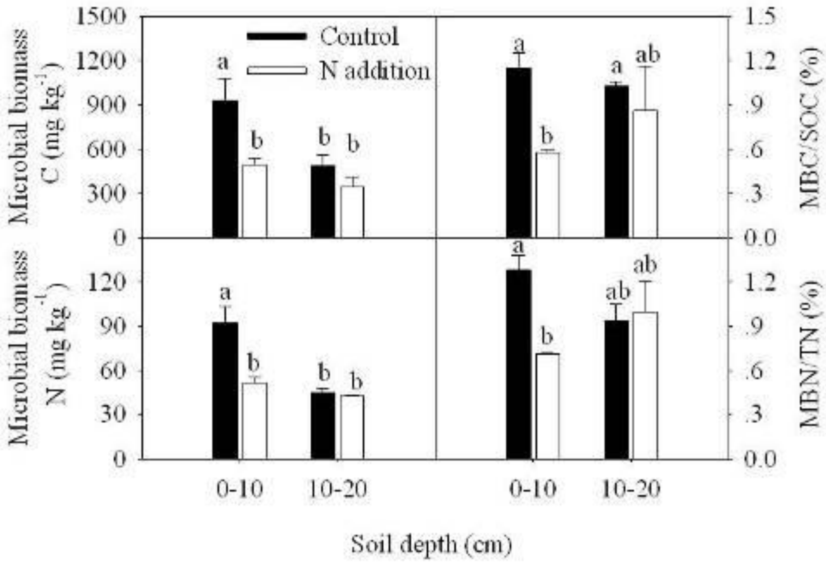


Figure 2



Control
N addition
Microbial biomass C (mg kg-1)
1500
1200
900
600
300
0
a
b
b
b
1.5
1.2
.9
.6
.3
0.0
MBC/SOC (%)
a
b
a
ab
Microbial biomass N (mg kg-1)
120
90
60
30
0
a
b
b
b
MBN/TN (%)
1.2
.9
.6
.3
0.0
a
b
ab
ab
0-10
10-20
0-10
10-20
Soil depth (cm)

P 3.1.04

Carbon sequestration under natural vegetation restoration and tree plantation on Chinese Loess Plateau

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The Loess Plateau of China has undergone extensive vegetation restoration to reduce soil erosion and improve the degraded ecosystems in the last few decades. However, the dynamics of ecosystem carbon stocks with vegetation restoration in this region are still not well understood. This study examined changes in ecosystem carbon stocks (plant and soil carbon stocks) under natural vegetation restoration and tree plantation through the use of chronosequences and associated space-for-time substitution. Two natural vegetation chronosequences with the maximum restoration time of about 150 years and 30 years respectively, and one tree plantation chronosequences with the maximum restoration time of about 48 years were used in the study. Our results indicated that cultivated land returned to native vegetation (natural restoration) and tree plantation both had increased ecosystem carbon sequestration. Tree plantation sequestered higher carbon than natural vegetation restoration over the course of decades due to a rapidly increase in plant biomass. Restoration time had different effects on the dynamics of biomass and soil carbon stocks. Biomass carbon stocks increased with restoration time, while the dynamics of soil carbon stocks were depth-dependent. Soil carbon stocks gradually increased during vegetation restoration in soil layers within 0-20 cm of the ground surface; yet an initially decrease and then increase trend was observed in 0-100 cm soil layers. There was a time lag of about 15-30 years between biomass and soil carbon sequestration in 0-100 cm, which indicated a long term effect of vegetation restoration on deep soil carbon sequestration.

P 3.1.05

Response of soil CO_2 emissions to warming and nitrogen deposition in degraded meadow of Wugong mountain, China

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Carbon dioxide (CO_2) is one of the most important greenhouse gas. CO_2 concentration increasing is an important driving factor of global warming. Alpine meadow grassland ecosystems are large carbon (C) pools around the world. Slight changes in soil CO_2 emissions from meadow soil would lead large variations in atmospheric compositions. An increasing number of meadow ecosystems are experiencing degradations following excessive perturbations and have been restored by implementations of vegetation restoration, which might further alter soil CO_2 emissions and the response to warming and N depositions. However, few studies have identified the response of CO_2 emissions to warming and N depositions in degraded meadow ecosystem restorations. We conducted an incubation study using soils collected from degraded and restored plots in Wugong mountain meadow to understand CO_2 emissions from restored soils and response to warming and simulated N depositions. The results showed that soil dissolved organic C varied among plots restored by different plant species, exceeding that of the non-restored plots. Soil CO_2 emission rates were increased by all vegetation restorations ($F_{1,336}$=880.6, P<0.0001). In addition, sensitivities of CO_2 emission rate to warming (Q_{10}) were significantly increased by restoration species ($F_{1,112}$=3.7, P=0.027). Moreover, Q_{10} of CO_2 emissions were higher in soils collected from plots with vegetation restorations and plots with N depositions relative to bare soils without any treatment ($F_{1,112}$=6.1, P=0.015 and $F_{1,112}$=7.9, P=0.006, respectively). The results showed that vegetation restoration of degraded meadow soils altered C cycling and CO_2 emission response to warming and N depositions under future global changing context. Degraded meadow ecosystems and their restorations should be considered in future studies on soil CO_2 budgets and global warming potential assessment.

P 3.1.06

Exotic perennial forb invasions into an annual grassland enhanced soil carbon emissions and litter decomposition rate

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Exotic plant invasions may alter ecosystem carbon processes, especially when native plants are displaced by plants from different functional groups. Forb invasions into grasslands are common, yet little is known about how they impact carbon cycling. We conducted a field study over two years in China to examine changes in soil respiration (R_{soil}) following perennial forb invasions (*Alternanthera philoxeroides* or *Solidago canadensis*) into an annual grassland dominated by native annual grass *Eragrostis pilosa*. Seasonal measurement of R_{soil} was taken weekly in fields that were non-invaded or invaded by one of the forb species using static chamber-GC method. Aboveground litterfall of each species was collected biweekly and litter decomposition rates were measured in a 6-month litterbag experiment. R_{soil} increased following invasion by either forb species. The increases in cumulative R_{soil} were smaller with *Solidago* than with *Alternanthera* invasion (~36% vs. ~65%). Both invasive forbs are associated with high litter quantity and quality (e.g. C:N) relative to the native annual grass. Compared to the native annual grass plots, each invasive forb species produced larger amounts (*Alternanthera* ~155%, *Solidago* ~361%) of more rapidly decomposing litter (litter decomposition constant, $k_{Alternanthera}$: $k_{Solidago}$: $k_{Eragrostis}$ ~3.8: 2.0:1). Functional groups of invaders and the natives they replaced appear to be useful predictors of directional changes in R_{soil} but the magnitude of effects on soil carbon fluxes seem sensitive to variation in invader functional traits.

P 3.1.07

Increasing dissolved organic carbon and nitrogen fluxes in forest soils recovering from acidification between 2002 and 2013

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1. Introduction

Atmospheric nitrogen (N) and sulphur depositions on forests decreased during the past two decades, enabling an initial chemical recovery of the forest soil solution. More information is needed about the effects of these changing conditions on soil organic matter dynamics. Long-term data of dissolved organic carbon (DOC) and nitrogen (DON) concentrations and fluxes collected at ICP Forests intensive monitoring plots are a crucial element in improving our understanding of this matter.

2. Objectives

The objectives of this study were: 1) to evaluate the trends and patterns of DOC and DON concentrations and fluxes and the molar ratio between DOC and DON (DOC/DON) in the deposition and soil solution of forests, 2) to assess the dependence of soil solution DOC/DON on factors such as soil texture, soil C/N ratio, N stock, forest type, hydrological conditions and nitrate (NO_3^-) concentration.

3. Materials & methods

Samples of deposition and soil solution were collected two times per month at five ICP Forests intensive monitoring plots (Level II) in Flanders, Belgium, between 2002 and 2013 and analyzed for DOC, DON and NO_3^-. The Seasonal Mann Kendall test was used to evaluate long-term trends of DOC and DON concentrations and fluxes and of DOC/DON in throughfall and 4 soil horizons. Simple linear regression was used to assess the dependence of soil solution DOC/DON on factors.

4. Results

Concentrations and fluxes of DOC and DON generally increased during the monitoring period. In the stand precipitation (throughfall + stemflow) and in the O and A horizons, DON concentrations increased faster than DOC concentrations, resulting in a decrease of DOC/DON. Soil solution DOC/DON depended on the forest type, soil texture and hydrological conditions, but not on soil C/N ratio and soil organic N stock, while the results were inconclusive with regard to NO_3^- concentration.

5. Conclusion

Concentrations and fluxes of DOC and DON are increasing significantly in five forest soils, possibly related to their on-going recovery from acidification. Further research is needed to test the dependence of these evolutions on factors like latitude, forest cover, length of the growing season, hydrology and topography.

P 3.1.08

Evaluations of soil organic carbon stocks after natural broad-leaved forest reforesting with Japanese cedar and bamboo plantations

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Introduction

Land use changes affect SOC stocks through afforesting or reforesting with different tree species. Soil carbon stock reduced when land use changed, decreasing 13 % from naive forest to plantation and 42% from native forest to crop (Guo and Gifford, 2002). The vegetation governing SOC accumulation could be referred to characteristics and biomass of litters. Kononova (1966) suggested that the stabilization and decomposition degree and rate of organic matter were associated with the components of litter. Most natural forests in Taiwan had been reforested, and plantations became major forest stands. Therefore, the contribution of plantations to SOC stocks is critical and effects of litters under different plantations on SOC stocks need to be further investigated.

Objectives

To estimate the effects of litter decomposition rate of various vegetation types on litter carbon stocks and SOC stocks after natural broad-leaved forest replaced by Japanese cedar and bamboo forests.

Materials and methods

The study was conducted in adjacent natural broad-leaved, Moso bamboo (*Phyllostachys edulis*), and Japanese cedar (*Cryptomeria japonica*) forests in Xitou, Experimental Forest, NTU in central Taiwan. Litter components, C/N, lignin/N, and C functional groups of litters and H/S materials were investigated and used to evaluate litter decomposition rate. Then, the effects of litter decomposition rate of various vegetation types on litter carbon stocks and SOC stocks after natural broad-leaved forest reforested with two plantations were estimated.

Results

The greater lignin content, ratios of C/N and lignin/N in litters under Japanese cedar indicated the slower litter decomposition rate than bamboo, which could be referred to remain more OC in litters and reduced the accumulation of SOC in surface soil. Paul et al. (2002) suggested that litters from pine plantations (*Pinus radiata*) decayed slowly because of the poorer substrate quality of coniferous needles than broad-leaved leaves. Allelopathic compounds released from bamboo leaves and the higher litter decomposition rate could reduce litter mass and accumulate less OC in litter, but the high bulk density could lead to higher SOC stocks (Table 1). CPMAS ^{13}C NMR spectra also supported the results of litter carbon stocks and SOC stocks because of higher alkyl C and aromatic C in litters under Japanese cedar forest and higher O-alkyl C in litters under bamboo (Table 2).

Conclusions

Compared with in bamboo forest, in Japanese cedar forest litters decomposed slower and then organic carbon accumulated more in soils. In bamboo forest, high decomposition rate and allelopathic compounds released would be adverse in the litter mass accumulation. Higher ratios of C/N and lignin/N and lignin content in litters under Japanese cedar forest than bamboo indicated the lower litter decomposition rate of Japanese cedar. Besides, CPMAS ^{13}C NMR spectra run on litters and H/S materials showed that the distribution of C functional groups changed because of reforestation. The higher O-alkyl C found in bamboo litters than in Japanese cedar litters implied the abundant easily decomposed components and the higher litter decomposition rate; however, the higher alkyl C and aromatic C in Japanese cedar litters revealed the higher content of lignin and lower litter decomposition rate. We suggested that litter carbon stocks increased but SOC stocks decreased in Japanese cedar forest after natural broad-leaved forest reforested

Though bamboo litter had the lower mass, organic carbon content, and higher decomposition rate, which was not benefit to accumulate more SOC, the high soil bulk density could still contribute to the higher SOC stocks and result in almost equal SOC stocks to broad-leaved forest.

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Figure 1

Table 1. SOC (Mg C ha^{-1}) stored at each soil layer for three vegetation types

Vegetation type	SOC stock (Mg C ha^{-1})				
	0-5 cm	5-10 cm	10-30 cm	30-50 cm	Total
Natural broad-leaved	32.0 ± 16.9	26.5 ± 7.90	51.4 ± 3.28	43.6 ± 2.66	154 ± 16.3
Bamboo	31.7 ± 10.9	22.8 ± 13.0	50.3 ± 4.34	46.3 ± 8.81	151 ± 28.4
Japanese cedar	28.1 ± 6.22	14.2 ± 1.82	56.7 ± 15.1	42.7 ± 20.4	142 ± 4.73

Figure 2

Table 2. Distribution of C functional groups in litters and H/S materials in three forests.

	Chemical shift	Broad-leaved	Bamboo	Japanese cedar
	ppm	--------------------------	%------------------	
Litters				
Carbonyl C	165-220	5.4	6.2	5.6
Aromatic C	110-165	14.4	12.7	15.4
O-Alkyl C	45-110	61.3	67.0	56.5
Alkyl C	0-45	18.9	14.0	22.5
H/S materials				
Carbonyl C	165-220	6.5	7.2	6.8
Aromatic C	110-165	13.9	13.1	17.6
O-Alkyl C	45-110	46.0	55.3	46.2
Alkyl C	0-45	33.5	24.5	29.4

P 3.1.09

Soil carbon and nitrogen stocks in different land uses and soil types in semiarid Northeast Brazil

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Soil carbon and nitrogen stocks in different land uses and soil types in semiarid Northeast Brazil

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1, UFPE; 2, EMBRAPA

Introduction - Fossil fuels consumption and land use changes have increased the atmospheric greenhouse gases concentration, especially CO_2. Compensatory measures include sequestration in plant biomass and soil organic matter stocks, which are influenced by the conversion of pasture and agricultural areas to native forests. Agriculture is being discontinued in the semiarid area of Northeast Brazil, due to its low economic return, and the areas are reverting to native “caatinga”. Comparisons of C stocks in different land uses and soil types are absent in the region.

Objective - The study aimed to assess carbon and nitrogen stocks in four land uses and four soil types in the western semiarid portion of Pernambuco state, Brazil.

Material and methods - Soil samples were collected in seven layers in 0.7 x 0.7 x 1.0 m trenches, located in three points at each combination of land cover (dense caatinga, open caatinga, pasture and agriculture) and soil type (Argisol, Latosol, litholic Neosol and Planosol). The points were randomly selected in areas of each combination determined by satellite images.

Results - In general, the highest C stocks were under dense caatinga and in Argisols and the lowest in open caatinga or agricultural fields and in Planosols (Table 1). Differences in N stocks were less marked and agricultural fields tended to be similar to dense caatinga. Argisols are preferred for agriculture while Planosols and Neosols are seldom planted, and, if so, mostly with pasture. Agricultural fields in Argisols had high C and N stocks. The C and N stocks in the western portion of Pernambuco, considering the different land uses and soil types, are 0.13 and 0.013 Pg, respectively.

Table 1 - Carbon and nitrogen stocks (Mg ha^{-1}) under land uses and soil types (Argisol = A; Latosol = L; lytholic Neosol = N; Planosol = P)

Land use	C				N			
	A	L	N	P	A	L	N	P
Dense caatinga	98.3	72.1	54.5	27.7	8.6	5.8	5.0	3.
Open caatinga	67.1	63.3	39.0	24.9	7.2	4.8	3.7	3.3
Pasture	76.5	66.1	51.6	19.0	8.7	6.2	4.9	2.6
Agriculture	90,4	56.1	21.7	15.2	10.5	5.7	2.8	3.0

Conclusion - Converting low production agricultural to dense caatinga may increase C stocks from 8 to 60% and converting to pastures from 5 to 31%, depending on the soil type.

P 3.1.10

Long-term effect of integrated no-till crop and pasture-based livestock systems on soil organic matter fractions and soil quality (W.Cape, Sout Africa)

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Total soil organic matter (SOM) and its different functional pools (free particulate, aggregate-occluded, mineral-bound) are important indicators of soil quality and fertility. Within the Western Cape grain production regions of South Africa, limited information was available regarding the long-term effect of integrated no-till crop and pasture-based livestock production systems on soil C and N accumulation and distribution in the different SOM functional pools. In these grazed systems, below-ground C inputs through roots were anticipated to play an important role in determining the SOM content. Long-term field trials under grazed no-till management were initiated in 2002 at Tygerhoek Research Farm, near Riviersonderend, Overberg region, Western Cape, South Africa. The following five dryland cropping systems ranging from 100 % pasture to 100 % crop (continuous cropping) were investigated; permanent lucerne, Medic-Medic-Wheat (MMW), Medic-Medic-Wheat-Wheat (MMWW), Wheat-Barley-Canola-Wheat-Barley-Lupin (WBCWBL4) and Wheat-Barley-Canola-Wheat-Barley-Lupin (WBCWBL1). Soil samples were taken at 0-5, 5-10, 10-20, 20-30 cm. The objectives of this study were: (1) to examine the long-term (11 years) effect of different grazed crop and pasture rotation systems on the soil C and N content and C and N stored in the functional pools [free particulate organic matter (fPOM), occluded POM (oPOM) and mineral fraction (MOM)] (2) to determine the role of the below-ground root biomass of the crop and pasture systems on the soil C and N content and (3) to examine the relation between the SOM fractions and soil quality. After 11 years, the greatest soil C and N stocks (0-30 cm depth) were found in crop-pasture systems containing barrel medics (70.2-74.9 Mg C ha-1 and 8.3-8.4 Mg N ha-1), compared to permanent lucerne pasture (63.4 Mg C ha-1 and 7.7 Mg N ha-1) and continuous cropping (54.7-58.9 Mg C ha-1 and 6.3-6.7 Mg N ha-1). Significantly higher amounts of labile C and N (fPOM fraction) were observed in crop-pasture systems (1.37-1.74 g C kg-1 and 0.107-0.110 g N kg-1 in 5-10 cm depth) than in continuous cropping systems (0.9-1 g C kg-1 0.042-0.045 g N kg-1). These findings are mainly attributed to high below-ground C inputs of the medic roots compared the other rooting systems. A greater extent of physical disturbance in the 0-10 cm depth further contributes to lower C and N stocks, as well as lower labile C and N content in continuous cropping systems. On average, the fPOM pool and oPOM fraction contributed 6-9% and 0.4-2.4% of total SOC content in all systems respectively. The major part (85-93%) of SOC was associated with the MOM fraction with the MMWW treatment containing the highest C content (18.7 g kg-1, 5-10 cm depth) in this fraction. Significant positive correlations were found between C and N content (total and functional pool fractions) and soil quality parameters (CO2 efflux, ECEC, and aggregate stability) and wheat yields. The results highlight the importance of the barrel medic pasture in enhancing SOC and N stocks under integrated livestock crop and crop-pasture farming systems. With an average gross margin similar to that of continuous cropping, the medic-wheat system doesn't only contribute to soil quality but economically it is also a viable system.

P 3.1.11

Assessing the Impacts of Miscanthus on Soil Properties - A case study on 20-yr old Miscanthus fields in Upper Rhine Region

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The use of biomass as a renewable energy source has become increasingly popular in Upper Rhine Region to meet the demand for renewable energy. Miscanthus is one of the most favorite biofuel crops, due to its long life and large yields, as well as low energy and fertilizer inputs. However, current research on Miscanthus is mostly focused on the techniques and economics to produce biofuel or the impacts of side products such as ash and sulfur emissions to human health. Research on the potential impacts of Miscanthus onto soil properties, especially carbon stability after long-term adoption, is very limited. Some positive benefits, such as sequestrating organic carbon, have been repeatedly reported in previous research. Yet the vertical distribution and stability of newly sequestrated organic carbon and its potential impacts onto global carbon cycling remain unclear. To fully account for the risks and benefits of Miscanthus, it is required to investigate the stability as well as the potential CO_2 emissions of soil organic carbon on Miscanthus fields.

As a part of the Interreg Project to assess the environmental impacts of biomass production in the Upper Rhine Region, this study aims to evaluate the carbon quality and the potential CO_2 emissions after long-term Miscanthus adoption. Soils were sampled at 0-10, 10-40, 40-70, and 70-100 cm depths on three Miscanthus fields with up to 20 years of cultivation in Ammerzwiller France, Münchenstein Switzerland, and Farnsburg Switzerland. Soil texture, pH, organic carbon, stable isotope ^{13}C signature, and nitrogen content were measured for each sampled layer. The respiration rates of the top two layers were also monitored for 42 days to determine the long-term mineralization potentials of SOC stored in surface soils.

Our results show that: 1) Miscanthus cultivation can significantly increase the SOC stocks compared to grassland. However, the benefits of SOC sequestration may only occur on the surface soil. 2) Less depleted 13C signature in the Miscanthus soils indicates that partial of the SOC stock on Miscanthus fields is derived from Miscanthus, confirming the contribution of Miscanthus in sequestrating SOC. 3) Soils from the Miscanthus fields had greater respiration potentials and produced more CO_2 emissions than the grassland, suggesting that the Miscanthus-derived SOC thus potentially lead to additional atmospheric CO_2 emissions. 4) Topsoils from the Miscanthus field also tend to have acidification despite of agricultural lime application every 5 years.

Overall, our results confirm the contribution of Miscanthus to atmospheric CO_2 sequestration. Yet, the additional mineralization from the Miscanthus soils indicates the greater liability and decomposition potentials of the newly sequestrated SOC and thus caution the negative feedback to the global carbon cycle if widespreading Miscanthus. Consequently, further studies aiming at a full Life Cycle Assessment are required to assess the overall environmental impacts of biomass production in the Upper Rhine Region.

P 3.1.12

Effects of long-term nitrogen deposition on soil organic matter quality in different soil organic matter fractions of two temperate forest soils

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Nitrogen (N) deposition due to anthropogenic activities has several well-known negative effects on ecosystems including eutrophication, acidification and loss of biodiversity. However, N deposition may also have a positive effect on net carbon (C) sequestration in boreal and temperate forests. This may be attributed to stimulated net primary production, altered litter quality, shifts in microbial communities and enzyme activities and impeded organic matter decomposition (Griepentrog et al., 2014; Janssens et al., 2010; Prescott, 2010). These factors may alter soil organic matter (SOM) chemistry and increase long-term soil organic carbon (SOC) sequestration.

In this study, we investigate the effects of long-term N deposition (> 20 yrs) on SOM quality in two temperate Norway spruce forest sites. The sites located in Denmark (Klosterhede, Podzol) and Switzerland (Alptal, Umbric Gleysol) have regularly received NH4NO3 in amounts of 35 kg N ha-1 yr-1 (since 1992) and 30 kg N ha-1 yr-1 (since 1995), respectively. Soil samples were taken from two organic and 2-4 mineral horizons.

Mineral soil samples are additionally separated into three different functional pools by a combined density and particle size fractionation resulting in following fractions: I) light fraction, obtained by density separation using sodium polytungstate (1.6 g cm-3), II) coarse heavy fraction (2 mm - 63 µm),and III) fine heavy fraction (< 63 µm).The three fractions are analyzed by mid infrared spectroscopy showing SOM functional group distribution. In addition, pyrolysis-gas chromatography/mass spectrometry (PyGC/MS) is carried out to identify the distribution of compound classes.

Analyzing different SOC functional pools may uncover mechanisms affecting soil C dynamics caused by an elevated N input. As the light fraction represents the unprotected pool and may be thus more susceptible to external factors, we expect the most significant changes upon increased N deposition in the light fraction including increases of N containing SOM compounds and preferential decomposition of easily degradable compounds but enrichment of more recalcitrant ones.

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P 3.1.13

Study of Comparison of carbon sequestration in part of soils of Southern Khorasan province (Case Study: Hossein Abad Sarbishe in Southern Khorasan, Iran)

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Abstract

The great challenge of today's world, especially in arid and semi-arid, warming and climate change, caused by greenhouse gases in the atmosphere caused by human activities, as well as the density of carbon dioxide, the Earth's warming trend is considerably increased. One of the known strategies to reduce atmospheric carbon is carbon sequestration in vegetation and soil organic matter (SOM) which also important to its impact on improving the soils physical properties and water conservation. This study aimed to investigate the effect of two hands planted, including Atriplex and Haloxylon on carbon sequestration of soils in the piedmont plain and floodplain lands in part of South Khorasan in four different regions which protected from: 2005, 2008, 2009 and 2010. Soil samples was taken on a regular basis near and out of plants from soil depth of 0-10 and 10-20 cm and soil organic carbon, ECe and pH were measured in the laboratory. Soil profile in each region were dogged and was recorded some soil physical and morphological properties. The results of soil organic matter showed significant differences for both of two plants (Atriplex, Haloxylon) compare to unplanted soil. On the other hand, SOM had significant differences between years of 2005 and 2010. Results showed that Atriplex increased soil salinity but adding of organic matter by plant could modify soil salinity. It could be estimated that between 6 up to 10 ton C/ha precipitated in different parts of the study by two plants.

Keywords: Carbon sequestration, ECe, Atriplex plant, Haloxylon,

P 3.1.14

Effects of land-use changes on soil organic carbon content in a tropical deciduous *Sal* forest in Bangladesh

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Changes of land-use from natural forests to farmland and tree plantation are widespread in countries like Bangladesh where land scarcity is severe. This study aimed to characterize the influence of different land-use changes on soil physico-chemical properties with emphasis on soil organic carbon (C) stocks considering its relevance to global warming as well as implications on sustainable soil resource management. Natural deciduous *Sal* (*Shorea robusta* Roxb. Ex Gaertn.) forest stands and the stands those were converted into pineapple farmland and *Acacia* plantation about 30 years ago were selected for collecting soil samples in this study. Soil samples were collected at 0-5, 5-10 and 10-15 cm depths. Data showed that soil organic C content was significantly affected by both land-use types ($P < 0.02$) and soil depth ($P < 0.003$), although no significant interactions appeared between these two factors. Soil organic C content was significantly low in natural forest sites compared to the other two land-use types and it decreased significantly with the depth of soil. Soil organic C content was higher in 0-5 cm depth (0.47%) followed by 10-15 cm (0.37%) and 10-15 cm (0.33%) depths. When correlation analysis was done across land-use types, soil organic C showed significant correlation with soil moisture content ($r = 0.819$, $P < 0.0002$). However, when correlation analyses were done separately, it was found that organic C content showed no significant correlation with soil properties studied in the natural forest sites. In *Acacia* plantation, soil organic C content correlated significantly and positively with soil moisture ($r = 0.94$, $P < 0.02$) and root biomass ($r = 0.98$, $P < 0.004$) and in pineapple farmland it showed significant negative correlation with soil pH ($r = -0.93$, $P < 0.02$). Results of the present study indicate that changes in land-use cover in the deciduous *Sal* forests have the potential to alter soil organic C stocks and such changes are influenced differently by different factors.

P 3.1.15

Estimation of Soil Carbon Stock as affected by Land Use and Land Cover Change in *Desa'a Dry Afromontane* Forest, northern Ethiopia

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The dynamics of land cover changes demand for monitoring of degree of degradation of soils at various soil depths. The soil carbon stock of the *Desa'a dry afromontane forest* which covers about 120,000 ha in northern Ethiopia was estimated through studying the soil morphological, physical and chemical properties on varying landscapes, land use/cover types and soil depth ranges. Soil Bulk density was between 1.19g/cm^3 on the upper (0-20cm) and 1.25g/cm^3 on the lower (20-40cm) soil layers. The sand content (40%) at the farmlands was higher than those observed for the open forest, grazing land and dense forest. The OC (1.90%) and total N (0.26%) were higher for the middle landscape position than that observed for the upper and lower landscape positions. Soil OC that ranged from 1.2% (on farmland) to 2.3% (on dense forest) was significantly varying with the land use/cover types. Soil OC was significantly different among dense forest (2.3%), open forest (1.7%), grazing land (1.6%), and farmland (1.2%). Total N significantly varied from 0.15% on the farmland to 0.31% on the dense forest. The OC and total N were 2.0% and 0.20% on top soil and 1.5% and 0.27% on lower soil layers, respectively. Soil carbon sequestration of the middle landscape position (43.4t/ha) showed higher mean values than those obtained for the upper (38.9t/ha) and lower (37.4t/ha) landscape positions. The carbon sequestration for dense forest (48.5t/ha) was higher than that of grass land, open forest and farm land. Excessive grazing and clearing by the highland farmers from *Tigrai* at the upper landscape positions and by the *Afar* pastoralists at the lower landscape positions are causing forest degradation. Thus, these findings suggest that the relic forest should be protected as a buffer in the escarpments of the *Rift Valley* from encroachments for expansive farming and grazing.

Keywords: Landscape position, Land use/cover type, Soil property, Carbon sequestration,Rift Valley,Ethiopia

P 3.1.16

The effects of vegetation and exposure on organic matter stocks in the uppermost part of soils of subalpine and alpine meadows (połonina) in Eastern Carpathians

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Climatic conditions of Eastern Carpathians determine peculiar altitudinal zonation with distinctive occurrence of unique subalpine and alpine meadows called 'połonina'. Despite natural origin of połonina meadows significant influence of pastoralism on range, composition and structure of plant communities occurred in the past few centuries till the end of 1940s. From that time a regeneration of plant communities close to natural have been observed. Currently vegetation of połonina meadows is dominated by grasslands and shrubs (mainly *Vaccinum* sp.). This altitudinal vegetation zone is particularly liable to any climate change influence which could affect the shift of upper timberline.

The aim of the research was to determine soil organic carbon and nitrogen stocks within uppermost part of soil profile (0-30 cm) under different vegetation and on the slopes of opposite exposure on Połonina Caryńska (Polish part of Bieszczady Mountains). Research plots were located along transects on the slopes of exposure SSW and NNE. For each research plot two soil pits were made under grassland and under Vaccinietum shrubs respectively. Bulk undisturbed samples (using core sampler) were collected from 0-10 cm, 10-20 cm and 20-30 cm depth of the soil profiles. Laboratory analyses were carried out for samples of air-dried and sieved through 2 mm mesh. Living roots were also removed. Bulk density, soil pH and concentration of total carbon as well as nitrogen (using gas chromatography method) was determined.

Soil properties did not differ significantly due to slope exposure, while there were big differences (especially within top part of soil) between soils developed under grassland and under shrubs vegetation. Despite the large difference in energy supply (the average power of radiation/insolation, based on a theoretical model assuming no cloud cover is approximately 1.20 MWh $m^{-2}yr^{-1}$ with SSW exposure and 0.75 MWh m^{-2} yr^{-1} with NNE exposure) there was no significant differences in the carbon and nitrogen stock in the uppermost part of soil. Generally in the top part of the soil (0-30 cm) on the slopes of SSW exposure the higher carbon and nitrogen stocks were found. More significant differences in the carbon and nitrogen stocks have been determined between soils developed under different vegetation.

P 3.1.17

Nitrogen dynamics during composting of liquid pig slurry in the presence of biochar

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Introduction. Composting is an alternative treatment for sustainable fate of liquid pig slurry (LPS). During the process, losses of N occur, either by volatilization (NH_3) as by N_2O emissions, which can reduce the agronomic value of the compound. Biochar (BC), due to its high specific area may retain ions such as NH_4^+ and NO_3^-, thereby reducing losses of N.

Objective. This study aimed to evaluate the effect of BC on the N dynamics (N_2O and NH_3 emissions and mineral N) along the LPS composting.

Materials & Methods. LPS composting was conducted in 500L vessels employing sawdust (S) and wood shavings (WS) as substrate. Three treatments were performed: composting without BC (BC0%) and two treatments with different proportions of BC (BC20% and BC40%). The mineral N content (micro Kjeldahl), volatilization of ammonia (titration) and N_2O emissions (GC-ECD) were determined periodically throughout the composting.

Results. The concentrations of volatilized NH_3 were around 28.3 mg m^{-2} h^{-1} for BC0% and 25.2 mg m^{-2} h^{-1} for treatments BC20% and BC40% and did not differ among treatments during composting. The NH_4^+ concentration in BC0% in the first seven days of the composting process was greater than that observed for BC20% and BC40%. However, thenceforth NH_4^+ contents in BC20% and BC40% were greater than in BC0% up to 30 days, when the levels reached low values in all treatments until the end of composting. Regarding NO_3^-, until 15 days of composting, BC20% and BC40% showed lower levels than those observed in BC0% indicating that there was inhibition of nitrifying bacteria for oxidation of ammonia. N_2O emissions remained low in all treatments during the first 7 days of composting (Figure 1). However, after the second LPS application. BC0% emission was higher than those observed for BC20% and BC40%, and remained high up to 30 days of composting process. The reduction of N_2O emissions occurred after the 30-day period for all treatments. The smaller flow in treatments with BC can be attributed to preservation of ammonia nitrogen and inhibition of the nitrification process.

Conclusion. Biochar affected the distribution of N in the different compartments during composting, reducing N_2O the emission of and the concentration of available mineral nitrogen. Possibly, the biochar adsorbs inorganic and organic compounds, decreasing the concentration of precursor forms for N_2O formation.

Figure 1

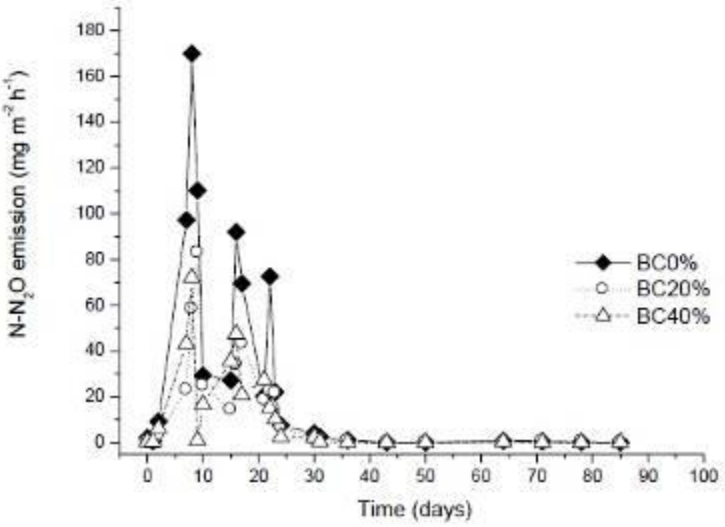

Figure 1. Emission of N-N_2O during pig slurry composting in BC0%, BC20% and BC40%.

P 3.1.18

Carbon Storage in Hedge Landscape in Loess Areas of Alsace (France)

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Introduction

The issue of carbon storage in soils is a major challenge. Indeed, with the agronomic and environmental changes (soil fertility, chemical and physical characteristics of the soil, carbon sinks, etc.) it is essential today to understand the carbon fluxes in soils at different scales. To understand this phenomenon, we must be able to quantify a stock, but also simulate the evolution of this stock of carbon at different time scales.

Within the different existing agricultural practices, fragmented systems with hedges (bocage systems in a watershed) combined with cropping activity are very good field of study to measure changes in carbon stocks at the slope scale. Indeed, with such a configuration, it is possible to measure all inputs / outputs of different agricultural erosion phases (colluvial), and quantified products of this erosion (colluvium). Coupled with a historical study of the hedge landscape, the rhythm of C accumulation in the system can also be estimated

Objectives

The objective of this study is to measure / quantify the storage capacity of soil organic carbon in both:

- Colluvium deposited behind and under the hedges (when the hedge is uplift)

- The entire watershed following a representative transect perpendicular to the slope, intersecting one or more ”hedge system” (hedge plus colluvium) from the top to the bottom of the watershed

From these measures we estimate the carbon stock changes in the watershed.

Material & methods

To carry out the measurements of organic carbon stocks, the prevailing formula is as follows:

$$\mathbf{Q_{(Organic\ Carbon)} = Thickness_{(m)} \times Organic\ Carbon_{(\%)} \times Apparent\ density\ surface_{(m^2)}}$$

The measures of these stocks are made on regular sampling of soil samples every 10 cm of each pits. The figure 1 shows the location of the different pits (HABS01 to HABS10) performed at the watershed scale for one of study site : Habsheim, 68, France).

Figure 1 : Localisation of the10 sampled pits and the hedges for the site of HABSHEIM (FRANCE/Alsace/68) ; Source : Lucie Froehlicher, 2015

Results

The measurements of organic carbon stocks in these agricultural soils associated with agrarian structures like hedges, clearly show a trend of organic carbon storage behind the hedges (HABS03, HABS06). The figure 2 shows the evolution with depth of this organic carbon stock every 10 cm for each pit across the transect.

Figure 2 : Evolution of the organic carbon stock for the site of HABSHEIM (FRANCE/Alsace/68) ; Source : Lucie Froehlicher

Conclusion

Although loess soils are not likely to store carbon due to their particle size characteristics, the evolution of organic carbon stock can be significant. Indeed, for HABS06 behind the hedge the stock is four times higher than in the upper part of the field (HABS05). A couple of other studied sites show the same tendency. Thus, hedges appear as a possible solution to carbon sequestration.

Figure 1

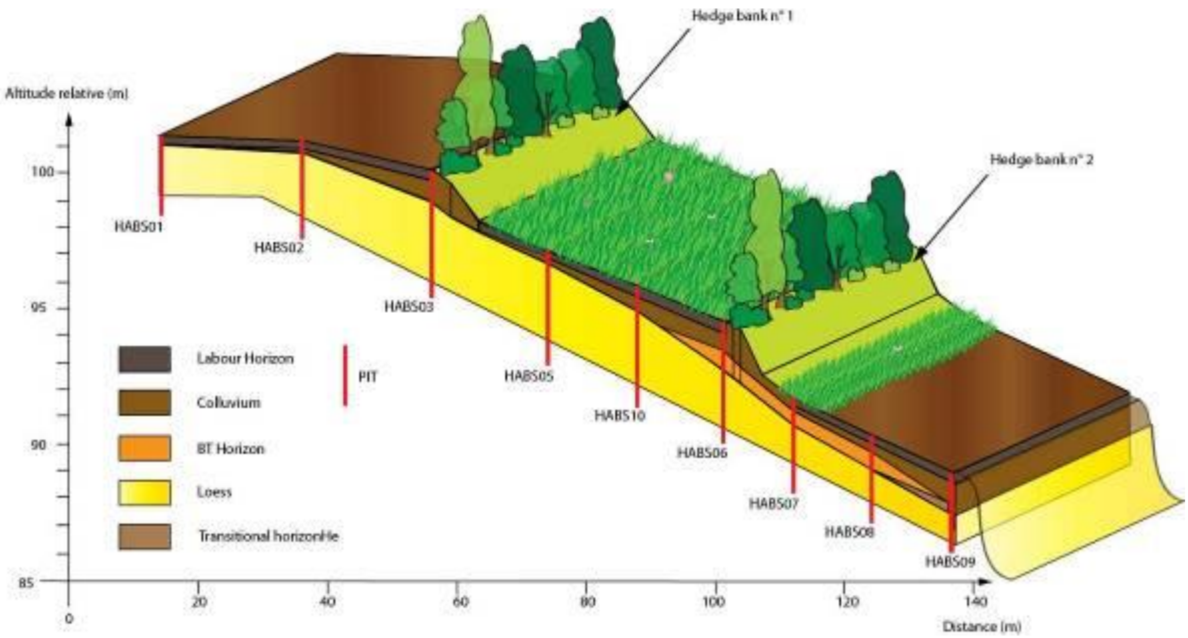
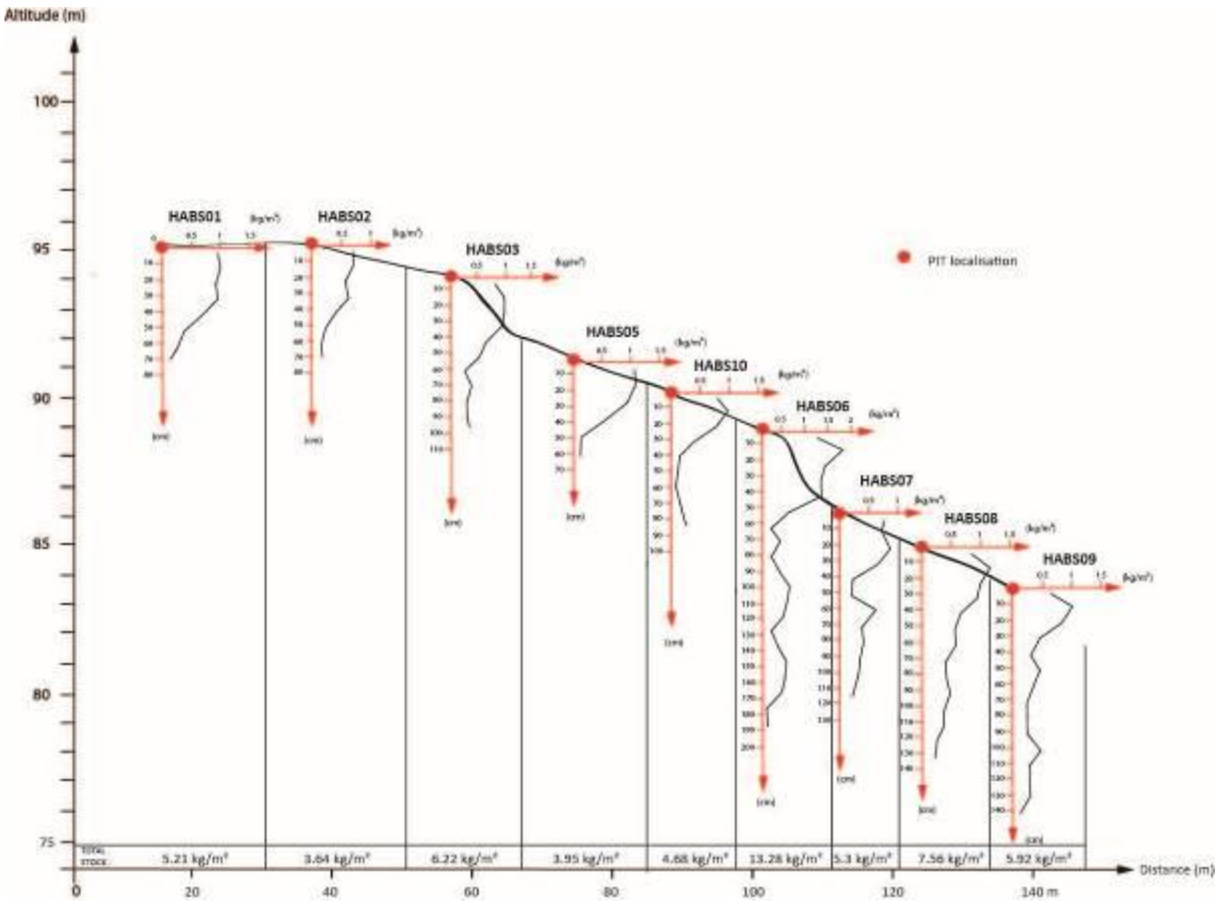


Figure 2



P 3.1.19

Nitrogen and sulfur addition alter decomposition dynamics of litter and soil organic carbon in a subtropical forest: consistent effects on litter but divergent role on soil organic carbon

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1. Questions. The objectives of this study are: (1) to assess the effects of different levels of N and S on litter and SOC decomposition, and (2) to link SOC and litter decomposition to functional microbial groups.

2. Methods. Soil had 3.70 mg C g−1 and 0.50 mg N g−1 and a δ13C value of −23.52‰. 13C-labelled leaf litters of Pinus massoniana had 444.0 mg C g−1, 15.7 mg N g−1 and a δ13C value of 270‰. Fresh soil (100 g on oven-dried basis) with leaf litters (0.5%) gently mixed was incubated in a glass jar for 420 days at 25 °C. NH4NO3 (0, 81 and 270 mg N kg-1 for control, N1 and N2, respectively) or Na2SO4 (0, 121 and 405 mg S kg-1 for control, S1 and S2, respectively) solution was added. Gas samples were collected for measurement of CO2 concentration and δ13C value. Soils were destructively sampled during incubation and analyzed for NH4+, NO3−, SO42−, DOC, specific UV absorptivity of DOC (SUVA) and phospholipid fatty acids (PLFA).

3. Results. 3.1 Effect of N addition During the 420-d incubation, the amount of decomposed litter was 594 mg C kg−1 in the control and increased by 27.2% and 28.9% in the N1 and N2 treatment, respectively. In contrast, the decomposed amount of soil organic C in the N1 and N2 treatment, decreased by 30.6% and 53.6% compared with the control. N showed stimulation effects at the early stage (day 0.5-56) but suppression effects on day 57-420. N addition greatly enhanced DOC from 13C-labelled litters and stimulating effect on DOC for N2 was significantly higher than for N1. DOC quality responded to N addition variously at the different stages, and had a low SUVA at the early stage and a high SUVA at the later stage in N-treated soil. The size of active pool of mineralizable C in litter increased by 38.3% for N1 and 53.1% for N2, and the slow pool decreased by 44.4% in N-added soil. N significantly increased 13C incorporation into fungal rather bacterial PLFA compared with control, suggesting that N stimulated the proliferation of fungi, which in turn resulted in differences of litter decomposition at the early stage. However, fungi were inhibited by N addition to decompose litter at the later stage, probably because Basidiomycete fungi are unable to synthesize oxidative enzyme when inorganic N added. As for SOC decomposition, N stimulated the growth of G− bacteria by using SOC at the early stage and in contrast, inhibited the growth of G+ bacteria, fungi and actinobacteria to use SOC at the later stage. 3.2 Effect of S addition Addition of S application significantly stimulated litter decomposition during the incubation period. It also enhanced, but not significantly, the decomposition of SOC. S increased DOC derived from 13C-labelled litters by 25.8−40.3% and from SOC by 44.8−85.2%. S showed a stimulation effect on decomposition of litter and SOC at the early stage but a negative effect on decomposition of litters rather than SOC at the later stage. We found that litter decomposition was higher in the S2 treatment than in the S1 treatment at the early stage. DOC with low SUVA and derived from 13C-labelled litter was higher in S2 treatment than in control treatment at the early stage, while no difference was found in the S1 treatment. S initially increased the amount of G+ bacteria and fungi to utilize litter but suppressed the growth of G+ bacteria and actinobacteria at the later stage. With regard to SOC decomposition, S contributed largely at the later stage. Our result suggested that more S is required for the growth of microbes when the microorganisms are decomposing recalcitrant substrates. DOC derived from soil enhanced under both S levels at the later stage, with significant effect of S on fungi to use SOC. Sulfate should first be phosphorylated via adenosine triphosphate and reduced to organic form in fungi.

4. Conclusion. N and S consistently stimulated litter decomposition by increasing the growth of fungi. S also increased the decomposition of SOC and in contrast, N showed a suppression effect by reducing the proliferation of G+ bacteria, fungi and actinobacteria. In the future, the decrease of S deposition and increase of N deposition would improve SOC.

P 3.1.20

The effects of forest gaps on soil organic carbon in artificial *Cryptomeria japanica* forest in Lushan Mountain, China

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Forest soils are large components of the carbon pools across the globe. Slight changes in forest soil carbon pools due to unintended disturbances may cause large variations in carbon cycling. Thereby, understanding the dynamics and distributions of forest soil carbon following large disturbances will be vital in carbon cycling assessments and forest ecosystem managements. Here, we evaluated the effects of forest gaps with different ages on total soil organic carbon (TOC), dissolved organic carbon (DOC) and microbial biomass carbon (MBC) in artificial *Cryptomeria japanica* forest of Lushan Mountain, China. The results showed that TOC concentrations in forest gaps decreased with their ages. Forest gaps that were more than 40 years old were lower in TOC in both the 0-20 cm and 20-40 cm soil layers relative to those less than 20 years old ($F_{2,17}$=3.9, P=0.04 and $F_{2,17}$=27.0, P<0.0001 for 0-20 cm and 20-40 cm soil layers, respectively). Forest gap TOC positively correlated with that in the control plots across soil layers (R^2=0.59, P=0.0002). However, both soil DOC and MBC were higher in forest gaps more than 20 years old, indicating different response to forest gap age with respect to TOC. In addition, except significant effects of soil layers on DOC and MBC in 8-year forest gap, no difference was observed in forest gaps more than 20 years. Our results suggested that forest gaps with different ages might differ in their effects on soil carbon components and distributions. Thereby, forest gap ages should be considered in future studies aimed to understand soil carbon cycling as affected by forest gaps.

P 3.1.21

Soil carbon dioxide emissions in response to precipitation frequency in the Loess Plateau, China

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Precipitation events can induce episodic CO_2 emissions, so called the *"Birch Effect"*, but how precipitation frequency influences the mechanisms responsible for this effect in dryland cropping systems is not well known. We evaluated the effect of three precipitation frequencies (5-, 10-, and 20-d intervals [I5, I10, and I20, respectively]) on soil CO_2 fluxes for 60 days during fallow and soil chloroform-fumigated (CFE) and nonfumigated (EOC) C and microbial biomass C (MBC) in the Loess Plateau of China. The CO_2 flux increased immediately following precipitation events, with peak fluxes of 7.9, 8.2, and 7.7 µmol CO_2 m^{-2} s^{-1} for I5, I10, and I20, respectively. Cumulative CO_2 flux from 55 to 60 d was greater for I5 and I10 than I20. Soil C fractions were not affected by precipitation simulation at the first event, but CFE and MBC increased from the first to the last precipitation event, especially for I5 and I10. The CO_2 flux was strongly correlated with CFE and EOC at the first event, but the correlation decreased from the first to the last event for I10 and I20. In contrast, the correlation of CO_2 flux with MBC increased. Greater precipitation frequency at shorter precipitation intervals increased CO_2 emissions than longer intervals due to increased soil water content. The dominant mechanism for the "*Birch Effect*" shifted from "substrate supply" at the first precipitation event to "microbial stress" at the last event, especially for shorter precipitation intervals.

P 3.1.22

Carbon footprint of rice production under biochar amendment — a case study in a Chinese rice cropping system

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Question:

Previous studies have investigated bicohar's role in soils from different single aspect, and plenty of benefits have been reported respectively, such as increased crop yield, raised soil carbon, and reduced soil greenhouse gas (GHG) emissions, etc (Woolf et al., 2010; Cayuela et al., 2010; Field et al., 2013). However, there still exists an uncertainty in the carbon mitigation potential of biochar strategy, since biochar system involves a whole cycle including not only plant and soil feedbacks but also the energetic performance of biochar production. Therefore, it is imperative to make a life cycle analysis of biochar application before its large-scale practice.

An indicator to evaluate the contribution of an individual event to global warming is carbon footprint (CF), which sums up all the carbon sources and carbon sinks by conversion to CO_2-C_e emissions over the whole life cycle (Wiedmann & Minx, 2008). As such, CF assessment on biochar system could provide an insight into its carbon mitigation potential.

In this study, carbon footprint of rice production under biochar amendment was investigated. Questions addressed were: (i) was biochar able to mitigate global warming from a life cycle view? (ii) what were the sensitive factors to decide biochar mitigation potential?

Methods:

A field experiment in a three-year scale was performed with three treatments: no residue amendment (Control), 6 t $ha^{-1}yr^{-1}$ straw amendment (Straw), and 2.4 t ha^{-1} yr^{-1} straw-derived biochar amendment (Biochar). Carbon footprint was calculated by considering carbon source processes (pyrolysis energy cost, fertilizer and pesticide input, farm work, and soil GHG emissions) and carbon sink processes (soil carbon increment and energy offset from syngas). A variety of pyrolysis settings with different energy efficiency was taken into account. $Biochar_{min}$ and $Biochar_{max}$ refer to the scenario of the lowest and highest net energy input of biochar production, respectively.

Results:

Carbon footprint

Straw treatment had a much higher carbon footprint of rice (5.08 t CO2-Ce ha-1) than that of Control (1.78 t CO_2-C_e ha^{-1}), resulting from large soil GHG emissions (mainly CH_4). Biochar amendment significantly increased soil carbon pool and showed no significant effect on soil total N_2O and CH_4 emissions relative to Control; however, due to a variation in pyrolysis energy cost based on different biochar production facilities, carbon footprint of rice under Biochar treatment ranged from 0.27 to 3.44 t CO_2-C_e ha^{-1} (Fig.1).

Sensitivity analysis on carbon intensity

Net energy input of biochar production (E_{net}) is the most sensitive factor in influencing carbon footprint value of biochar system. Base on a conservative $T_{1/2}$ value of 100 yr, the 40% conversion ratio from biomass to biochar, and the syngas recycling technique, E_{net} should be confined below 3.40 MJ kg^{-1} dry feedstock, otherwise, the carbon intensity of rice from biochar treatment will surpass that of control treatment, implying a less sustainable biochar strategy (Fig.2).

Conclusions:

Based on syngas recycling pyrolysis technique with low energy cost, biochar amendment could reduce carbon footprint of rice production compared with conventional straw return management, benefiting from significant soil carbon sequestration and reduced CH_4 emissions. This study indicated that biochar production process was a crucial factor to decide biochar mitigation effect. An optimized pyrolysis technique is highlighted to pursuit a maximum carbon profit in the view of energy input, energy output, and soil carbon sequestration.

Fig.1 Carbon footprint of rice production

Fig.2 Carbon intensity of rice production under biochar amendment in response to net energy input of biochar production and half life of biochar-carbon

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Figure 1

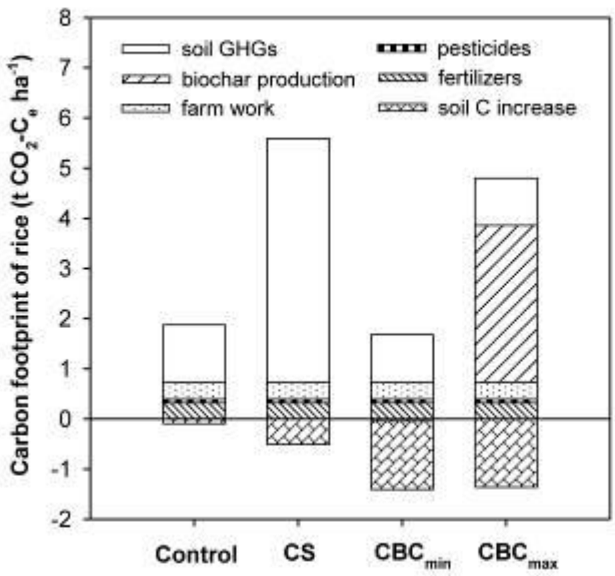
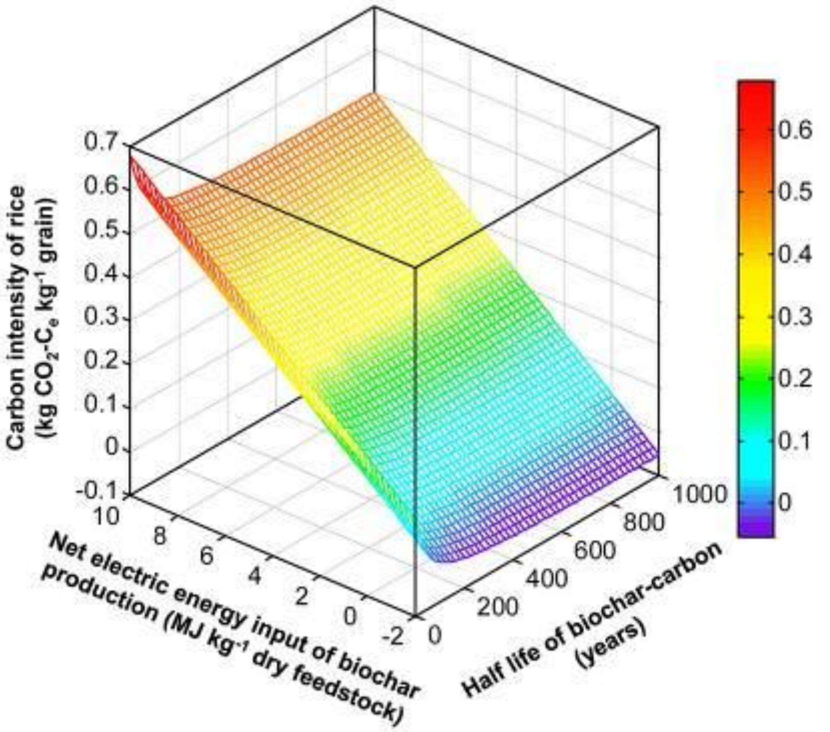


Figure 2



Carbon intensity of rice (kg CO2-Ce kg-1 grain)
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
-0.1
10
8
6
4
2
0
-2
Net electric energy input of biochar production (MJ kg-1 dry feedstock)
0
200
400
600
800
1000
Half life of biochar-carbon (years)
0.6
0.5
0.4
0.3
0.2
0.1
0

P 3.1.23

Soil organic carbon pools and nutrient characteristics of 'forest islands' and adjacent ecosystem types in West Africa

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[6]*Istituto Nacional de Pesquisas da Amazonia, Manaus, Brazil., Brazil, Brazil*
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Just north of the forest-savanna transition zone of West Africa, there are many examples of unusually dense tall woody stands of vegetation surrounding local villages in what is an otherwise open (savanna) type landscape. Although the human activities through which 'forest islands' are created are now well established, the underlying biogeochemical mechanisms behind this intriguing phenomenon remain to be elucidated. Through a series of feedback mechanisms, we suggest that improved water and nutrient availabilities of the system combine synergistically resulting in greatly enhanced plant growth potentials and that the overall increased productivity of the system is reflected in greater organic C inputs. To understand these mechanisms, we are in the process of identifying 'forest islands' in three agro-ecological zones and adjacent ecosystem types (managed and unmanaged vegetation types) in each three West African countries viz. Ghana, Burkina Faso and Nigeria; these encompassing a range of climates and soil types. Over the coming years, comprehensive measurements of a range of soil parameters will be made with our key focus being soil carbon properties. Prominently aggregate fractionation and associated soil organic pools will be carried out using appropriate techniques with measured soil carbon pools of the 'forest islands' and other edaphic properties compared with those of local adjacent ecosystems. Nutrient status and aboveground carbon stocks of the various supported plant communities will also be evaluated. This poster summarizes the proposed study and outlines the possible outcome(s) with regard to the question: Are forest islands fundamentally the same? More importantly, we expect information generated to be useful in carbon offset programmes in the era of climate change and to inform agronomic practices in West Africa.

P 3.1.24

The addition of straw increases soil organic matter mineralization in sudano-sahelian context

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The incorporation of crop residues in a soil may increase soil organic matter (SOM) mineralization. This so called "*priming effect"* mechanism has been studied very little in arid environments which are characterized by long periods of drought punctuated with irregular rainy events. Agricultural soils from north Cameroon were amended with ^{13}C-labelled rice straw and incubated at 28°C to evaluate the impact of wetting-drying cycles on CO_2 emissions, *i.e.* SOM and straw mineralization. Soils were either kept at constant moisture or were subjected to five wetting-drying cycles through the incubation period (i.e 70 days). Each wetting-drying cycle included two periods, a 7 day-wetting period and a 7 day-drying period. CO_2 emissions were measured at days 4 and 7 after each period of drying or wetting by gas chromatography coupled with a mass spectrometer. The CO_2 emissions increased on straw amended soils compared to soils without straw, respectively 1356 µg C-CO_2 g^{-1} soil and 435 µg C-CO_2 g^{-1} soil from soils with constant moisture. The priming effect represented 99 µg C-CO_2 g^{-1} soil after 70 days incubation. The wetting-drying cycles have significantly reduced total CO_2 emissions of 19% for soils without straw and 11% for soils with straw. The mineralization of the straw also decreased with the wetting-drying cycles, thus the amount of straw remaining on soils was 102 µg C g^{-1} soil on re-wetted soils compared to 48 µg C g^{-1} soil on soils with constant moisture. Conversely, the wetting-drying cycles increased slightly (+ 14 µg C-CO_2 g^{-1} soil) but insignificantly, the priming effect on straw amended soils. Under the sudano-sahelian context, characterized by long period of drought and rapid and irregular events of rain, we demonstrate that the priming effect and the straw mineralization were not increased compare to soil maintained at constant moisture. This lack of response of the soil respiration to added water could be linked to the poor nutrient status of the soils and strengthens the need to quantify and model C dynamic in such specific arid environment.

Keywords: *Priming effect*, wetting-drying cycles, soil organic matter, straw, soil respiration

P 3.1.25

The geomorphic control of spatial change of soil CO_2 emission in reforested hillslope of the Loess Plateau, China

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Changes in vegetation as a result of converting cultivated land into forested areas are known to effectively prevent the soil erosion as well as significantly increase the soil organic carbon storage in these regions. However, the spatial change of soil CO_2 emission and its control mechanism are poorly understood and can thus lead to further uncertainties in the quantitative estimations of soil carbon sequestration in these reforested areas. A typical re-forested hillslope was selected in order to investigate the spatial variation of soil CO_2 emissions and its control mechanism in the Loess Plateau. This study aims to provide a scientific basis for further understanding the Loess Plateau organic carbon turnover and improve methods for estimating the carbon balance of terrestrial ecosystems. In order to determine tempo-spatial dynamics of soil CO_2 emission of sloping cultivated land and its influencing factors, the re-forested hillslope (250m total length) was divided into 5 sections - hilltop, shoulder, upper, middle and lower slope - and each section analyzed. The Point method was used to estimate the vegetation coverage of all study plots selected at intervals of 10 meters along the entire slope. Soil samples were collected by drill and root density, soil organic carbon (SOC) content and ^{137}Cs inventory were analyzed. *In situ* soil CO_2 emission was monitored by LI-8100 carbon flux automatic systems on a monthly basis, and soil water content and soil temperature (at a depth of 5cm) were also measured. Correlation and regression analysis was applied to determine the main factors that affect spatial soil CO_2 emissions. The results show that the temporal dynamics of soil CO_2 emission rates at different slope positions during the data collection period was highest in the summer, followed by autumn, with spring having the lowest observed soil CO_2 emission rates. When calculating the average value of soil CO_2 emission rates across the whole hillslope, emission rates for summer and autumn were found to be higher by 48% and 9%, respectively, when compared to spring. Analysis of the spatial patterns of soil CO_2 emission rates were found to be similar across spring, summer and autumn and the average emission rates of the three seasons was found to decrease as follows across the slope: hilltop (reference) [2.51±0.07μmol/(m^2·s)] > shoulder [2.19±0.17μmol/(m^2·s)] > lower [1.88±0.12μmol/(m^2·s)] > middle [1.71±0.09μmol/(m^2·s)] > upper [1.62±0.12μmol/(m^2·s)]. Using the hilltop as a reference, the ^{137}Cs inventory in the upper and middle hillslope was lower by 46% and 29%, respectively; however ^{137}Cs inventory calculated at the shoulder and lower region of the hillslope was 88% and 52% higher than the reference. These results indicate that there was serious soil erosion at the upper section of the hillslope with lighter soil erosion at the middle section. Furthermore, soil accumulation occurred at both the shoulder and lower sections, with more significant accumulation occurring at the shoulder. We found that soil CO_2 emission rates significantly correlated with the slope gradient ($p<0.01$) and ^{137}Cs inventory ($p<0.01$) during the data collection period. Interestingly, only in summer did the soil CO_2 emission rates have significant correlation with soil moisture, soil temperature and SOC stock ($p<0.01$). No significant regression relationship was found between soil CO_2 emission and root density. These results suggested that soil erosion and deposition processes induced by the change of topographic slope are the main factors controlling the spatial variation of soil CO_2 emission rate on the Loess plateau ecological forest slopes. These factors should thus be taken into consideration in the quantitative evaluation of the effectiveness of soil carbon sequestration by the Grain to Green Project.

P 3.1.26

Organic matter, labile and humified carbon in *Pachiterric Histosol* affected by renaturalization

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The aim of this study was to determine organic matter, labile water extractable organic carbon (WEOC) and humified carbon of peat soil depending on changes in land-use. The *Pachiterric Histosol* (*HSs-ph*) was investigated in this research, and the 5 treatments of former different land-use in Radviliškis site, Lithuania (55°49'43.19" N, 23°28'36.34" E). Peat samples were taken from 0-10, 10-20 and 20-30 cm layers in 3 field replicates in 2012-2014. Chemical analyses were carried out at the Chemical Research Laboratory of LRCAF. The differences of organic carbon pools in investigated soil remained still between treatments of differently used peat soil during the renaturalization after 12 years since the end of field experiment. The highest content (434.8 g kg^{-1}) of SOC was accumulated in former perennial grasses field fertilized with commercial NPK, which shows that the most favourable processes for carbon stabilization and conservation are taking place there, and the lowest content of SOC, compared with other treatments, was found in un-used peat (407.8 g kg^{-1}). The lowest share of labile organic carbon in SOC was determined in the treatment of former perennial grasses applied with NPK fertilizers - 0.22%. The content of mobile humified carbon ranged from 72.2-87.0 g kg^{-1} in the investigated treatments. The high accumulation of SOC in the 0-30 cm soil layer in the former perennial grasses fertilized with NPK treatment, small relative content of labile organic carbon and high relative content of mobile humified carbon in SOC demonstrates the higher stability of SOC existing during the renaturalization, compared to other land-uses. We concluded that the most efficient way to maintain, conserve and sustain organic carbon in *Histosol* is to grow perennial grasses under non-intensive management.

P 3.1.27

The influence of a diverse leaf litter cover and soil fauna on carbon fluxes during interrill erosion in subtropical forests

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Soil erosion is crucial for the degradation of carbon (C) pools in the soil. If C contents in the eroded sediment and runoff are not only related to soil pools but also resulting from decomposition of litter cover, the system gets more complex. The role of these amounts for C cycling during interrill erosion processes in subtropical forest ecosystems has not been in focus of research so far.

We established 96 runoff plots that were deployed with seven domestic leaf litter species. Runoff plots were covered with 1-species, 2-species and 4-species mixtures as well as with a bare ground feature. Every second runoff plot was equipped with a fauna exclusion feature to investigate the role of soil meso- and macrofauna on C cycling. Erosion processes were initiated by a rainfall simulator. Sediment discharge and runoff volume were measured for 20 minutes of rainfall duration. Two time steps were carried out (summer and autumn 2012) to investigate the role of leaf litter decomposition on soil erosion. Total C amounts as well as C contents were quantified in the solid sediment. Leaf decomposition rates were calculated based on leaf mass and leaf litter coverage was measured. In addition, C contents of corresponding soils were measured.

Total amounts of carbon losses during the 20 min rainfall simulations were 99.13 ± 94.98 g m^{-2}. Total C amounts and C contents both were affected by soil fauna. Total C amounts were higher with presence of soil fauna, while C contents were higher with an absent soil fauna. Leaf litter diversity did not affect total C amounts, but it positively affected C contents if soil fauna was absent. Total C amounts were negatively affected while C contents were unaffected by litter cover. A strong correlation was found between initial C contents in the soil and the eroded sediment.

Soil meso- and macrofauna contributed to litter decomposition only marginally. Thus, we assume that the increase of total C in the eroded soils resulted from slackening, processing and loosening of the top soil by those organisms, and not due to a faster decomposition of litter cover resulting in higher sediment discharge. It is likely that the top soil C content was enriched by undisturbed litter decomposition in those plots where soil fauna was not present thus explaining the difference between eroded sediment from plots with and without soil meso-and macrofauna. Higher C contents in eroded sediment from more diverse leaf litter mixtures could be due to a faster decomposition by microorganisms resulting in an enrichment of C from leaves in the top soils. Nevertheless, further analyses are needed to clarify the influence of soil fauna and leaf litter diversity on C dynamics.

P 3.1.28

Pasture degradation modifies soil organic matter properties, PLFA profiles and enzyme activities of Tibetan grassland ecosystems

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Introduction

Kobresia pygmaea pastures of the Tibetan Plateau represent the world's largest alpine ecosystem. However, undisturbed root mats are affected by freezing and thawing processes, which cause initial ice cracks. As a consequence decomposition of root mat layers will be accelerated and current sedentarization programs with concomitant increased grazing intensity may additionally enhance root mat degradation. Finally, cracks are enlarged by water and wind erosion as well as pika activities until bare soil surface areas without root mat horizons occur.

Objective

The aim of this study was to understand the impact of the *Kobresia* root mat layer on soil organic carbon stabilization and microbial functioning depending on soil depths and to predict future changes (OC, N and nutrient losses, soil microbial functioning in SOM transformation) by overgrazing and climate change.

Methods

We investigated the mineral soil below *Kobresia* root mats along a false time degradation sequence ranging from intact root mat (stage 1) to mats with large cracks and bare soil patches (stage 4). Vertical gradients of $\delta^{13}C$ values, neutral sugar, lignin, cutin and suberin contents as well as microbial biomass estimated by total phospholipid fatty acid (PLFA), microbial community composition (PLFA profiles) and activities of six extracellular enzymes involved in the C, N, and P cycle were assessed.

Results

Soil OC and N contents as well as C/N ratios indicate an increasing translocation of topsoil material into the subsoil with advancing root mat degradation but also and enrichment of more complex SOC compounds as for example lignin. This was confirmed by more negative $\delta^{13}C$ values as well as significantly ($p \leq 0.05$) increasing contributions of cutin derived hydroxy fatty acids and lignin phenols to OC in the subsoils with increasing degradation stages. PLFA profiles were surprisingly similar in the subsoils of degradation stages 1, 2 and 3 although OC contents and composition in the subsoil changed progressively from stage 1 to 4. Only the PLFA profiles of stage 4 differed from those of the other subsoils, suggesting that microbial communities were mainly controlled by other factors than C and N contents and SOM composition. These findings were also confirmed by the activities of β-glucosidase, xylanase, amino-peptidases and proteases. Those enzyme activities were highest in the subsoil of degradation stage 4, whereas degradation stages 2 and 3 showed low enzyme activities in the subsoil if related to soil OC amount and composition.

Conclusions

We conclude that pasture degradation decreases not only mechanical protection of soil surface by Kobresia root mats, but also changes their biochemical and microbial functions.

Fig. 1. Contribution of lignin phenols to soil organic matter with increasing *Kobresia* root mat degradation.

Fig. 2. β-Glucosidase (left) and phenol oxidase (right) activities of *Kobresia pygmaea* patches with different degradation status.

Figure 1

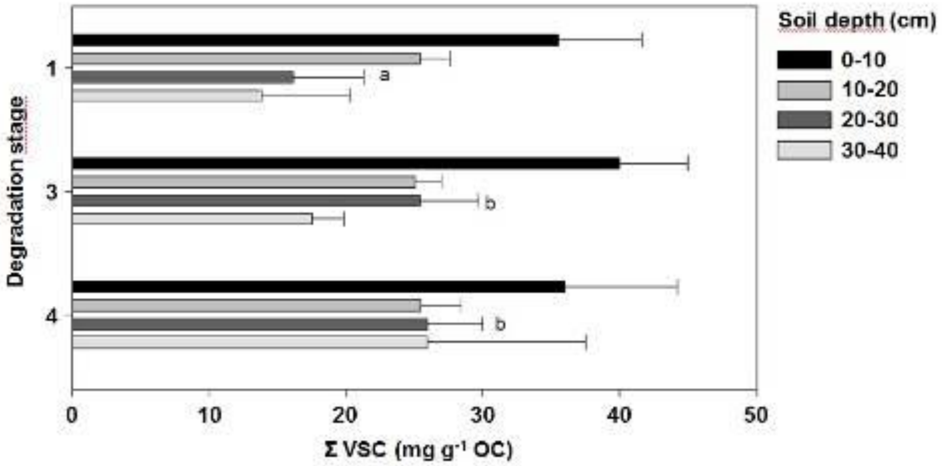
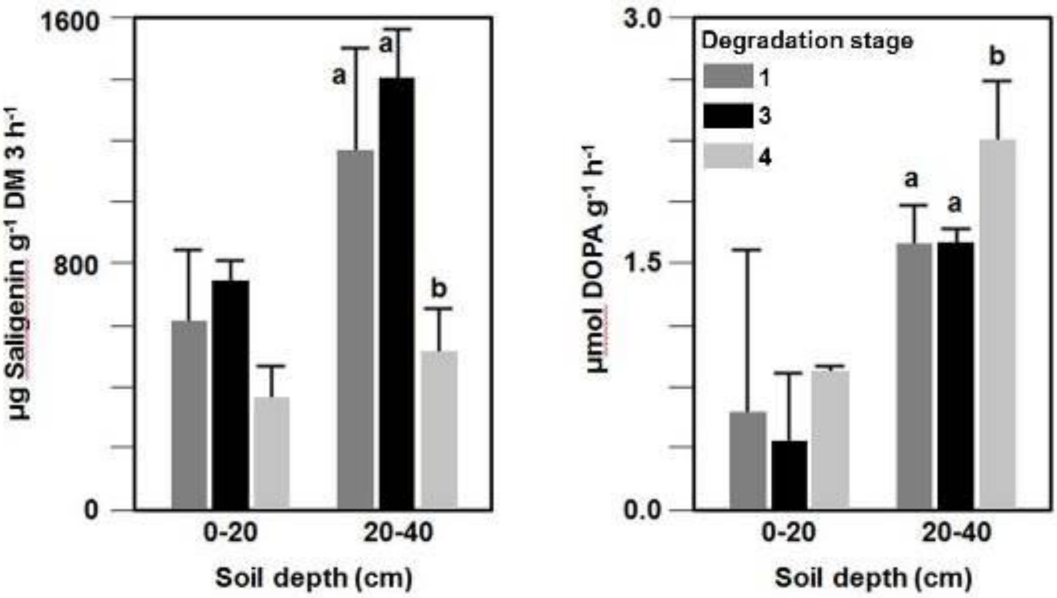


Figure 2



P 3.1.29

Accomplished field sampling for refining soil organic carbon stock and stock change estimations for Irish forested mineral soil

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1. Introduction

A need for additional sampling of Irish forested mineral soil was recognised within the CForRep project, which aims to improve the estimates of C stocks, stock changes and emissions for Irish forests [1]. Additional sampling of mineral soil, first rotation, afforested sites, aged ≥ 20 years, and selected from the Ireland's National Forest Inventory (NFI) database, was performed during *c*. December 2013 - March 2015.

2. Objectives

Soil sampling presented here intends to contribute to refinements of soil organic carbon (SOC) stock and stock change estimations for Irish forested mineral soils [1, 2]. The goal was to sample 60 sites across the Republic of Ireland. Data from sampled sites are planned to be used together with the climatic, geographic and previous land use data for geostatistical SOC modelling under the CForRep project.

3. Materials & methods

Stratified sampling for 60 sites was developed for eight mineral soil types (Fig. 1; Gleys were initially excluded). This was done by using a statistical Neyman allocation [3] on screened NFI data [4] (step 1 and step 2, Fig. 1a), and by including the sampling recommendations from the geostatistical SOC model analysis [5, 6] (step 3, Fig. 1a). The soil types presented in Fig. 1b are based on Irish soil classification [7], with accompanying international classification [8]. Conditions observed at the field (step 4, Fig. 1a) had to be taken into account during the sampling as well. The six soil types presented in bold (Fig. 1b) were of a high-priority status for the sampling (according to the model-based sampling recommendations [5, 6]). Further details in regard to sampling of Gleys, Peaty Podzols and Rendzinas are given in Fig. 1b.

4. Results

Fig. 1b shows the allocated number of sites per soil type initially aimed for sampling. Changes/differences in land conditions observed at the field had an additional effect on the sampling (Fig. 1b), and as a result 55 sites (excluding Gleys and Rendzinas) were sampled out of 75 still remaining sites. After re-introducing Gleys back into the sampling (due to lack of other available sites) the final number of all sampled sites achieved in this study was 61 (Fig. 1b). Sampling covered 94 % of the all remaining selected soil types with a high-priority sampling status (presented in bold, Fig. 1b) from the screened NFI database.

5. Conclusion

73 % of all remaining selected Irish forest mineral soil sites (excluding Gleys and Rendzinas) were sampled from the screened NFI database (first rotation, afforested sites, aged ≥ 20 years). It is expected that the accomplished field sampling, which covered 94 % of soil types with a high sampling priority status in this study, will provide sufficient data for SOC modelling needs under the CForRep project.

Fig. 1 Schematic presentation of the main steps for allocating the number of sites per soil type aimed for sampling (a) and the number of actually sampled sites (b)

Acknowledgements

The CforRep project is funded by the Irish Department of Agriculture, Food and the Marine under the CoFoRD programme. The work used data from the Ireland's National Forest Inventory Database 2012. Thanks go to Gero Jahns and Martijn Leenheer for their support during the parts of field sampling.

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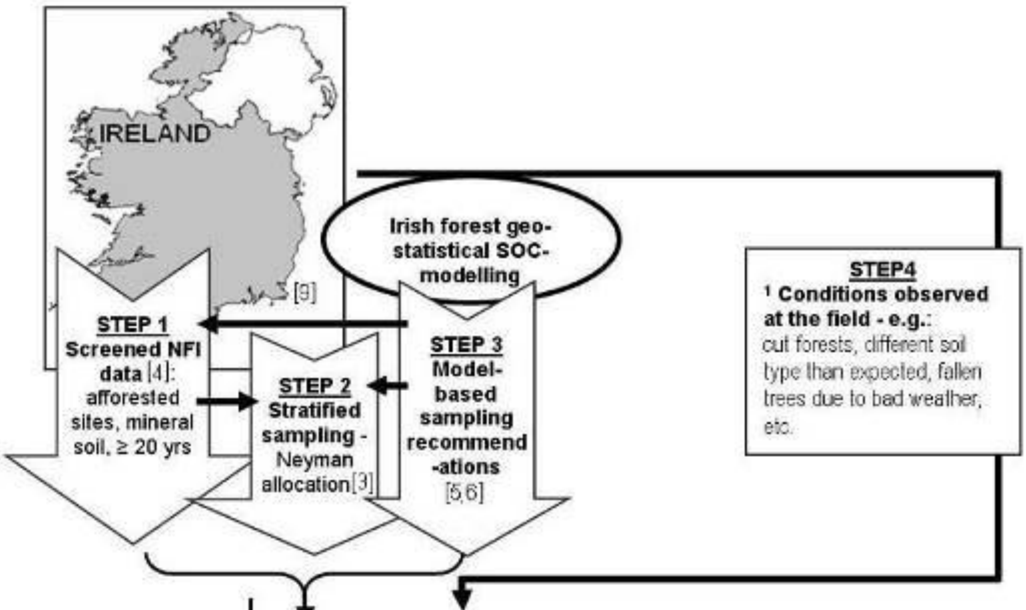
Figure 1

a



b

World Reference Base (WRB) for Soil Resources classification [8]	SOIL TYPE (STRATUM) [a] [7]	Sites from the screened NFI database: Initially aimed for sampling	Remaining sites (still available for sampling) [b, d]	Sampled sites [b, c]	% sampled per each stratum out of still available sites
Podzol	P	9	8	7	88 %
	PP	11	27 [c, d]	10 [b, c] sampling stopped	37 % [b, c] sampling stopped
	BP	8	4	4	100 %
Luvisol	Lu	6	3	3	100 %
Cambisol	CBE	7	6	6	100 %
	ABE	10	18	16	89 %
Dystri-lithic Leptosol	Li	9	9	9	100 %
Rendzic Leptosol	R [e]	NA [e]	NA [e]	NA [e]	NA [e]
Gleysol	G [f] initially excluded	initially [f] excluded	initially [f] excluded	6 [f] additionally sampled	NA [f] additionally sampled
	TOTAL	60	75	55 excluding G 61 including G	73 % excluding G, R 94 % excluding PP, G, R

Abbreviations:
P ... Podzol; PP ... Peaty Podzol (podzol that has a top peat layer); Lu ... Luvisol; BP ... Brown Podzolic; CBE ... Calcareous Brown Earth; ABE ... Acid Brown Earth; Li ... Lithosol; R ... Rendzina; G ... Gley.

[a] Soil-type classification may undergo further changes. [b] Due to conditions at the field there were not enough available sites for sampling of some soil types. [c] PP sampling stopped after 10 sites have been sampled (based on the modeling recommendations received during the later stage of the sampling phase). [d] Not all of the recorded PP sites have been checked because the sampling stopped after 10 sampled sites. [e] NA - not applicable: R were initially planned to be sampled only if there would be enough resources because only four sites were in the screened NFI database. [f] NA - not applicable: G were initially excluded from sampling, but were later re-introduced in sampling due to lack of other available sites. They were additionally sampled at the end of the sampling phase in order to fulfil the sampling requirements of minimum 60 sampled sites.

P 3.1.30

Dynamics of SOM influenced by site and tree species in short rotation coppices

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1. Introduction

Contradictory results about the impact of short rotation coppices on C-sequestration have been observed. Differing results are due to different land use and management before the SRC was established, in addition soil type and climate also play a role. Other factors, influencing C-dynamics, like stand age, rotation type and tree species have rarely been investigated. Poplar and willows, both frequently planted trees in SRC, differ in growth rates of wood and aboveground litter production as well as litter quality, thereby influencing the turnover of organic matter. Interactions of site and tree species on SOM dynamics are probable, because poplar and willow have different habitat requirements. Nevertheless, studies on interactions have never been tested for SRC´s with similar stand age, rotation type and density of trees. Franzluebbers (2002) hypothesized that the degree of stratification of soil organic C and N pools with soil depth, expressed as a ratio, indicates soil quality, because surface organic matter is essential to erosion control, water infiltration, and conservation of nutrients. Therefore, it is hypothesized that the stratification ratio of soil organic C and N pools indicates changes in SOM quality of soils under SRC which were formerly under arable landuse.

2. Objectives

The objectives were to (1) investigate interactions of tree species and site on amount and quality of aboveground litter fall as well as on dynamics of SOM, (2) evaluate if the amount of litter and the quality have an effect on SOM dynamics (3) test if the stratification of soil organic C and N pools detects changes in soil quality 7 years after establishment of short rotation coppices.

3. Materials & methods

In 2008, field experiments with SRC short rotation coppices were established at sites in Germany. Poplar and willow clones planted at a density of 11000 trees ha^{-1} in 4 replicate plots of a randomized block design. Wood biomass is harvested every third year. At 4 sites, the amount of aboveground litter and the CN ratio was determined in the 2. and 3. year of the second rotation and the 1. year of the third rotation. Seven years after establishing the field experiments, soil under poplar and willow clone was sampled in 0-5 and 0-30 cm depths. Soil analyzed for C and N, microbial biomass C and N, basal respiration, and potential N-mineralization.

4. Results

The C input to soils with litter fall is 1.3 and 0.8 t C ha^{-1} in the mean of three years for poplar and willow, respectively. But it varies within the rotation cycle. Maximum C-input of 1.8 and 1.1 t C ha^{-1} is observed in the third year of a short rotation cycle of poplar and willow respectively. Minimum rates of 0.6 t C ha^{-1} litter fall observed the first year after harvest, for willow and poplar clones. Despite the fact that the same clones are planted on the sites, the CN ratio of the litter fall is tree species and site specific. In the second and third year of the rotation the CN ratio ranges from 40 to 66 for the poplar clone and from 38 to 52 for the willow clone. A negative relationship between CN ratio and litter fall indicates that the N return with litter is due to litter productivity as well as N concentration. Nevertheless, no relationship of N-input of litter and potential N-mineralization is observed. Microbial biomass and basal respiration differed between the soils of the sites but no difference of tree species is observed. Furthermore, seven years after tree planting, sites with high N return are characterized by low as well as high microbial biomass N and C. Stratification of soil organic C and N pools show an accumulation of labile C and N at the upper soil layer at all sites, but stratification ration neither correspond to litter input nor to CN ratio of the litter.

5. Conclusion

Interaction of tree species and site on amount and quality of aboveground litter mass is observed in the second and third year of the second rotation of SRC. But no interaction of tree species and site is detected on dynamics of SOM. Litter mass and quality have no effect on SOM dynamics, because litter decomposition is high in young SRC at former arable sites. The small amount of aboveground litter potentially entering the soil has minor effect on the soil C pool. Therefore, the evaluation of the impact of belowground C-input on SRC is warranted. Seven years after establishment of SRCs changes of soil quality are detected by applying the stratification ratio of soil organic C and N pools. The stratification ratio is high at sites with a low concentration of SOM, but it remains unclear whether this observation is caused by a lower litter decomposition and bioturbation or a lower C-saturation of these soils.

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P 3.1.31

Nitrogen mineralization capacity in surface horizons of maize soils afforested with different tree species

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Introduction

Afforestation of agricultural land involves the substitution of crop species by forest species and the periodic input to the soil of fresh organic matter in the form of leaves from trees and the understorey. It also involves a change in land management, including the cessation of ploughing, liming and fertilization. In Galicia (NW Spain), intense afforestation of agricultural land, which previously received large inputs of nitrogenous fertilizer, has been carried out in recent years. The discontinuation of N inputs will obviously have an important influence on the N dynamics in the afforested soils. Nonetheless, although large areas of land have been transformed with a large variety of species, very little is known about the effects on the soil N dynamics in afforested soils.

Objectives

We investigated modifications in the N mineralization capacity of soils in different areas throughout Galicia that have been afforested with different tree species; we also explored whether the alterations are related to the type of tree species used (deciduous or evergreen).

Materials and methods

The soil nitrogen mineralization capacity (Leirós et al., 2000) was determined in the upper 10 cm of soils from 29 sites afforested (AF) with deciduous species (D) and 8 sites afforested with evergreen species (E). In each case, samples of a maize cropped soil (AG) located close to the afforested soil were also collected and analysed. The soil samples (< 4 mm) were incubated in the dark for 10 days at 25 ºC and at optimal moisture content (water retained at 10 kPa). The total inorganic nitrogen (Nit), ammonium (NH_4^+-N) and nitrate (NO_3^--N) contents were extracted before and after incubation with 2 M KCl, and the N content of the extracts was determined according to Bremner and Kenney (1965). The main physical and chemical properties of the soils were determined according to Guitián and Carballas (1976).

Results

Afforestation led to an increase in the organic matter content of the soils, which was greater in the plots of deciduous trees than in plots of evergreen trees, and to decreased soil density and pH, the latter of which was greater under evergreen trees than under deciduous trees (Table 1).

The mean values of the different initial N forms increased (non significantly) in all afforested soils (Table 2); the increase was smaller in the soil under evergreen trees than in the soil under deciduous trees, especially in relation to ammoniacal N.

The organic N mineralization capacity was higher in the afforested soils than in the cropped soils. In the plots afforested with evergreen species, the rate of ammonification was higher and the rate of nitrification was lower than in the corresponding cropped soils. However, in the plots afforested with deciduous species, both ammonification and nitrification rates were higher than in cropped soils, and the difference was greater for nitrification than for ammonification.

Conclusions

The change in land use has not affected the availability of inorganic N in the soil.

The discontinuation of inorganic fertilization stimulates N mineralization mechanisms in the soil.

The type of tree species used in the afforestation clearly affects the organic N mineralization capacity. The presence of acidifying forest species, such as evergreen trees, stimulates ammonification. The presence of deciduous trees particularly increased nitrification, probably because growth of nitrifying bacteria was favoured.

Acknowledgements: This research was financially supported by the Spanish MICINN (CGL2008-01992/BTE) and by MINECO (CTM2011-25664), both co-financed with FEDER founds from the EU.

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Legends:

Table 1. Mean values ± standard deviation (sd) of the main properties of agricultural and afforested soils. Mean values followed by the same letter are not significantly different.

Table 2. Mean values ± standard deviation (sd) of initial and mineralized N contents [total inorganic N (Nit), ammonium (NH_4^+-N) and nitrate (NO_3^--N)] in agricultural and afforested soils. Mean values followed by the same letter are not significantly different.

Figure 1

	Initial N			Mineralized N		
	Nit±sd	NH_4^+-N±sd	NO_3^--N±sd	Nit±sd	NH_4^+-N±sd	NO_3^--N±sd
AG-D	8.46±2.92a	2.54 ± 1.33a	5.93 ±3.02a	13.30 ± 6.90a	0.05 ± 3.63a	13.23 ± 7.12a
AF-D	8.80±6.58a	2.69 ± 2.11a	6.13 ± 5.40a	17.56 ± 13.51a	1.08 ± 4.50a	16.48 ± 11.23a
AG-E	10.75±4.85a	2.85 ± 2.25a	7.90 ± 3.50a	21.21 ± 8.49a	4.83 ± 6.42a	16.39 ± 6.55a
AF-E	11.46±8.87a	3.33 ± 2.81a	8.14 ± 6.63a	22.53 ± 13.21a	7.57 ± 8.34a	14.96 ± 14.90a

Figure 2

	Initial N			Mineralized N		
	Nit±sd	NH_4^+-N±sd	NO_3^--N±sd	Nit±sd	NH_4^+-N±sd	NO_3^--N±sd
AG-D	8.46±2.92a	2.54 ± 1.33a	5.93 ±3.02a	13.30 ± 6.90a	0.05 ± 3.63a	13.23 ± 7.12a
AF-D	8.80±6.58a	2.69 ± 2.11a	6.13 ± 5.40a	17.56 ± 13.51a	1.08 ± 4.50a	16.48 ± 11.23a
AG-E	10.75±4.85a	2.85 ± 2.25a	7.90 ± 3.50a	21.21 ± 8.49a	4.83 ± 6.42a	16.39 ± 6.55a
AF-E	11.46±8.87a	3.33 ± 2.81a	8.14 ± 6.63a	22.53 ± 13.21a	7.57 ± 8.34a	14.96 ± 14.90a

P 3.1.32

Influence of type of tree on the quality and quantity of water soluble SOM in afforested maize soils

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Introduction

Afforestation signifies a change in the input of organic material to the soil, and the practice is therefore expected to modify the characteristics of the soil organic matter (SOM). This particularly affects highly labile fractions with a high turnover rate, which include fractions that are soluble in both hot and cold water and that provide a good estimation of the amount of labile C in soils.

Objectives

The aims were to determine, both quantitatively and qualitatively, the modifications in some labile fractions of the SOM of afforested soils in relation to both the original agricultural soil and the type of forest species (deciduous or evergreen) used.

Materials and methods

Surface soil samples (0-10 cm depth) were obtained from 37 soils afforested 4-12 years previously with either deciduous species (AF-D; 29 sites) or evergreen species (AF-E; 8 sites). Paired control agricultural soils were also sampled (AG). Total carbon (Ct), carbohydrates (CH-C) and polyphenols (PP-C) soluble in cold water (1 h at room temperature) and in hot water (24 h at 80 ºC) were determined following the methods described by Ceccanti et al. (1993).

Results

In general, and independently of the type of extraction, higher amounts of total C, carbohydrate-C and polyphenol-C were extracted from the afforested than from the agricultural soils (Table 1). For extraction at 80 °C, the PP-C/CH-C ratio was always lower in the afforested soils than in the agricultural soils (Fig. 1). For extraction in cold water, in the soils afforested with deciduous trees the ratio was lower than in the agricultural soils, while in soils afforested with evergreen trees the ratio was higher than in agricultural soils.

Conclusions

Afforestation increases the amount of water-soluble organic matter in the soils.

Afforestation and the type of forest species used alter the composition of the aqueous soil extracts.

Afforestation always leads to carbohydrate enrichment; the presence of evergreen species increases the percentage of polyphenols, and the presence of deciduous species decreases this percentage.

Acknowledgements: This research was financially supported by the Spanish MICINN (CGL2008-01992/BTE) and by MINECO (CTM2011-25664), both co-financed with FEDER founds from the EU.

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Legends.

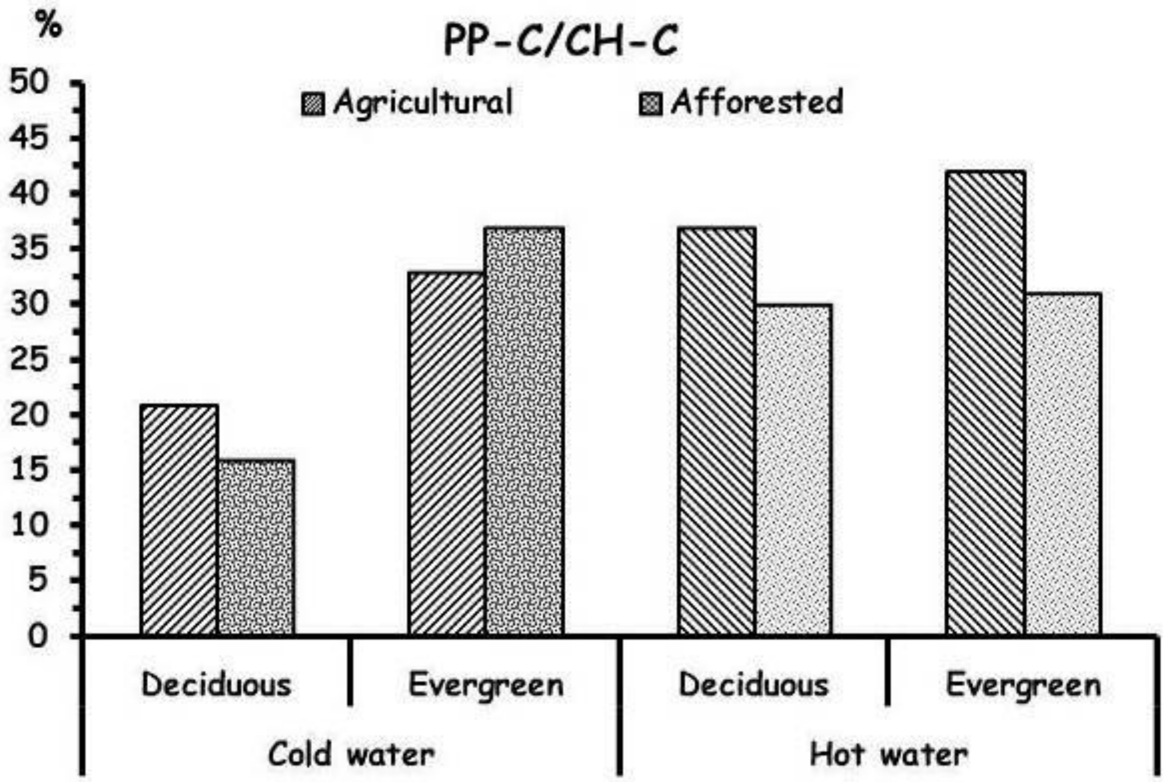
Table 1. Mean values ± standard deviation (sd) of total carbon (Ct), carbohydrates (CH-C) and polyphenols (PP-C) soluble in hot water and in cold water, for all soils considered.

Fig. 1. Values of the ratio between hot and cold water soluble polyphenols and carbohydrate (C-PP/C-CH*100) in the agricultural soils and soils afforested with deciduous and evergreen species.

Figure 1

	Ct ± sd	CH-C ± sd	PP-C ± sd
COLD WATER			
AG-D	180 ± 59 a	57 ± 27 a	12 ± 7 a
AF-D	223 ± 96 a	73 ± 46 a	12 ± 12 a
AG-E	180 ± 38 a	48 ± 16 a	16 ± 10 a
AF-E	198 ± 115 a	62 ± 28 a	23 ± 19 a
HOT WATER			
AG-D	977 ± 339 a	207 ± 96 a	77 ± 36 a
AF-D	1096 ± 478 a	247 ± 131 a	74 ± 37 a
AG-E	977 ± 198 a	184 ± 48 a	77 ± 33 a
AF-E	964 ± 126 a	218 ± 31 a	67 ± 25 a

Figure 2



P 3.1.33

Influence of organic matter content of the previous agricultural soil on the enzymatic activity in afforested soils

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1. Introduction

Afforestation involving conversion of agricultural land into forest land has been common practice in Galicia (NW Spain) since 1992. The aim of the practice was to enhance carbon sequestration in soils. However, this land use change has probably modified the organic matter content and biochemical activity of the soil, which would obviously lead to an increase in metabolic soil processes. This may have had a negative feedback effect on soil carbon sequestration, thus reducing the proposed effectiveness of the practice.

2. Objectives

The aim of the present study was to evaluate the alterations in the activity of diverse enzymes as a result of afforestation and the extent to which these modifications are related to the characteristics of the original cropped soil.

3. Materials & methods

The upper 10 cm of 35 pairs of soils were analyzed. Each pair included a soil that had been afforested 4-12 years before sampling and an adjacent agricultural soil representing pre-afforestation conditions. The activities of diverse hydrolases involved in C, N, P and S cycles and of diverse oxidoreductase enzymes were analyzed according to García et al. (2003). General properties (pH, total C and N contents, texture, density, etc.) were determined according to Guitián and Carballas (1976).

4. Results

Afforestation tended to increase the soil organic matter content, although the increase was not statistically significant (Table 1). The activity of the different enzymes was very variable, but was generally higher in the afforested soils than in the agricultural soils.

Given the variability in the results, we decided to establish whether the effect of afforestation on the enzyme activities is related to the OM content of the original agricultural soils. For this purpose, the agricultural soils were grouped according to OM content (2-3%, 3-4%, > 4%) and the mean variations in the different enzyme activities in the afforested soils were calculated relative to each of these groups.

Analysis of the changes in enzyme activity in relation to the OM content of the original agricultural soil revealed that afforestation of soils with a low OM content (<3%) generally led to increased enzyme activity. However, afforestation of soils with a higher OM content (> 4%) led to scarce or no modifications and in some cases the enzyme activity even decreased (Fig. 1).

5. Conclusions

The OM content of the initial agricultural soils has a huge influence on enzyme activity in afforested soils.

In agricultural soils containing low amounts of C, carbon sequestration may be nullified by the increase in the soil biochemical activity generated by afforestation.

By contrast, in agricultural soils containing more than 4% C, afforestation has a positive feedback effect on carbon sequestration via the decreased soil biochemical activity. ***Acknowledgements:*** This research was financially supported by the Spanish MICINN (CGL2008-01992/BTE) and by MINECO (CTM2011-25664), both co-financed with FEDER founds from the EU.

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Legends

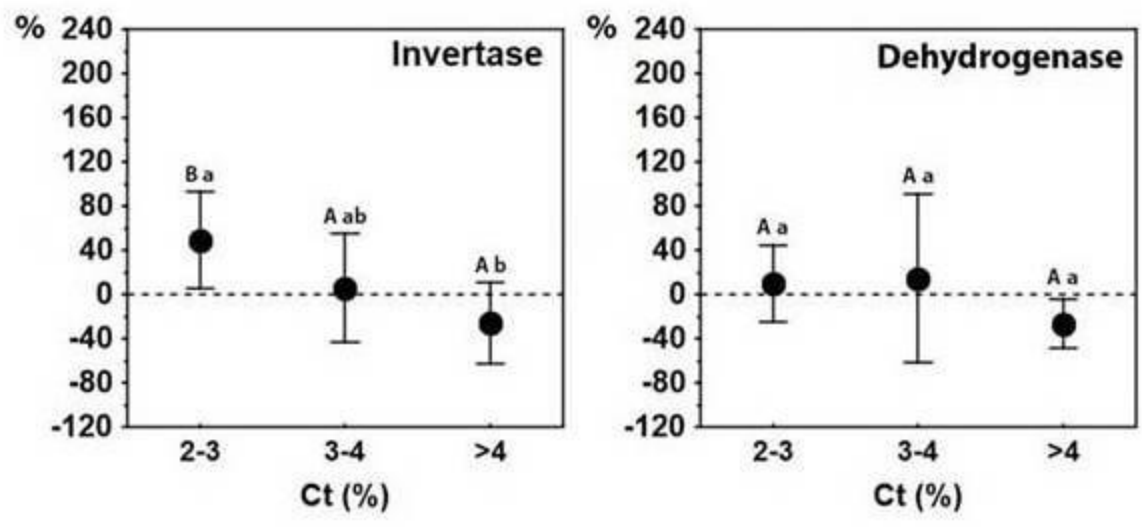
Table 1. Range of variation and mean values+standard deviation (sd) of the general properties of agricultural and afforested soils. For each property, different letters indicate significant differences (p≤0.05) between the mean values for agricultural and afforested soils

Fig. 1. Mean percentage variations (and standard deviations) in the invertase and dehydrogenase activities in afforested soils in relation to the total carbon content (Ct) of the original agricultural soils. Different uppercase letters indicate significant differences between the values of each set of afforested soils and their corresponding original agricultural soils (*p*≤ 0.05). Lowercase letters indicate significant differences between the different variations observed for each of the sets of afforested soils among themselves (*p*≤ 0.05).

Figure 1

	Agricultural soils			Afforested soils		
	Mean±sd	Minimum	Maximum	Mean±sd	Minimum	Maximum
Total C (%)	3.48±1.37a	1.99	6.99	3.8±1.8a	1.8	7.15
Total N (%)	0.29±0.10a	0.16	0.49	0.31±0.09a	0.14	0.5
pH H_2O	5.33±0.48a	4.53	6.42	5.09±0.41b	4.23	5.71
pH KCl	4.22±0.38a	3.34	5.24	4.10±0.29a	3.48	4.63
Bulk density (g cm^{-3})	1.00±0.19a	0.63	1.33	0.89±0.20b	0.54	1.47
Pi* (mg kg^{-1})	71±55a	6	248	62±55a	5	224
Sand (%)	60±13a	34	78	62±11a	28	76
Clay (%)	12±4a	6	19	11±3a	7	21

Figure 2



P 3.1.34

Soil organic matter sequestration under poplar and willow agroforestry systems

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Agroforest (AF) and short rotation coppices (SRC) are two techniques to bring forest vegetation into agricultural practice. To evaluate the effect of AF and SRC on carbon (C) and nitrogen (N) sequestrations and changing of soil organic matter (SOM) quality the experimental agroforest sites, established in 2011 on agriculturally used soils, have been chosen. Poplar and willow form the pure SRC plots and willow forms willow-AF plot. Common agricultural field has been used as a control.

Soil samples have been collected from 0-3, 3-20, and 20-30 cm soil depths in 2014. Bulk soil samples were analyzed for: organic C and N, microbial biomass carbon (MBC); amount of labile C (incubation during two months with constant measuring of CO_2 efflux); aggregate structure. Additionally samples from 0-3 cm horizon were separated by density to obtain particulate organic matter (POM) and mineral fraction. Aggregate and density fractions have been analyzed for C and N.

Organic C and N contents increased compare to agricultural plot in the top 0-3 cm horizon and were maximum (18.2 g kg^{-1} soil and 1.8 g kg^{-1} soil) under willow SRC plot, following willow-AF (15.6 g kg^{-1} soil, 1.5 g kg^{-1} soil) and poplar SRC (13.7 g kg^{-1} soil, 1.3 g kg^{-1} soil). Changes were not visible in the deepest horizons.

The highest portions of soil C and N for forest stands were found in macroaggregates (>2000 µm), ranging from 70-80%. In contrast, in cropland soil maximum amount of C and N were accumulated in the small macroaggregates (250-2000 µm). There were no differences in C and N accumulation in free POM fraction between forest and cropland stands. The main parts of SOC (75%) and N (90%) were associated with mineral fractions of AF and SRCs plantation soils.

MBC varied between the plantations in the top soils with maximum under willow SRC (788.7 µg C g^{-1} soil) and minimum (266.4 µg C g^{-1} soil) under cropland. The highest amount of decomposed C (1.4 mg C g^{-1} soil) was observed for poplar SRC plot, whereas the lowest (0.6 mg C g^{-1} soil) for cropland plot in the upper horizon. Two times more CO_2 were emitted from the top 0-3 cm soil layer than from the lowest horizon for all plots, besides cropland.

Thus, afforestation in the first years mainly affects C accumulation in the topsoil. Early stage of trees development lead to C accumulation in stable fractions, whereas C associated with free POM even decreased in some case (poplar SRC). Differences in plant community chemistry and not C content seem to be the leading factor effecting on C mineralization in soil.

P 3.1.35

The evolution characters of the amount, fractions and chemical structures of soil organic carbon restored from parent material of a Mollisol under different agricultural practices

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A range of agricultural practices influence the quantity and quality of soil organic carbon (SOC), such as tillage and organic C inputs, however such effects are largely unknown at the initial stage of soil formation. Using an eight year field experiment established on exposed parent material (PM) of a Mollisol, our objectives were to: (1) determine the effects of field management and restoration time on the amount, physical and chemical fractions of SOC; (2) to elucidate the differences of SOC in relation to PM, compared to an arable Mollisol (MO) without organic C input. The treatments included two no-tilled soils supporting perennial plants (natural fallow and N-fixing alfalfa), and four tilled arable soils under maize and soybean rotation system, with or without mineral fertilization and organic C input. Over the 10 year of soil restoration, SOC content increased from 4.8 g kg^{-1} to 7.5-12.7 g kg^{-1} in the field treatments, with higher SOC in soils with larger amount of organic C input, but only accounted for 40% of the SOC in Mollisol (29.4 g kg^{-1}). The C sequestration efficiencies ranged from 0.27 to 0.85 g C kg^{-1} yr^{-1}, the higher values were observed in soils with higher amount of organic C input and alfalfa treatments. The amount of SOC in the occluded light fraction (oLF) increased significantly, indicating that oLF fraction was more sensitive than the free light fraction (fLF) and heavy fraction (HF) to detect changes in soil due to agricultural practices at the initial forming stage of soil. Heavy fraction (HF) accounted for the largest portion of total SOC (78-90%), which sequestrated most portion of SOC. In the chemical fraction of SOC, the proportion of fulvic acids (FA) was greater than that of humic acids (HA). The C contents ranged from 15 to 19%, and 21 to 42%, respectively. The C content in humin showed a positive relationship with cumulative C input, showing that C inputs were incorporated into stable SOC in a relatively short period of time compared to the supposed timescale of soil formation. In general, the parent material at this experimental site was low in fertility and “starved” for C. For this reason, we observed a dramatic short-term effect of C inputs, by which C was stabilized in the mineral matrix. The dynamics of C accumulation was followed by using three distinct indices of SOC properties, providing insight into the mechanisms by which SOC accumulates, leading to improvements in soil fertility.

P 3.1.36

Wood source and temperature interaction on PyOM structure and soil degradation rates

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Introduction. Surprisingly little is known about how shifts in tree species composition and increases in forest fire frequency and intensity will affect one of the most important and stable pool of soil organic matter, pyrogenic organic matter (PyOM or charcoal). This is in part because the role of the wood source in controlling PyOM formation is unclear, and because field experimental evidence of how wood source and pyrolysis temperature influence the turnover of PyOM *in situ* is scant.

Objectives. Herein, we address how wood source and pyrolysis temperature interact to control PyOM structure and turnover in soils.

Materials & methods. We used two co-occurring gymnosperm and angiosperm species at the boreal-temperate ecotones, i.e., highly $^{13}C/^{15}N$-enriched Jack pine (JP; *Pinus banksania*) and Red maple (RM; *Acer rubrum*), pyrolysed at temperatures regimes occurring in high-latitude wildfires, i.e., 200, 300, 450 and 600 °C. We characterized PyOM structure using high-resolution ^{13}C, ^{15}N and ^{1}H solid-state nuclear magnetic resonance, ^{13}C-labeled tetramethylammonium hydroxide thermochemolysis, thermal analyses, diffuse reflectance infra-red Fourier transform spectrometry, helium pycnometry and surface area. We investigated the *in situ* degradation rates, microbial uptake and vertical movements of JP wood, JP-derived PyOM formed at 300 °C, (JP300) and 450 °C (JP450) and RM-derived PyOM formed at 450 °C (RM450) in a high-latitude forest soil during the first three years after application (N=4).

Results. Our results show a strong wood source by temperature interaction on (1) PyOM structure and potential reactivity. While both species shared the same general pattern of PyOM formation, wood sources controlled the efficacy PyOM formation (mostly ≤450°C; Fig. 1), likely because of distinct anatomical designs. (2) PyOM field degradation rates (0-3y). Mineralization rates (Fig. 1) show that increasing pyrolysis temperature decrease PyOM mineralization rates, whereas wood source explain modest differences for PyOM produced at the same temperature. No priming effect was measured in PyOM treatments.

After 1 y *in situ*, PyOM-derived C and N recoveries in soils were unaffected by pyrolysis temperature or wood source; JP wood-derived C was ~35% lesser, and JP wood-derived N ~9% lesser than for PyOM materials. Vertical movements in the soil profile and losses as dissolved organic C were negligible. Collembola detritivores tended to be more abundant with JP wood and JP300 than with JP450 or RM450. Bacteria were large sinks for PyOM-derived C as pyrolysis temperature increased (Fig. 2). The estimated substrate use efficiency decreased with increasing pyrolysis temperature, with no effect of the wood source.

Conclusion. Wood source appears as an important, but yet underestimated, driver of PyOM structure and turnover. We further provide direct evidence for the greater mineralization of low-temperature PyOM compared with higher temperature and potentially more reactive PyOM. Taking into account this interaction will help providing more accurate large-scale assessments of PyOM stocks and reactivity potentials under current and future climate conditions

Figure 1. 150 MHz cross polarization magic-angle spinning (CPMAS) ^{13}C NMR spectra obtained with a spinning rate of 30 kHz from $^{13}C/^{15}N$-enriched JP (left) and RM (right) wood and PyOM formed from 200-600 °C.

Figure 2. Total (top) and wood or PyOM-derived (bottom) soil CO_2 efflux measured during the first 996 d *in situ* (N=4).

Figure 1

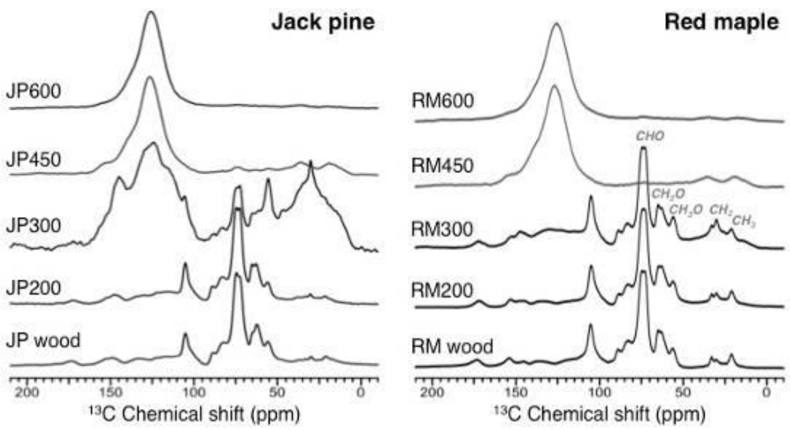
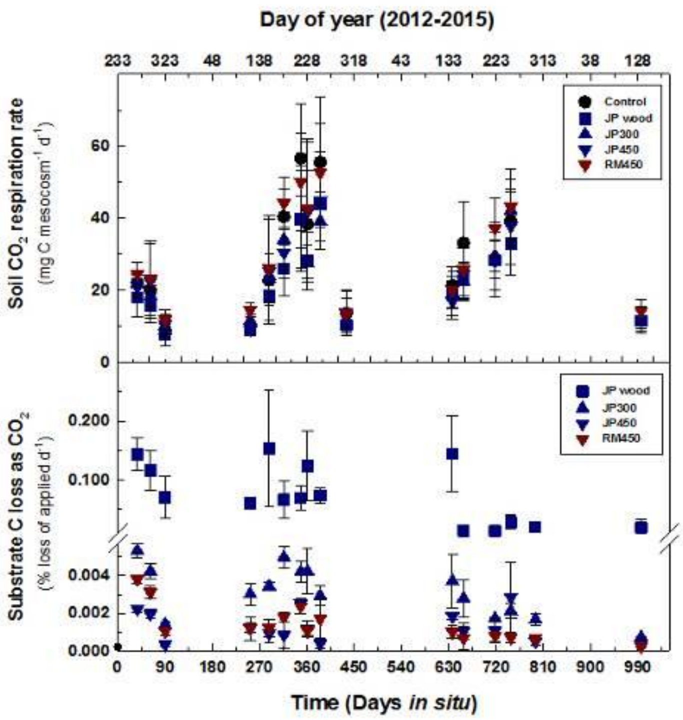


Figure 2



P 3.1.38

The response of soil organic carbon to freezing rain and snow disaster in artificial *Pinus elliottii* forest in the mid-subtropical area, China

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The freezing rain and snow storm happened in 2008 covered south Chinacaused serious damages to forest ecosystems. Jiangxiprovince, located in mid-subtropical China, is one of the places seriously damaged by the storm, among all the species, the *Pinus elliottii*, introduced from

the United States, was the worst ones. The objective of this study was to identify the responses of soil organic carbon to this storm event in the areas dominated by *Pinus elliottii*. In April 2012, we established vegetation plots according to damage severity (heavy, medium, and light) with three replications for a total of nine plots, and the plot size is 20×20 m in artificial *Pinus elliottii* forest which condition of site and stand were similar at Taihe county, Jiangxi province. We hypothesized that the soil organic carbons responds the storm severity accordingly. Namely, the heavier the storm attack, the more server the soil organic carbons would respond. We also hypothesized that the upper level of soil organic carbons responds quickly than the deeper ones. We sampled [Q1] top 30cm depth of soil within each plot (two layers were separated as 0-15cm and 15-30 cm) for estimations of total soil organic carbon (TOC), microbial biomass carbon (MBC) and soil dissolved organic carbon (DOC) to understand the response of soil organic carbons to the storm event. The results showed that: 1. TOC in the damaged plots were increased with time[Q2] . TOC was 11.29g.kg^{-1}in 2008, and 12.04 g.kg^{-1}in 2012.The storm significantly increased top soil layers TOC. For example, the TOC was 18.9 g.kg^{-1}, 16.6 g.kg^{-1} and 14.0 g.kg^{-1} for heavy, medium and light damage levels, respectively. Furthermore, the TOC in the heavy damage area was also significantly higher than that in the others.(Fig. 1) 2. MBC were 188.0 mg.kg^{-1}, 161.8 mg.kg^{-1} and 133.0 mg.kg^{-1} for areas with heavy, medium and light damage levels, respectively, with heavy damage level area significantly higher than the light damage level area(Fig.2). No significant differences were observed in C to N ratio among plots.(Fig.3) 3. Soil DOC showed similar trend as MBC, also heavy (129.2mg.kg^{-1})> medium (114.8 mg.kg^{-1})>light (94.1 mg.kg^{-1}) damage level areas and DOC in heavily damaged area was significantly higher than lightly damaged areas ($p<0.05$)((Fig.4). In conclusion, freezing rain and snow storm caused significant variations in soil TOC, MBC, and DOC, especially in the top soils (0-15cm), thus, it might have future implications on the forest ecosystem carbon balances. The potential causes might associate with altered soil environmental conditions coupled with increased woody and litter inputs.

Keywords: mid-subtropical area; artificial *Pinus elliottii* forest; freezing rain and snow disaster; soil organic carbon

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Figure 1

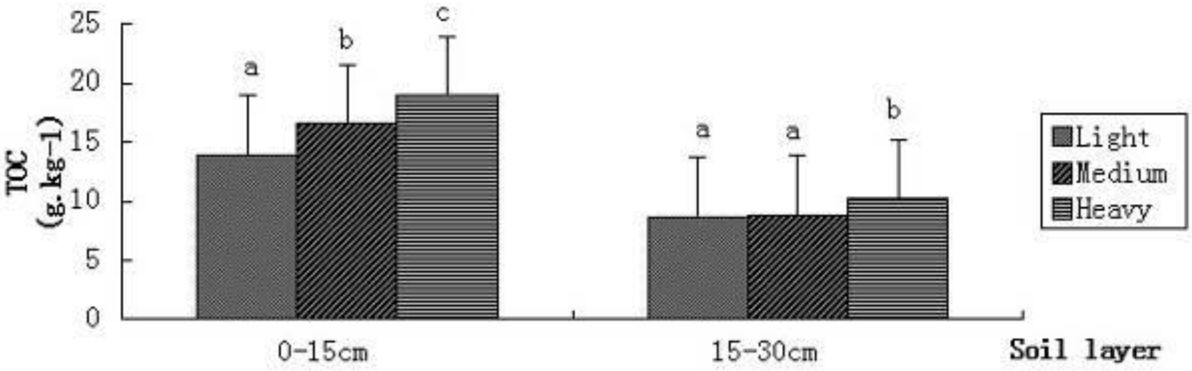
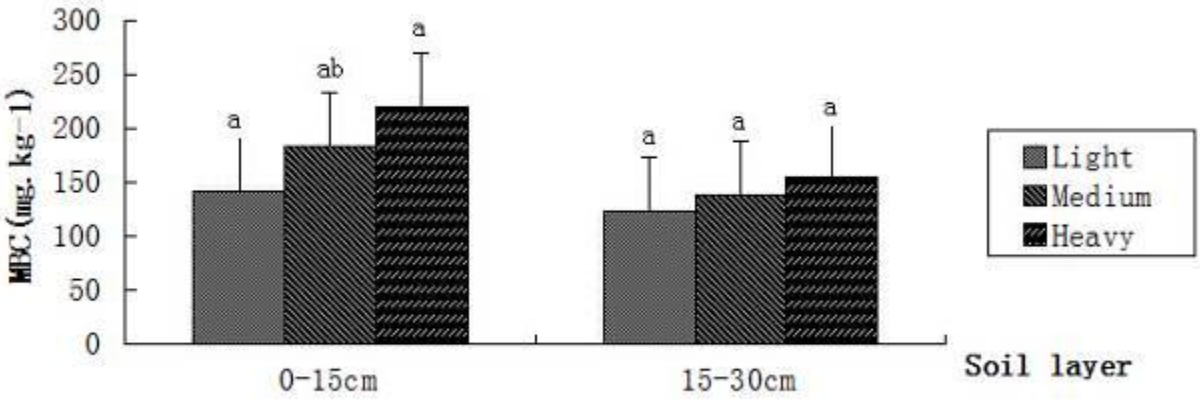


Figure 2



P 3.1.39

The role of microbial biodiversity in soil C stabilization

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Introduction: In macroecology, diversity-function relationships indicate that increases in species diversity result in increases in ecosystem productivity. Similarly, microbial culture studies have shown positive relationships between microbial biodiversity and function of the community, but these findings are not easily extended to the complexity of soil. A handful of studies have manipulated microbial diversity directly in soil and found variable impacts on the magnitude and direction of ecosystem function. However, many of these studies were performed before the advent of modern sequencing tools, and therefore likely grossly underestimated the microbial diversity in their treatments. In addition, no previous studies have addressed the effect of microbial diversity on C stabilization during litter decomposition, but rather have targeted functions such as respiration or denitrification.

Objectives: The objective of our experiment was to determine the role of microbial biodiversity on soil C cycling and stabilization.

Materials and methods: We designed an experiment to take advantage of a management-induced difference in soil microbial biodiversity between a remnant woodland and a perennial pasture system on the same soil type on the Fleurieu Peninsula, South Australia. In addition, we varied the diversity in soil microcosms by sterilization and inoculation with native microbial communities with varying levels of species richness (through a dilution series), and tracked the fate of the ^{13}C litter during decomposition into $^{13}CO_2$ production, ^{13}C dissolved organic carbon, and stable soil fractions. Biodiversity was explored using Ion Torrent next-generation sequencing of the 16S and ITS genes at specific time intervals.

Results and conclusions: Results are forthcoming. We expect that soils with higher microbial diversity will process C more efficiently, leading to greater amounts of mineral-stabilized organic matter than in lower diversity mesocosms.

P 3.1.40

Modelling Carbon Sequestration of *Eucalyptus grandis* Forest Plantations in the Intermediate Zone of Sri Lanka

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Introduction

With the concerns about enhanced greenhouse effect, the world has turned towards many approaches to reduce increased CO_2 concentrations in the atmosphere. One approach is the use of forest plantations in carbon sequestration process due to their potential to store carbon in long lived pools especially in the soils. However methods available for measuring sequestered carbon amount are tedious and time consuming, especially methods of measuring sequestered stable carbon stock. Nevertheless it has been found out that many parameters of the forest ecosystem control carbon sequestration process and multiple associations between these parameters could be used in formulation of models to predict soil carbon sequestration. In the present study an effort was made to develop a model for soil stable carbon stock in order to elucidate the control of carbon sequestration in *Eucalyptus grandis* forest plantations in the intermediate zone of Sri Lanka. The reason for focussing on stable carbon fraction is because it is the representative fraction for carbon sequestration characterization and these models would enhance the ability of assessing sequestered carbon quantity rapidly and effortlessly with minimum costs.

Objective

Formulation of model to predict stable carbon fraction in *E. grandis* forest plantations in intermediate zone of Sri Lanka.

Materials and Methods

We studied changes in soil stable carbon fraction , total organic carbon (TC), pH, silt, sand and clay percentages, litter dry mass, tree Dbh, tree height, crown width, basal area of trees in four *E. grandis* forest plantations along a chronosequence of age. We selected *E. grandis* forest plantations of four different age groups (4, 10, 19 and 27 years) belonging to same agro ecological zone (with virtually similar geological characteristics to minimize microclimatic influences i.e. slope) and demarcated six plots (20 m x 20 m) in each plantation. Systematic soil sampling was carried out resulting 72 composite soil samples and 24 litter samples from each site. Tree heights of 2/3 of all the trees (whose diameter at breast height was greater than 10 cm) in each plot were measured using a Suunto clinometer. Stem diameter of trees (whose heights were taken) were measured at breast height using a diameter tape. Tree crown widths were measured for the same trees by projecting the edges of the crown to the ground and measuring the length along one axis from edge to edge through the crown centre. The pooled data were analysed using Principal Factor Analysis (PFA), with varimax rotation. Several clusters were separated in the factor plot, which included factors influencing stable carbon fraction.

Results

Multiple regression analysis of the variables generated a model which significantly ($p < 0.01$) explained 98% in the variability of stable carbon stock with stand age and TC being the most significant predictor variables.

$$\text{Stable carbon} = -15.74 - 0.70AG + 1.77TC + 0.02AG^2 - 0.02TC^2$$

$R^2 = 0.98$

(AG and TC are stand age and total organic carbon respectively)

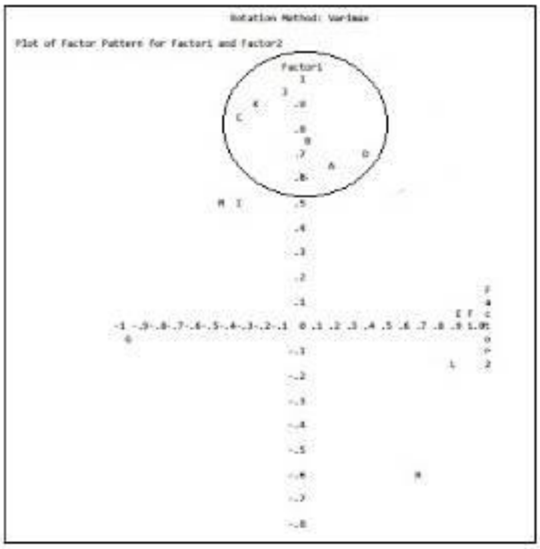
In the studied *E. grandis* forest plantations, stable carbon content in soil showed increasing trend with increasing stand age. Numerous studies, together with chronosequence, have undeniably advocated that carbon accumulates in the forest floor as the stand ages. Further it has been found that masses of aggregates in soil increase with stand development of forest plantations which ultimately results in increased stable carbon fraction. These aggregates reduce accessibility of soil enzymes and microbes to organic matter, lowering the carbon turnover rates, thus increasing stable carbon fraction.

In addition organic carbon content strongly correlates to aggregate stability thus influencing stable carbon stock in soil. Therefore soil aggregate development and aggregate stability which are strongly correlated to soil organic carbon content and stand age could be the reason for the above consequences.

Conclusion

Finally, we can conclude that carbon sequestration potential in *E. grandis* forest plantations is more sensitive to stand age and TC stock. Further our results suggests that stable carbon stock in soil increases with the stand age of the forest plantation. Moreover using the developed statistical model, we can straightforwardly predict stable carbon stock in soil of *E. grandis* forest plantations in intermediate zone of Sri Lanka with only stand age and TC stock.

Figure 1



A = Stable carbon, B = Total organic carbon, C = Stand age, D = Soil moisture content, E = Clay content, F = Silt content, G = Sand content, H = Soil pH, I = Litter dry mass, J = Mean Tree Dbh, K = Mean Tree crown width, L = Basal area, M = Mean Tree height

Figure 01: Factor plot variables responsible for stable carbon fraction of the *E. grandis* forest plantations. Highly correlated variables clustered on the plot are encircled with a dotted circle.

Figure 2

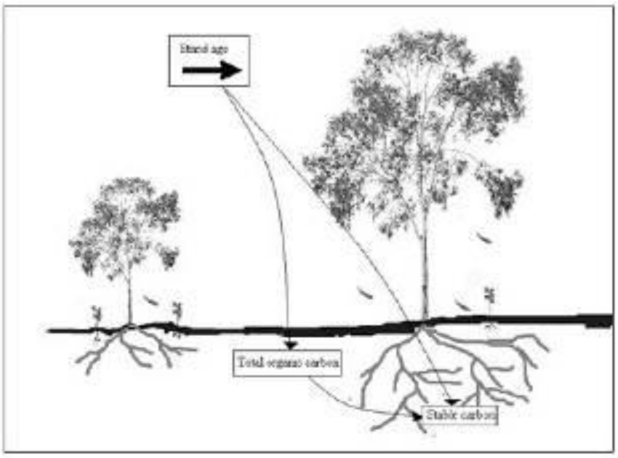


Figure 02: Diagrammatic representation of factors controlling stable carbon fraction in *E. grandis* forest plantations in intermediate zone of Sri Lanka.

P 3.1.41

Changes in Organic Matter Dynamics in the Transition from Dryland to Irrigation

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INTRODUCTION

In arid and semiarid regions, water is the most limiting factor for agricultural production. Irrigation is therein the most common and most fruitful strategy to achieve sustained and stable crop productions. In the last 50 years, the surface under irrigation has doubled, and this is expected to be the trend in the near future, under the scenario of global change and increasing food demand. Introducing irrigation in dryland cropland can have consequences in the dynamics of agroecosystems. Irrigation implies a significant change in the soil water balance, but also an intensification of fertilization and a change in soil management practices.

In relation to the organic fraction of soils, a net increment of C inputs from crop residues is the logical consequence of increased crop yields with irrigation. Higher biological activity and less limiting conditions for soil organic C (SOC) mineralization can also be expected. As a consequence, SOC stocks do not always increase in the same proportion than yields upon irrigation adoption. Few studies have however studied the effects of these changes in organic C dynamics.

OBJECTIVES

The objective of this work was to quantify the differences in the incorporation of crop residues and in the turnover of organic C between dryland and irrigated agriculture during the first four years after the conversion to irrigation in a dryland agricultural district in NE Spain.

Our hypothesis was that changes in the agrosystem induced by the introduction of irrigation should lead to (i) increased SOC stocks, and (ii) changes in the rates of C incorporation from crop residues and in the mineralization rates, resulting in different turnover rates of SOC.

MATERIALS & METHODS

An experimental field located in Enériz (Navarra, Spain. 42° 40' 18,74"N; 1° 45' 4,65"W), was especially designed including four treatments: non-irrigated and irrigated wheat (DW and IW), and corn (DC and IC), with three replicates (n=3). Crops were managed following the conventional practices in the region. On average, this included 180 kg N /ha and chisel plowing for wheat (growing season November to June), and 290 kg/ha and moldboard plowing for corn (May to November).

Disturbed and undisturbed soil samples were collected at 0-5, 5-15 and 15-30 cm at the onset of the experiment (baseline), and in years 2 and 4 after the implementation of the experiment. Because of the different growing season, thermal integrals were calculated to allow for an equivalent accumulation of degree-days between crop residues burial with tillage and sampling in wheat and corn.

Samples were analyzed for total C, C in the form of particulate organic matter (POM-C) and isotopic signature for ^{13}C ($d^{13}C$). Bulk density data from undisturbed samples were used to determine SOC and POM-C stocks. Isotopic analyses were used to quantify the proportion of maize-derived C in SOC and POM-C at years 0, 2 and 4 in DC and IC. An exponential decay model was used to determine the average mean residence time (MRT) of SOC and POM-C.

RESULTS

As expected, results showed that irrigation increased SOC stocks, although differences were observed between wheat and corn. From the original stock of 4.40 kg SOC/m^2, irrigated wheat and corn stored 5.46 and 4.63 kg SOC/m^2 at the end of the fourth growing season under irrigation in the upper 0-30 layer. Most of this increment was observed in the upper 5 cm. Different crop management routines can partially explain these differences. Also, POM-C accounted for an increasing proportion of the total SOC stock. No changes wer observed in the non-irrigated treatments.

The incorporation of corn residues in IC was also different than in DC. At the end of the fourth growing season, the proportion of corn-C was 5 times greater on average for SOC and 10 times greater for POM-C under irrigation (IC), with some variability in the different studied depth. Considering the increment in corn yields and residues, this implies not only a greater amount of corn residues being incorporated into the soil, but also a greater proportion of the total amount of residues. Irrigation favored thus the incorporation of crop residues, very likely because it grants better soil conditions (moisture stored in the soil and residual N availability) after harvest.

The calculation of mean turnover rates using an exponential decay model showed that the introduction of irrigation reduced the mean residence time of SOC and POM-C in the studied layers from >100y without irrigation to 25y with irrigation for SOC and from 35y to 9y for POM-C.

CONCLUSIONS

Our results show that changes in the water balance, in fertilization and in soil management accompanying irrigation can therefore significantly accelerate organic C dynamics in these agroecosystems.

P 3.1.42

Study of Humification index the organic matter in the soil by Laser Induced Fluorescence Spectrocopy - Upper Rio Negro basin-AM

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Soil organic matter is a complex mixture resulting from deposition the plants and animals at different stages of decomposition chemical, physical and biological. It is widely distributed in soil and has a significant proportion of organic carbon. After deposition the organic matter, suffered changes, including the humification. Some soils have an important participation by organic matter in the formation and transformation processes, as podzolization soils. These soils have a strong vertical differentiation diagnosed by the presence of spodic horizon (Bh), which accumulate organic matter (LUNDSTRÖM et al., 2000). In the upper Rio Negro basin the podzolization soils occupy the lower Amazon plateau and they are progressively replacing the Acrisols (Nascimento et al., 2004). In this way understand the dynamics of organic matter in these soils tropical environments are important, as part of the global carbon dynamics. The laser-induced fluorescence spectroscopy (LIFS) is a technique used to analyse the humification index of the organic matter of the soil and the association with minerals from the soil matrix (Milori, et al., 2006). Therefore, the main aim to evaluate the humification index soil of a watershed in the Amazon using the LIFS technique. The site investigation is situated in the São Gabriel da Cachoeira city, located in the Amazonas state. This is a watershed whose mainstream has dark waters have identified two soil sequences: one of the high side, the NW of the watershed, the presence of soils Well drained Spodosol, Hydromorphic Spodsol and Criptopodzol, and the second, opposite the first, that part of the lower strand the same stream with the presence of Gleysol coming to Criptopodzol. The soil samples were collected in open trench and sent to laboratory, which were air dried, grinded, and sifted through a 2 mm mesh. The percentage of carbon (C) of the soil samples were determined using a Perkin Elmer elemental analyzer, Model 2400. The laser-induced fluorescence spectroscopy (LIFS) were determined using a portable system with wave laser at 405 nm with 20 mW power and resolution of 4 nm using an equipment developed by the Embrapa Instrumentation (EMBRAPA , 2003), whose the parameters adopted were: acquisition range 475 to 750 nm; integration time of 200 ms; boxcar 3 and 3. The humification index (H_{LIFS}) were determined by calculating the ratio between the area of the fluorescence emission spectrum (Ex: 465, Int from 450 to 700 nm) (ACF) and the amount of total organic carbon (%) (TOC) present in the soils samples (Milori et al., 2006). The results obtained to assess the pattern of C distribution and the H_{LIFS} to well drained spodosol, hydromorphic spodosol and Criptopodzol have similarities in the C percentages, elevated surface (horizon) (10%, 5% and 40% respectively), and low H_{LIFS}. From the Well Drained spodsol the AE horizon and Hydromorphic spodsol and the BH_3 criptopodzol the C values start to decline and H_{LIFS} increases, and again the subsurface horizon (Bh and CBHs), the percentage of C increases and decreases H_{LIFS}. The albic E horizon of spodosol was not considered in this study, due to the low percentages of C and the technical limits of detection. The Gleysol profile does not show the same trend of the previous vertical profiles, C percentage decrease in the direction of depth of soil accompanied by increased H_{LIFS}. This trend reflects in part the distribution and transformation of the nature of organic matter and the watershed soils, which have differences in the distribution of carbon and consequently on the H_{LIFS}. On the surface H_{LIFS} is lower because the organic matter is fresh and processed bit, since the subsurface H_{LIFS} rates increase due to structural transformations of the C, becoming more complex accumulation on the horizon. The Gleysol profile, which does not observe the development of Podzolization process and therefore the H_{LIFS} behavior, is not the same. Thus, knowing the humification index by LIFS technical studies can contribute to the understanding of the structural changes of soil organic matter and its accumulation in deep horizons, in addition to emphasizing the need for environmental preservation of the ecosystem.

Keywords: Organic Matter, Humification, Amazon,Podzolization

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P 3.1.43

Estimating the SOC pool stable at the pluri-centennial timescale using Rock-Eval pyrolysis

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Long-term C_3/C_4 vegetation changes and ^{14}C measurements showed that soil contains organic carbon with highly contrasted residence time ranging from a few years to millennia. Soil organic carbon (SOC) stable at the pluri-centennial timescale represents a significant part of total SOC (order of magnitude ~30%). Such a persistent SOC is represented in SOC dynamics model by “passive” or even “inert” SOC pools. With the exception of some specific long-term experiments, the size of the stable pool cannot be estimated accurately which is a recurring problem for the initialization of SOC dynamics models. The determination of the amount of pluri-centennial SOC would also be of great interest to assess SOC stocks stability.

Long-term bare fallow (LTBF) experiments, in which C inputs have been stopped for several decades, provide a unique opportunity to study persistent SOC without the inherent artefacts induced by extraction procedures, the hypothesis being that SOC is gradually enriched in persistent C with time as labile components decompose. The modelling of SOC decays in five LTBF experiments across Europe (Askov (DK), Grignon (FR), Rothamsted (UK), Ultuna (SW) and Versailles (FR)) allowed estimating the size of the pool of SOC stable at the pluri-centennial timescale (Barré et al., 2010). We then analyzed archived LTBF soil samples from these 5 LTBF sites using Rock-Eval pyrolysis. We found a general relationship (r^2= 0.84, n=93) between the temperature at which 50% of SOC has been oxidized (S4 peak of Rock-Eval) and the percentage of pluri-centennial SOC in total SOC. We used this indicator to estimate pluri-centennial stable SOC on a variety of soil types under forest and crops. We propose that Rock-Eval pyrolysis can be considered as a very useful tool to both quantify the passive SOC pool of models and more generally to assess SOC biogeochemical stability.

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P 3.1.44

Relation of soil organic carbon pools to soil type, vegetation cover and altitude in Karkonosze Mountains, SW Poland

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Introduction

Fragile mountain ecosystems in temperate climate are most subjected to climate change. One possible aspect of these changes is reduction of the soil organic matter (SOM) content affecting the structure, fertility and exchange capacity of soils. The slow and difficult to perceive climate change is applied to human interference in ecosystems, leading to changes in the forests composition and structure, which also affects the balance of organic carbon stocks in the soil. The well-known is the overall impact of individual environmental factors on the content of soil organic carbon (SOC), but the less-known is the effect of the simultaneous impact of a set of natural and anthropogenic factors on the amount and spatial diversity of carbon stocks in the soils of the mountain areas.

Objectives

The aim of the study was to characterize soil organic carbon pools in mountain soils across a climate-elevation gradient, taking into account vegetation cover and soil typology.

Material and Methods

Karkonosze Mountains, although they are relatively medium-high mountain range (the highest peak Śnieżka Mount - 1602 m a. s. l.), are characterized by the presence of the climate-vegetation zonality typical for the higher mountains. Examined material was collected in 75 profiles, situated at different altitudes (<400, 400-600, 600-800, 800-1000, 1000-1200, and 1200-1400 m asl) and under different vegetation (arable fields, grassland, beech stands, spruce stands, and mountain pine shrubs). Investigated soils are Stagnic Luvisols, Dystric Cambisols, Folic Albic Podzols, and Histic Albic Podzols. Total carbon concentration was determined in fine earth fractions (Ø<2 mm) and in litter samples by dry combustion at 550 °C (Ströhlein CS-mat 5500). Soils in the Karkonosze Mountains are in general acidic and free of carbonates, thus, the total carbon is recognized to be a soil organic carbon. SOC stocks (Mg ha−1) were calculated in the forest litter — from the SOC concentration and litter mass per hectare, while in the mineral horizons (up to 50 cm depth) — from SOC concentration and soil bulk density, corrected by the skeleton content.

Results

SOC pools in the soils of the Karkonosze Mountains are very diverse and depend on vegetation and altitude. The average SOC content is ca. 118.8 Mg ha^{-1}; the lowest values were found in the soils of arable land at the altitude of 400 m a. s. l. - 35.2 Mg ha^{-1}, and the highest in soils under beech stands at the altitude of 800 m a. s. l. - 238.7 Mg ha^{-1}. In the case of altitude gradient there is a clear trend of SOC content increasing with altitude. The lowest values were found in the soils of the foothills (<400 m a. s. l.) - 52.2 Mg ha^{-1}, growing twice at an altitude of 600 m a. s. l. - 109.78 Mg ha^{-1} and three times at an altitude of 800 m a. s. l. - 143.1 Mg ha^{-1}, up to 164.1 Mg ha^{-1} at 1000 m a. s. l. In the upper forest zone and subalpine zone SOC pools stabilize at level 140 Mg ha^{-1} (fig. 1a). The most rich in SOC are soils developed under the spruce and dwarf mountain pine stands - 149.2 and 136.8 Mg ha-1, respectively, and under grasslands occurring in all zones of the Karkonosze Mountains - 148.2 Mg ha^{-1}. Soils under beech forests contain less SOC - 114.7 Mg ha^{-1}, and the least - the soils of arable land 46.7 Mg ha^{-1} (fig. 1b). Among the distinguished soil types the largest amount of SOC contain Histic Albic Podzols and Folic Albic Podzols occurring in the highest parts of the mountains - about 140 Mg ha^{-1}. Less SOC contain Dystric Cambiols - 93.6 Mg ha^{-1} and Stagnic Luvisols 65.9 Mg ha^{-1} (fig. 1c).

Conclusions

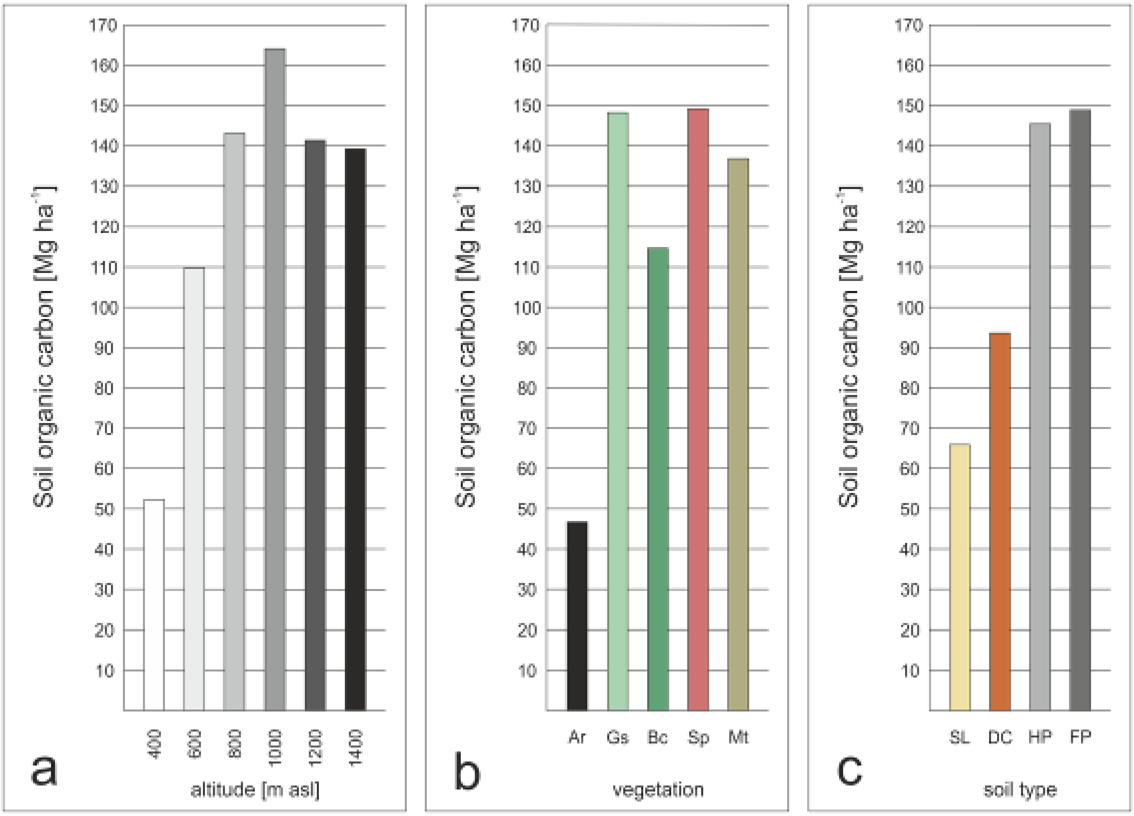
The SOC pools are affected by both climatic conditions and vegetation cover, as well as soil type, related to both these factors. In the subsequent elevation zones SOC stock increases significantly up to an altitude of 1000 m asl, and then stabilizes. It is result of changing with altitude climate and reduced biomass input to the soil. Equally important is the type of delivered organic matter, a reflection of this are higher SOC content in soils under spruce stands and mountain pine shrubs, where the needles are very susceptible to degradation. Resultant of these two factors is the content of SOC in various types of soils.

The research project was supported by the National Research Center of Poland, grant No. 2013/11/N/ST10/01528

Fig 1. Soil organic carbon pools in soils of Karkonosze Mts in relation to (a) altitude, (b) vegetation and (c) soil type.

Ar - arable lands, Gs - grasslands, Bc - beech stands, Sp - spruce stands, Mt - dwarf mountain pine stands, SL - Stagnic Luvisols, DC - Dystric Cambisols, HP - Histic Albic Podzols, FP - Folic Albic Podzols

Figure 1



P 3.1.45

Insights into organic matter stability from compound- and fraction-specific radiocarbon analysis of Swiss forest soils

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Introduction: Understanding controls on the stability of soil organic matter (SOM) has garnered attention in recent years in the context of its vulnerability to, and role in climate change, as well as its importance in soil function. Radiocarbon has proven to be a powerful tool for assessing SOM dynamics and is increasingly used in studies of carbon turnover. However, the heterogeneity of soils and convoluted underlying processes render it challenging to determine dynamics of different carbon pools from bulk radiocarbon signals.

Improved understanding of processes that influence SOM stability and vulnerability require identification and characterization of carbon pools that are both important for long-term storage and susceptible to degradation.

Objective: This project aims to assess the nature and dynamics of different SOM pools.

Materials and methods: This is done by investigating the abundance and radiocarbon signatures of molecular markers of vascular plant and microbial organic matter (lignin, plant waxes, glycerol dialkyl glycerol tetraethers) in both bulk soils and specific density fractions (free light fraction, occluded light fraction, heavy fraction). Our goal is to examine the turnover and fate of these specific biologically-derived components and to evaluate their utility as tracers of carbon flow and turnover within soils. We focus on soil profiles from specific well-studied sites that form part of the Long-Term Forest Ecosystem Research (LWF) program of the Swiss Federal Institute for Forest, Snow and Landscape research (WSL).

Results: Preliminary results reveal marked variations in the abundance and radiocarbon age of different molecular markers as a function of both soil type and depth, and that the distribution of these different markers varies among density fractions. Radiocarbon age relationships between specific markers and density fractions imply both distinct and evolving modes of association within the soil matrix. **Conclusion:** Ultimately, data emanating from this combined compound- and fraction-specific approach may serve to improve carbon turnover models by constraining the size and age of different SOM pools, enhancing our ability to assess SOM stability and to predict vulnerability to change.

P 3.1.46

Soil respiration and methane exchange in rubber plantation and rainforest: impact of land use change

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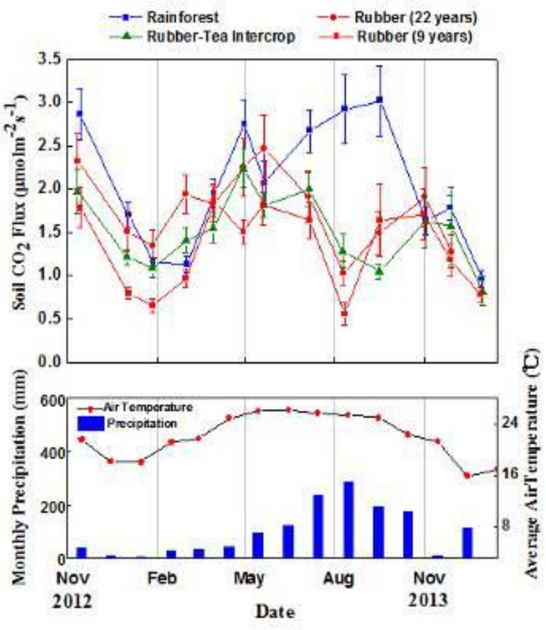
Rubber plantations have been expanded in past decades in the Mekong region where they were not traditionally grown replacing in part rainforest. Investigation of gaseous carbon loss from soil is an important component of evaluating the impact of land use change on carbon stocks and dynamics. Aiming to assess this land use change impact on gaseous C exchange, we conducted measurements of soil respiration, CH4 flux, gas concentration and isotope ratio of 13C in CH4 gas profile in rainforest and rubber plantations in Xishuangbanna, Southwest China.
We measured soil respiration in rainforest, two rubber plantations of different age and one rubber-tea intercropping monthly from November 2012 to December 2013. The respiration rate was found to be suppressed in rubber plantation during the wet period in rainy season when rainforest maintain high respiration rate. Given the higher soil moisture in rubber plantations than in rainforest, we hypothesized that rubber plantation produce more CH4 when CO2 flux suppressed. CH4 flux was measured on the same sites in the rainy season of 2014, and results showed the rubber monocultures produced more CH4 when rainforest and intercropping were the weak sink or source.
We assessed how land use change affect the function of tropical upland soil as CH4 sink, by measuring CH4 flux, CH4 concentration and 13C isotope ratio of CH4 profile in a transect covered rainforest and rubber plantations at 3 different age. The variation of monthly CH4 flux was large and there was no consistent difference between rainforest and rubber plantations in rainy season. All sites functioned as CH4 sink in dry season. The lower concentration of CH4 in deeper soil also confirmed the oxidation of CH4 by soil in dry season. Another sampling after days of heavy rain showed the similar concentration gradient in rainforest and young rubber plantation, but two older rubber plantations gradually changed to higher CH4 concentration in deeper soil. 13C enrichment of CH4 increased with depth in all sites, with higher delta 13C values in rainforest compared to rubber plantations in the late dry season sampling. In conclusion, CH4 consumption by the tropical upland soil was weaken by converting rainforest to rubber plantations.

Fig. 1 Seasonal dynamic of soil respiration in different land use systems and climate

Figure 1



P 3.1.47

Which between soil microbial carbon and organic carbon is the most sensitive to soil management changes under upland rice-common bean intercropping system on a ferrallitic soil?

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Introduction

One of the most important challenges which humanity faces nowadays is preserving natural resources and the environment, including soil, while increasing food production. As the world population increases, the pressure on natural resources is increasing too, making it difficult to maintain food security. In Madagascar, ferrallitic soils represent 46 % of the total area (Grinand *et al.*, 2009). These soils are mostly found on hills or "tanety" and they are characterized by a low amount of organic matter, low phosphorus availability and nitrogen is also a limiting factor in agricultural production. However, the use of legumes in cropping systems (especially in intercropping with cereal) and organic matter inputs could promote soil fertility. Otherwise, conservation agriculture, as mulching and no-till system, is one way to preserve soil. The combination of conservation agriculture, mineral phosphorus and organic matter inputs and the use of legumes in cropping systems is one way to improve sustainably crop yields. But between soil microbial carbon and organic carbon, which is the most sensitive to soil management changes?

Objective

The main objective of this study is to evaluate the effects of soil managements (no-till *vs*. tillage) on soil microbial carbon, as an indicator of soil biological activity, and organic carbon that can be considered as the total amount of carbon in ferrallitic soils. In other words, which is most sensitive to soil management changes in a context of cereal-legume intercropping system with phosphorus inputs?

Material and Methods

A field experimental trial was installed in a field located at Lazaina, Madagascar at 1290 m of altitude. Upland-rice and common bean were grown in intercropping on this field experiment. Two soil management systems were compared: Conventional Tillage (CT) and No-Tillage system (NT). These two soil management systems have been combined with two doses of TSP as mineral phosphorus: 5 kg P ha^{-1} (TSP5) and 20 kg P ha^{-1} (TSP20) corresponding respectively to a very low and medium dose of phosphorus inputs. Manure (M), with a dose equivalent to 20 kg P ha^{-1} (M20), has been combined with these two mineral phosphorus inputs. Otherwise, *stylosanthes* residues were also tested particularly for the dose of 20 kg P ha^{-1} of TSP in the two soil management systems. *Stylosanthes* residues were exogenous legumes residues used as green manure (GM) with the dose equivalent of 20 kg P ha^{-1}. Thus, to show the effects of soil managements on soil microbial carbon and organic carbon, CT-TSP5-M20 treatment was compared to NT-TSP5-M20 treatment; CT-TSP20-M20 was compared to NT-TSP20-M20 and CT-TSP20-GM20 was compared to NT-TSP20-GM20. At the flowering stage of bean, soil surrounding roots of rice and bean were collected. Soil organic carbon was determined by Walkley-Black (1934) procedure. Soil microbial carbon was extracted by fumigation-extraction method (Vance *et al.*, 1987).

Results

These first results showed that soil managements did not have effects on the soil organic carbon content for both rice and bean. On the other hand, different results showed significant difference between treatments for soil microbial carbon. Under rice, NT-TSP20-GM20 had significantly higher soil microbial carbon than CT-TSP20-GM20 with respectively 337 and 149 mg C kg^{-1}. This show that *stylosanthes* residues used as mulching and organic matter input enhanced soil microbial activity. Similarly, under bean, NT combined with manure (NT-TSP5-M20 and NT-TSP20-M20) had significantly higher soil microbial carbon than CT combined with manure (CT-TSP5-M20 and CT-TSP20-M20) with respectively 269 and 362 mg C kg^{-1} *vs.* 68 and 218 mg C kg^{-1}. However, under bean, soil microbial carbon of NT-TSP20-GM20 was lower than CT-TSP20-GM20 probably due to the high C/N ratio of *stylosanthes* residues.

Conclusion

In conclusion, this study showed that between soil microbial carbon and organic carbon, soil microbial carbon is more sensitive to soil management changes in the first year of culture. This concerns especially rice-common bean intercropping system on a ferrallitic soil.

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P 3.1.48

Conservation Rice-wheat Systems Improves the Soil Quality

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In conventional rice-wheat system, rice is transplanted in flooded puddled soil and after wheat harvest; wheat is sown by well pulverizing the soil. These conventional rice-wheat systems are major contributor of greenhouse gas emission, and escalating labor/water crisis are further worsening the situation. In this scenario, conservation rice-wheat systems offer a pragmatic option to sustain rice and wheat yields in this system by reducing the labor/water requirement and greenhouse gas emission with simultaneous improvement in soil quality and system productivity. In the first two years experiment conducted at farmer field in district Nankana, Pakistan, and district Sheikhupura, Pakistan. The rice-wheat cropping systems included the direct seeded rice (DSR), followed by zero tilled wheat (ZTW) or conventional till wheat (CTW), and puddled transplanted rice, followed by ZTW or CTW. During both years, the soil quality was better in conservation rice-wheat cropping system (DSR-ZTW) than conventional rice-wheat systems (TR-CTW), and there was a progressive increase in soil total carbon and soil microbial biomass carbon in the conservation rice-wheat systems. In second three year study, we evaluated the role of sesbania brown manuring in direct seeded rice, and impact of rice residues maintenance in no tilled wheat on the soil quality. The experimental treatments were (i) direct seeded rice (DSR) - zero tilled wheat (ZTW); (ii) DSR + sesbania (brown manuring) - ZTW; (iii) DSR - ZTW + crop residues; (iv) puddled transplanted rice (Pu TPR) - ZTW; (v) Pu TPR - conventional till wheat (CTW). During the first year, the impact of sesbania manuring and crop residues on soil quality was not prominent. However, we noted substantial increase in the soil quality due to sesbania brown manuring or crop residues maintenance in conservation rice-wheat systems in the following years. This was visible through improvement in the total soil carbon and soil microbial biomass carbon. Thus the promotion of conservation rice-wheat system may improve the soil quality in rice-wheat system.

P 3.1.49

Soil carbon sequestration in tropical rice based cropping systems

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Introduction

Paddy represents a large portion of global cropland. It is largely grown in South and East Asian countries. As more productive croplands, paddy fields are reported to have higher soil organic C storage and sequestration capacity with compared to drier croplands. Therefore maintenance of sol organic C in rice cropping system is important not only for improving agricultural productivity but also for reducing carbon emission. Many studies reported so far on paddy soils involve C sequestration and stock determination in rice cropping systems of India, Japan, China, Thailand and Indonesia. However crop rotations have not been studied for soil C buildup and nutrient status of lowland paddy soils.

Objectives

The objectives of this study are to quantify and compare soil organic C fractions and C stocks in tropical rice based cropping systems and to investigate their variation as affected by crop rotation with upland crops.

Materials and methods

This study was carried out on Reddish Brown Earth soil (Moormaan & Panabokke, 1961) in the North Central province of dry zone in Sri Lanka (5º54'N - 9º52'N latitude and 79º39'E - 81º53'E longitude). Four different cropping systems of paddy (Rice/Rice (RR), Rice/Soya (RS), Rice/Tobacco (RT), Rice/Onion (RO)) on same soil type (Reddish Brown Earth) were selected. Total organic C, microbial biomass C, water soluble C, KMnO4oxidizable C, pH, moisture and available macronutrients were analyzed at 0-15 and 15-30 cm depth. Carbon stocks were calculated.

Results

Carbon fractions and nutrient availability among the cropping systems varied significantly showing high contents in 0-15 than 15-30 cm depth. Except water soluble C which showed a higher content in 15-30 cm depth all the other fractions show higher content in 0-15 cm depth. Water soluble C moved down into deeper soil compartments as observed. Correlation analysis between chemical C fractions and macronutrients showed that soluble C fractions such as microbial biomass and water soluble C correlate significantly with $Ca2^{+}$ possibly due to the chelating effect of organic matter on metal ions. Nutrients showed a positive trend with carbon fractions showing that organic matter act as a source for nutrients and enhance nutrient retention. Crop rotation between rice-soya maintained the highest soil organic C stocks (65.18 Kg/ha) while rice-onion maintained the lowest (43.41 Kg/ha). The cropping system changes from rice- rice to rice-soya enhanced soil carbon sequestration. Cropping changes to other annual crops such as tobacco and onion reduced soil carbon sequestration compared to rice-rice. No residues will remain after harvesting onion as the whole crop is removed as the harvest while only below ground parts will be remained after harvesting tobacco. It is reported that soil C increase when a large amount of residues (more organic matter) returned to the soil after the harvest as soil carbon sequestration is the process of transferring carbon dioxide from the atmosphere into the soil through crop residues. The differences in soil C stocks in the cropping systems studied are mainly due to the differences of remaining crop residues in soil.

Conclusion

It is confirmed that tropical rice based cropping systems have a great potential in storing and maintaining C in soils and thereby to facilitate nutrient availability. Further, crop rotation with upland soya enhanced soil carbon sequestration than rice alone.

P 3.1.50

The response of human disturbance on subtropics alpine meadow soil middle element nutrients

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Question:

The altitude of Wugong Mountain is 1918 meters in Jiangxi province, China, from 1600 meters above the mountain stretches of distribution of 100,000 acres of meadow, which is a unique landscape advantage in mountain vegetation areas at subtropical area of the world. In recent years, the development of tourism in the region, the growth of human disturbance on the meadow area had an impact, such as soil fertility decline, water quality, etc.

Methods:

This study is based on human trampling caused grassland degradation and different degree of the surface exposed, which is divided into 3 levels and 1 contrast (no disturbance, vegetation coverage of 90% to 100%; slight disturbance, vegetation coverage of 60% to 90%; medium disturbance ,vegetation coverage of 30% to 60%; severe disturbance (vegetation coverage was 0%-30%), by using the soil nutrient system method (ASI), research different human disturbance trampling degree to different soil depth (0-20cm and 20-40cm) affect the distribution characteristics of soil medium nutrient elements, to provide reference for the regional sustainable development strategy of meadow restoration and ecological protection.

Results and Conclusions:

The results showed that: (1) the different interference degree of Wugong Mountain high altitude mountain meadow soil available Ca average content was 98.66 mg/L, the average content of available Mg was 15.26 mg/L, the average content of available S was 17.13 mg/L.

(2) The different degree of disturbance has significant influence on the meadow soil available S content ($p< 0.01$), available Ca, S have some difference (p value were 0.082 and 0.082); soil acidity difference is not obvious.

Key words: Disturbance; Meadows; Available Ca; Available Mg; Available S

Acknowledgement：

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P 3.1.51

Dry-rewet and ten-year warming reduce microbial biomass carbon and respiration in Australian alpine soils

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Introduction

Alpine soils are considered important carbon (C) sinks due to the slow decomposition rates of soil organic matter at the low temperatures. However, as ambient temperatures increase and summer precipitation becomes less frequent and more erratic, changes in the dry-rewet (DRW) patterns of soils can have significant impacts on the C dynamics and sequestration by altering microbial biomass and activity. Dry-rewet cycles in the South-Eastern Australian Alps are characterised by occasional droughts and infrequent rainfall during the summer. Climate change predictions for this region include increases in ambient temperatures by up to 2.9 ºC and precipitation changes between +2.3 and -24% by 2050. These are likely to translate into an increased number of dry days through faster soil drying and fewer rewetting events, which will alter dry-rewet cycles in this region.

Objective

The objective of this study was to determine whether long-term warming altered the responses of soil microbial biomass and respiration to DRW in alpine soils.

Materials & methods

An incubation study was conducted on fresh soils collected from an open heathland in the South-Eastern Australian Alps (1750 m a.s.l). The alpine soils were subjected to warming treatments over 10 years *in situ* from 2004 to 2014 (warmed, using open-top chambers, and unwarmed). Three moisture regimes were applied in the incubation study and these were a constantly moist control, maintained at 70% field capacity, three dry-rewet cycles (3DRW) and six dry-rewet cycles (6DRW), over 42 days. The soils in all moisture treatments were then incubated at 70% field capacity for a further 16 days. Respiration was measured at one, two, four and seven days after each rewet. Microbial biomass carbon (MBC) was measured on the first and last day of the incubation study.

Results

Dry-rewet, and long-term warming history had important implications for respiration and MBC in the Australian alpine soils. Cumulative respiration was significantly lower in the previously warmed soils in all moisture treatments. When the soils were subjected to DRW in the first 42 days, their cumulative respiration decreased by 60% with 3DRW and 40% with 6DRW, compared to the moist control. However, in the following 16 days, when the soils were last rewet and maintained at 70% field capacity, their respiration rates readily exceeded those of the moist control soils. At the end of the study, the total cumulative respiration of dried and rewetted soils was increased in the previously warmed soils (by 10%), but marginally decreased in the unwarmed soils (by 4%) compared to the moist controls. Microbial biomass C in the moist control was 36% lower in the previously warmed than unwarmed soils. Finally, DRW reduced MBC by a greater amount in unwarmed (47%) than previously warmed soils (29%), which had a lower initial MBC.

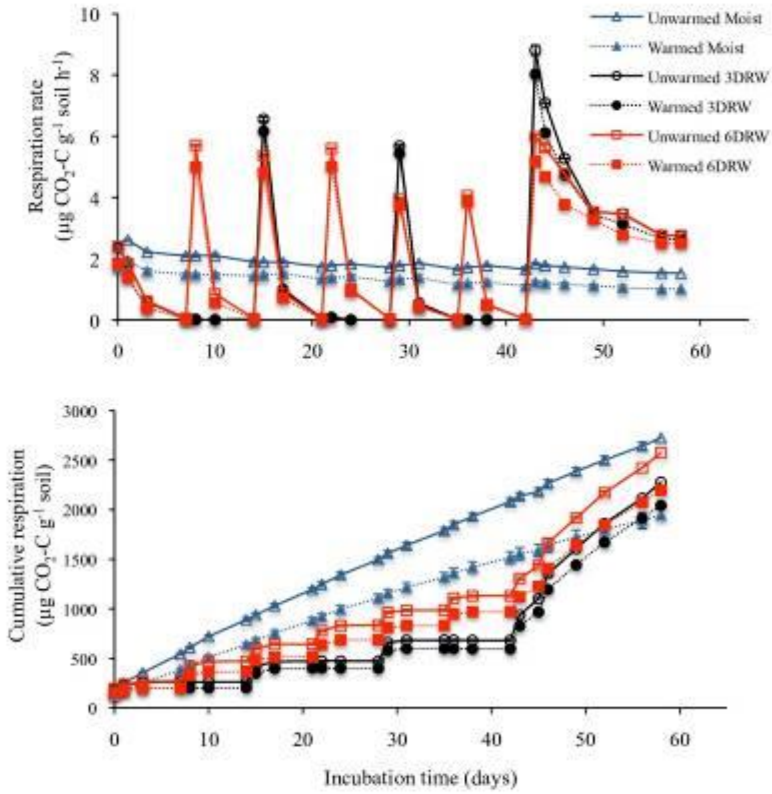
Conclusions

The 10-year warming history significantly decreased MBC and cumulative respiration, possibly through chronic soil drying and the reduction of the more labile C substrates from increased microbial activity during the initial years of warming. At this alpine site, irrespective of moisture treatment, total C losses were constantly higher in the unwarmed soils due to their greater MBC compared to the warmed soils. Our results imply that the declines in total C losses through respiration during summer dry-rewet cycles may be offset if these are followed by moist autumns.

Figure legend

The figures show respiration rates and cumulative respiration during 58 days of soil incubation at 25 ºC. The factorial experiment consisted of the following treatments: warming (unwarmed and warmed using open-top chambers over 10 years, from 2004 to 2014) and moisture treatments (three dry-rewet cycles (3DRW) and six dry-rewet cycles (6DRW), applied over 42 days, and a constantly moist control). After 42 days, all the soils were rewet to 70% field capacity and incubated for a further 16 days. Error bars represent the standard errors of means (n=4).

Figure 1



Respiration rate
(µg CO2-C g-1 soil h-1)
Unwarmed Moist
Warmed Moist
Unwarmed 3DRW
Warmed 3DRW
Unwarmed 6DRW
Warmed 6DRW
Cumulative respiration
(µg CO2-C g-1 soil)
Incubation time (days)

P 3.1.52

Comparison of Net Ecosystem Carbon Budget between Rice Cropping and Fallow season in Temperate Paddy Soil

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The net ecosystem carbon budget (NECB) was used as an indicator for estimating soil organic carbon (SOC) balance. In general, NECB was evaluated during cash crop cultivation in temperate arable soil, but carbon loss during the fallow season was ignored, mainly due to cold temperature and low microbial activity. In this study, in order to compare the contribution of each seasonal NECB to annual NECB scale, the changes of carbon input and output were investigated under different N fertilization for rice cultivation and fallow season. Net primary production (NPP) and fertilizer C were considered as C input sources, and CO_2 respiration, CH_4 emission, and crop removal were evaluated as C output sources. Carbon dioxide and CH_4 emission rates were simultaneously measured by the closed chamber method. In the control treatment which was managed by the standard N fertilization (90 kg N ha^{-1}) for rice cultivation, annual NECB was minus 1.5 Mg C ha^{-1} $year^{-1}$, which was contributed by 0.097 and minus 1.6 Mg C ha^{-1} during rice cropping and fallow season, respectively. Annual NECB was significantly increased by N fertilization increase, which was mainly influenced by the increased NECB during rice cropping season. Nitrogen fertilization apparently increased NPP of rice. Soil respiration and CH_4 emission were significantly increased by N fertilization during rice cultivation, but these C losses were not comparable with the NPP increase. Nitrogen fertilization for rice cultivation apparently increased soil respiration during the fallow season, but did not affect seasonal NECB scale, because of the increased NPP by weed. In conclusion, soil C loss was much bigger during fallow season than during rice cultivation in temperate rice paddy, irrespective with N fertilization. Annual NECB evaluation including cash cropping and fallow season might be essential to estimate soil C changes in temperature mono-rice cultivation system.

Key words: NECB, carbon balance, rice paddy soil

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P 3.1.53

Soil selected stability of enzyme systems versus flexibility

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Since microbial enzymes are responsible for SOM decomposition, the knowledge on enzymatic mechanisms of acclimation to temperature is required to predict effects of warming on decomposition. Despite intensive discussions on mechanisms of temperature sensitivity of enzymes, it remains unclear how the functional characteristics of enzymes in soil will be altered with temperature increase. This study was designed to test how the flexibility of six enzymes involved in the C, N and P cycles changes in the temperature ranges when maximal enzyme activity and substrate affinity exhibit maximal changes. To this end, we performed soil incubation over a temperature range of 0-40 °C (with 5 ° steps). We determined the kinetics of six enzymes involved in SOM decomposition: acid phosphatase, Cellobiohydrolase and β-glucosidase, xylanase, leucine amino peptidase and tyrosine amino peptidase. We compared flexibility of enzyme systems by changes in enzyme affinity (K_m) to substrate at increasing temperatures. Following to Bradford (2013) we hypothesized high enzyme flexibility (and gradual increase in K_m with temperature) within cold temperature range. In contrast, under warm temperatures we expected more stable enzyme systems (and low temperature sensitivity of K_m). Contrary to our hypothesis, the increase in K_m with temperature for most tested enzymes was not gradual. Within large range of temperatures from 0 - 15 °C (phosphatase), 0 - 20 °C (holo-cellulases) and 0 - 40 °C (proteases) the hydrolytic activity was governed by enzymes with nearly constant substrate affinity . Thus, temperature selected for more stable against flexible enzyme systems in soil.

Overall, the pattern of temperature response of soil enzymes seems to be unique for environment and may differ with soil type and climate. We found two kinds of variation in K_m: one, abrupt rise at 30 °C, which could be interpret as a shift in microbial community structure resulting in production of isoenzymes. Another one - gradual changes over a temperature ranges for phosphatase (15 - 40 °C), which demonstrate production of isoenzymes by the same microbial group. Commonly observed low temperature response of K_m within broad range of temperatures may be an adaptation to the cold and warm environment in order to regulate nutrient cycling during winter and summer period. Our results emphasize the key role of temperature and especial pattern of soil system in maintaining the SOM decomposition.

Key words: C,N,P cycles, soil enzymes, temperature sensitivity, stability, flexibility.

Bradford, MA (2013) Thermal adaptation of decomposer communities in warming soils. Front. Microbiol. ***4****.*

P 3.1.54

Climate change driven treeline advances in the Ural Mountains alter root dynamics and SOM storage

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Introduction: Roots contribute significantly to the formation of soil carbon (C), but their dynamics have hardly been studied in temperature-limited vegetation boundaries such as the upper treeline. Over the last century, field observations have identified striking advances of forest biomes towards higher elevations and latitudes. These shifts are largely related to continuous rises of global temperatures and changes in winter. In pristine regions of the Ural Mountains, comparisons of recent and historical photos indicate that in these regions the forest upper treeline has advanced upwards of 4 to 8 m per decade strongly altering the forest-tundra ecotone (Figure 1). Little is known about the effects of these treeline advances on the C cycling belowground.

Objectives: The main objective of our study was to test whether forest advances and changes in vegetation composition at the treeline in the Ural Mountains alter fine root biomass stocks, turnover and decomposition rates, ultimately altering C storage in soils.

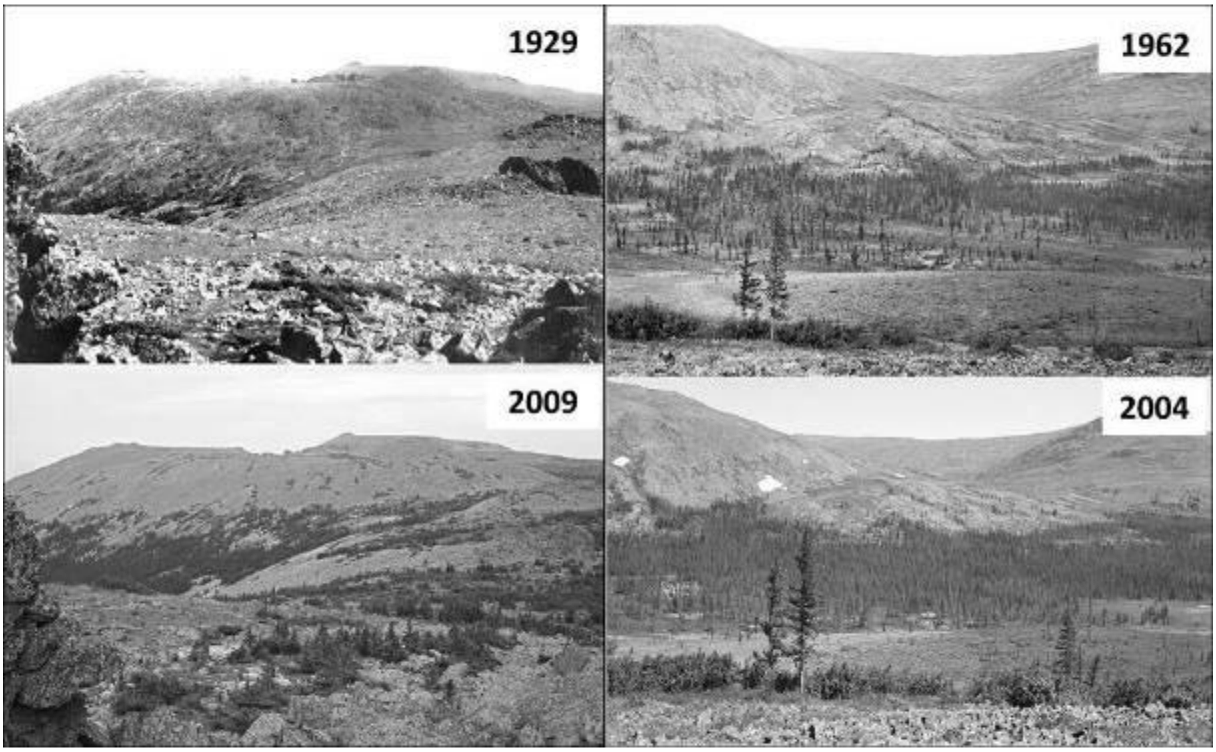
Materials and methods: Our approach was a 'space for time' substitution, estimating changes in ecosystem C along altitudinal gradients reaching from the open tundra to the closed forest in the South and Polar Ural Mountains. Soil and fine root biomass samples (diameter < 2 mm, subdivided in smaller diameter classes) were collected in summer 2013 at different soil depths under the tree canopy and in the open land. We excavated entire plant root systems and applied allometric functions to estimate the partitioning between below- and aboveground plant production. By combining the statistical results of Path Analysis Models and Linear Mixed Effect Models we explored the linkage of fine root dynamics and C storage with the local changes in climate, soil nutrient availability and vegetation composition.

Results: At the ecosystem level fine root biomass decreased from the tundra to the forest, in the South Urals by more than 50%. A one year root litterbag experiment revealed root decomposition rates to increase with decreasing elevation both in the South Urals and in the Polar Urals. Analysis of annual growth rings in the secondary xylem of roots showed that the turnover time of fine roots differs greatly between regions, with higher fine root ages in the Polar Urals (6 ± 1, mean ± SD) compared to the South Urals (2 ± 1), compensating the nearly twice as high biomass stocks in the Polar Urals. The ratio between belowground production and aboveground production increased by a factor of 1.5 to 2 with elevation. The Path Analysis indicates that local changes in the understory vegetation, driven by shifts in the growing period temperature and soil mineral N stocks, explained most of the variability in root biomass and soil C stocks (50% in the South Urals and 60% in the Polar Urals). In the Polar Urals with an increasing shrub biomass from the tundra towards the forest, SOM stocks were three times higher in the forest. However, in the South Urals where the shrubs decreased towards the forest, SOM stocks remained constant with elevation. Here, the decreasing C input by roots might have been compensated by an enhanced input from aboveground litter in the forest.

Conclusion: Our results indicate that climate change driven treeline advances decrease the relative allocation of plants to the belowground C. We observed that changes in the understory vegetation associated with treeline advances have a predominant influence on fine root biomass and SOM storage. Therefore, we suggest that on long timescales forest advances towards higher elevations and latitudes will heavily influence the regional C dynamics and storage as well as the quality of the soil organic matter.

Figure 1: Treeline advances in the South Ural (left) and in the Polar Ural (right). Pictures by P. Moiseev and S. Shiyatov.

Figure 1



P 3.1.55

Application of a microalgal suspension as a bio-stimulat of soil microbial activity

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1. Introduction

Waste effluent from agro-industrial activities can be an environmental management problem due to high nutrient loads. The LIFE+ Integral Carbon project aims to use microalgal cultures to fix these nutrients as well as the CO_2-C emitted by the agro-industrial process through photosynthesis. These algae can be subsequently applied in the field as a bio-fertilizer. We have postulated that this can increase soil organic matter contents and the fixation of atmospheric C into algal biomass.

2. Objectives

The effects of the application of algal cultures on soil microbial activity and nutrients were studied in a controlled laboratory microcosm experiment. Specific objectives were (1) simulate planned field application of algae to understand carbon sequestration potential by net C fluxes of the system as CO_2, (2) investigate the effect of algae and biomass applications on soil carbon and nutrient dynamics at different soil depths, and (3) improve understanding of the treatments' effects on the activity of soil microorganisms.

3. Materials & methods

Four replicates of each treatment were prepared. Soil at 40% of field capacity was packed into 49 cm^3 in PVC cylinder vessels (Ø= 5 cm) for a humid bulk density of 1.3 g cm^{-3}. A suspension of *Chlorella* sp. eukaryote microalga cultured in BG11 growth media was applied at an equivalent rate of 1.3 g dm m^{-2}. At day 21, additional aliquots were added to simulate a second application. Incubation was in a climatic chamber with a 16:8 photoperiod, photon density of 100 µmol m^{-2} s^{-1}, 25°-18° C during light-dark periods, respectively. All vessels were in 1 L bottles equipped with NaOH gas traps in order to evaluate CO_2 fluxes at days 1, 2, 3, 6, 10, 16, and 21, repeated after the second application (42 days total). Seven treatments were performed: SAL: soil with algal culture application; SL: soil in which a filtrate (0.45 µm) of algal culture was applied to normalize humidity and extracellular nutrients; SAA: soil with an autoclaved algal culture to test non-living biomass alternative; S-N: control soil; A: algal culture applied on inert fiberglass filters; SD: control soil incubated in darkness; SAD: soil incubated in darkness with algal application.

At the end of the study period, extent of chlorophyllic algal development was evaluated by image analysis. Soil was cut with a sterile radial blade at 0-4 mm, 4-8 mm, and 8-25 mm depths. In each fraction, total C and N were determined with a LECO elemental analyzer. Chlorophyll *a* absorbance was measured by spectrophotometry and concentrations calculated according to Jeffery and Humphrey's trichromatic equations.

4. Results

Algae growth extent in light treatments was (average values) SAL (31%) > SAA (27%) > SL (14%) > S-N (13.5%). Algae growth was significantly correlated with Chlorophyll-a concentrations in the 0-4 mm fraction (Pearson's r=0.79, p2-C evolution is shown in **Figure 1**. Algae treatments had the highest accumulated respiration, while the algal suspension on inert filters had a net sequestration of CO_2-C. This indicates that application of living algae stimulated the activity of soil heterotrophic microorganisms.

Figure 1: Cumulative CO_2-C evolution of treatments. Error bars are standard error of cumulative values.

Total C and N by depth are shown in **Table 1**. No differences in total C were detected at 0-4 mm, however at 4-8 mm significant differences in C content were obtained, SAL and SL having the highest mean concentrations. These treatments had the lowest concentrations in the 8-25 mm fraction, where S-N had the highest C concentration.

	Depth fraction (mm)	SL	SAL	SD	SAD	SAA	S-N
C (%)	0-4	0.85 a	0.9 a	0.84 a	0.9 a	0.86 a	0.84 a
	4-8	0.94 bc	1.00 c	0.85 ab	0.82 ab	0.81 a	0.80 a
	8-25	0.60 ab	0.56 a	0.71 bc	0.63 ac	0.68 bc	0.72
N (%)	0-4	0.05 a	0.05 a	0.06 a	0.08 a	0.07 a	0.05 a
	4-8	0.07 ab	0.08 ab	0.09 b	0.07 ab	0.06 ab	0.03 a
	8-25	0.04 ac	0.04 a	0.06 c	0.05 ac	0.06 bc	0.04 ab

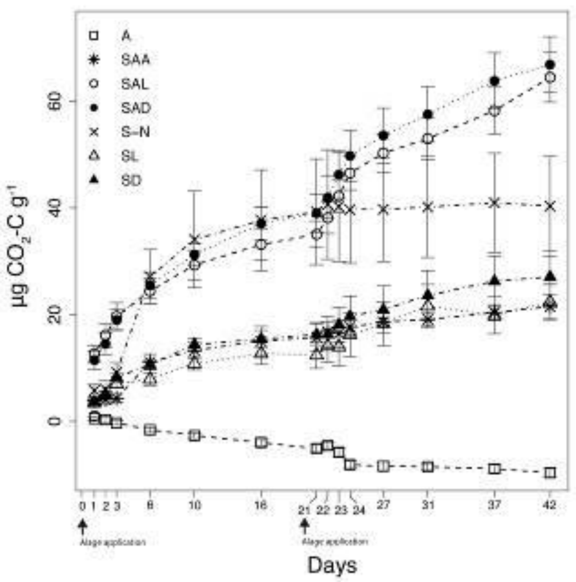
Table 1: Total C and N concentrations by depth in each soil treatment. Different letters within the same row indicate statistically significant differences as evaluated by Tukey's HSD test.

5. Conclusion

The stimulation of net respiration after the application of algal suspensions was an unexpected result indicating interactions between algae and other microbial groups, possibly due to algae heterotrophic adaptation or by the production of extracellular substrates. These may have caused differences in C concentration by depth. Soil biomarkers of microorganism groups and biochemical analyses will be employed in further investigation.

Acknowledgments: This work was financed by the project LIFE13ENV/ES/001251. Jorge Miñón benefits from a grant of the program "UVa-Banco Santander".

Figure 1



P 3.1.56

The urbanization-induced positive feedback on C, N and P cycling are temperature responsive across different vegetations in Nanchang, southern China

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Urbanization helps increase urban ecosystem temperature, and alters soil carbon (C), nitrogen (N) and phosphorus (P) transformation processes, but the variations in temperature sensitivity of soil C, N and P mineralization rates along the urban-rural gradient are unclear. We selected three typical vegetation types along an urban-rural gradient of Nanchang, and collected their topsoils in 27 plots to measure the C, N and P mineralization rates using thermostatic incubation method at the temperature of 5, 15, 25, 35 and 45 ºC. Our results showed that the rates of soil C mineralization, N nitrification and P mineralization generally decreased along the urban-rural gradient ($P<0.05$). Ammonification and net N-mineralization rates did not vary with the gradient. Temperature sensitive (Q_{10}) of soil C mineralization was highest in urban, followed by suburban, and lowest in rural sites, and the pattern was closely similar in forests, shrubs and lawns. In contrast, the Q_{10} value of ammonification was lower in urban than suburban and rural sites, the difference was not found on net N-mineralization across the gradient, and the nitrification response to temperature alteration was only found in urban sites. Phosphorus mineralization rate showed minimal variation across the five incubation temperatures, especially in suburban and rural sites. In sum, Q_{10} value was highest for C mineralization, followed by N mineralization, and lowest for P mineralization, and their Q_{10} variability along the urban-rural gradient were divergent. Global warming would accelerate urban soil organic C decomposition, and urban vegetation N saturation in subtropical China. Compared with rural vegetation, urban ecosystem C, N and P fluxes might be more asynchronous in response to elevated temperature.

P 3.1.57

Forest edge expansion and shift: possible concept of soil organic carbon stock change in soil after land use change

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Introduction

Information about soil carbon stock changes is crucial for calculations of CO_2 emissions/sequestration in the sector LULUCF (land use, land use change and forestry) within the greenhouse gasses reporting obligation (UN FCCC and Kyoto protocol).

There are several ways how to test carbon stock changes in soil after land use change. Using each of them faces great uncertainties both in spatial data information and time since land use change. Change of grassland to forest land is rather common land use change in Central Europe. This change can be caused by intentional afforestation or it can be natural process if extensive pastures or meadows are abandoned. After decades of missing grassland management, forest tree species can cover the former grassland by succession. Theoretically, it is possible to compare results of carbon stocks from original sampling with results from re-sampling after land use change - if data and precise localisations of sampling points are available. Other way is comparing data sets from landscape segments with different land use but the same (or very similar) soil and site condition. Rather specific and usually neglected is slow expansion of forest even if the neighbouring land parcel is managed as meadow. Due to technique of the mowing, the grassland just next the forest stand edge is not mown and seedlings of trees can survive and grow. This way, the forest edge can shift several meters or even tens of meters within the decades of years (see picture).

Objectives

The study is aimed at one of several approaches to assessment of soil carbon stock change calculation related to land use change. The main objective was to quantify differences of soil carbon stocks between forest, expanding forest edge (in fact - zone with a change from grassland to forest) and grassland.

Materials & methods

According to preliminary information about on variability of soil properties, samples of soil from the depths of 0-10 cm, 10-30 cm (as well samples of surface organic horizon) were taken from 5 transections across the edge of forest stand (hornbeam, oak, lime tree) in Central Slovakia. Two sampling points were in old forest stand (forest remaining forest - FF), two in the zone of forest edge in former grassland (grassland changed to forest - GF) and two in the grassland (grassland remaining grassland - GG).

Results

Results of C concentration as well as SOC intensity show trend of soil carbon stock increase in the transition zone. Values of SOC in soil to the depth of 10 cm (which can by most strongly influenced by vegetation) in transition zone (GF) were very similar to the stock in forest (F) and significantly higher than in grassland. The total calculated SOC density in soil (0-10 cm) was 46.3 ± 11.9 $Gg.ha^{-1}$ in forest (FF), 45.4 ± 8.5 $Gg.ha^{-1}$ in transition zone (expanded forest area) and 34.2 ± 12.9 $Gg.ha^{-1}$ in grassland. The stock of organic carbon in the overlaying organic layer is 3.5 ± 1.0 $Gg.ha^{-1}$.

According to the available information, the process started about 50 years ago. This means that the annual SOC accumulation rate is about 0.28 $Gg.ha^{-1}$.

Conclusion

Though the area of research locality was small and it was selected to be as homogeneous as possible (relief, soil units, tree species, exposition), statistical analyses need rather big data sets and generalization of the knowledge is limited. There are still discrepancies between needs of representative and reliable information about soil organic carbon stocks (and their changes) for national reporting obligation and feasibility of soil surveys.

Acknowledgement

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Figure 1

P 3.1.58

SOM composition under different mountainous land-uses in Bulgaria

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Introduction

Carbon in soil organic matter (SOM) makes up 80% of the terrestrial carbon pool and is referred as important potential carbon sink to mitigate the greenhouse effect (Bolin and Sukumar, 2000). Soil humus is a dynamic characteristic greatly vulnerable to land use and climate changes. However, not enough data is available regarding the quantitative and qualitative features of soil organic matter fractions under different land-uses and ecosystem types in mountain regions in Bulgaria.

Materials&methods

We studied the soil organic matter composition under different land-uses including pastures with extensive use, grasslands - abandoned meadow and different types of forests, as follows: spruce - natural and planted (*Picea abies* Karst.), Douglas-fir plantation (*Pseudotsuga menziesii* (Mirb.) Franco.), natural beech stand (*Fagus sylvatica* L.) and mixed coniferous stands (*Pinus sylvestris* L. with *Pinus nigra* Arn., and *Pinus sylvestris* L. with *Picea abies* Karst.). The studied plots are located in Central Balkan, West Rila and West Rhodopes Mountains in Bulgaria. All studied plots are characterized by the absence of management activities.

Soil organic matter content in *Cambisols* was determined by the modified method of Tjurin. The composition of soil organic matter in mineral soils was performed by the method of Kononova-Belchikova (Kononova, 1966; Kononova, Belchikova, 1973; Filcheva, Tsadilis, 2002).

Results

The humic acids predominated in all of the studied plots, except in two plots located in the Central Balkan - the meadow and the spruce plantation, where the humus type was referred to humic-fulvic type. Humic acids are "free" and bonded with R_3O_3 for soil horizons. Ca-bonded humic acids are determined in soil horizons with comparatively higher acid reaction, as well as in the deepest horizon under meadow vegetation. The values of total org. C and C-extracted by 0.1 N NaOH and their depth distribution were similar in most of the studied profiles. The quantity of 0.1N H_2SO_4 extracted carbon was lower than 10% (varying from 1.64% to 10%) in all examined soil profiles. This result was higher only in the last soil horizon under the mixed forest in Rila, which could lead us to be more essential and careful about ongoing destructive processes. Under some conditions we found absence of humic substances which means that in these soils the trace mineral elements are converted to insoluble precipitates.

Our results confirmed the typical distribution of soil organic matter in undisturbed soils, where the highest total carbon content is localized in the organic-mineral horizon and decreased toward deeper soil. The highest total carbon content is estimated at 14.04 % for pasture land-use in Central Balkan. For the forest land uses the highest total carbon content in the subsoil was found under the spruce plantation - 9.5%, and the lowest - under the meadow and all the forest land uses in Rila and Rhodope Mountains - between 1.29 % and 3.93 %.

Conclusions

The studied grassland showed that the *Humic Cambisols* under extensive pasture land use accumulated significantly higher quantity of total organic carbon along the whole profile, compared to *Distric/Eutric Cambisols* under the mountainous meadows. In addition the humus composition showed 100% "free" and bonded with R3O3 humic acid fractions in the pasture, and Ca-bonded in the deeper soil horizons under the meadow.

The soils with some parts Ca-bonded humic acid fractions in general showed higher pH, which could lead to higher microbial activity.

Higher amount of fulvic acids testified to the existence of conditions for ongoing destructive processes, which is also confirmed by the higher quantity of 0.1N H_2SO_4 extracted carbon is some horizons.

Prevail of the humic acids in the most of the studied horizons of studied mountainous *Cambisols* could be explained by the specifics incoming of the forest litter substances, which affects the oxidation processes.

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P 3.1.59

Effects of elevation and land use on soil organic matter composition in tropical Andosols of Mount Kilimanjaro

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Tropical mountain ecosystems cover about 20% of the earth´s terrestrial surface, and are characterized by a large variety of natural, agricultural and agroforestry land use systems. They cover a broad variety of climatic and biogeographic zones and are a global hotspot of biodiversity. However, these ecosystems are severely threatened by climate and land-use change, which also strongly affect soil properties. Mt. Kilimanjaro with its associated large climate and land use gradients provides a unique opportunity to observe and more fully interpret ecosystem responses to climate and land use. Montane Andosols are of specific interest regarding carbon sequestration and ecosystem services. They are characterized by thick litter layers and A horizons that contain up to 20% organic carbon with mainly stabilized humic fractions. Previous analyses of soil organic carbon (SOC) stocks in Kilimanjaro ecosystems have shown large differences along the elevation gradient and strong decrease of SOC with intensive land use. Our objectives are (1) to determine which SOC fractions are lost with land-use intensification, (2) identify the fractions that are affected by the different climatic conditions along a ~3000 m elevation gradient and (3) estimate the quantitative changes in the specific fractions.

Therefore SOM fractions were thermally decomposed using thermal gradient analysis (TGA), evolving gas analysis mass spectrometry (EGA-MS) and analytical Pyrolysis gas chromatography mass spectrometry (Py/GC-MS). EGA curves were used to quantitatively assess the results of Py/GC-MS.

Preliminary TGA results show a relative increase of easily oxidable carbon in higher mountain forests followed by a decrease in alpine ecosystems. More stable fractions were affected contrarily which is closely related to the overall ecosystem productivity. Land-use intensification altered the SOM composition mainly by decreasing lignin and microbial derived C. These changes are further affected depending on net primary production and agricultural management practices.

P 3.1.60

Drivers of Soil Organic Matter Vulnerability in Swiss Forest Soils

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In a changing climate, the mineralization of previously stabilized organic carbon can become one of the largest feedbacks from terrestrial ecosystems to the atmosphere (Lal, 2004). For this reason, it is of interest to understand the vulnerability of this carbon in relation to ecosystem drivers. In this study, soil organic matter (SOM) vulnerability is defined as the likelihood of a soil to lose its organic carbon due to the influence of external factors, and is quantified as the ratio between soil respiration and soil organic carbon content.

The objective of the study is twofold: firstly, to develop a robust statistical approach to allow the investigation of SOM vulnerability at large scales and, secondly, to determine whether climate, soil properties and/or terrain characteristics are driving the vulnerability of organic matter of Swiss forest soils.

The hypothesis of this research is that the main variables driving SOM vulnerability are climate (i.e. temperature and soil moisture proxy), soil (i.e. pH and % clay) and terrain (i.e. slope and aspect). Based on this hypothesis, 54 study sites, all part of the Swiss Federal Institute for Forest, Snow and Landscape Research (WSL) network, were selected to introduce a balanced combination of the variables and to enable a powerful hypothesis testing. To accomplish this, we first spread all the sites contained in the WSL database according to climatic data for the period 1981-2010. Then, we spread the sites spatially by using the productive regions of Switzerland (Schwaab *et al.*, 2015). Finally, we carried out a principal coordinates analysis with soils and terrain data before selecting the sites that were going to be part of the study.

Three non-overlaping topsoil (i.e. 20 cm) composites were collected within 40 x 40 m^2 plots at the 54 selected sites. Soils were sieved at 2 mm and incubated in the lab for 6 months under aerobic and controlled conditions of moisture and temperature (25 °C). Carbon vulnerability was investigated by quantifying heterotrophic respiration and soil water extractable organic carbon.

The first results from the regression analysis show a systematic influence of the drivers investigated on SOM vulnerability. Unexpectedly, soil properties play a more significant role than terrain characteristics and even climate.

A systematic influence of drivers on SOM vulnerability leaves a door open to produce predictive tools/models at the landscape level. These tools could assist in the assessment of the risk of soils becoming net sources of CO_2 into the atmosphere.

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P 3.1.61

Soil organic carbon and total nitrogen sequestrations in response to tillage and nitrogen fertilizer sources in cereal based cropping system

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Introduction

Wheat growers use 78% of nitrogenous fertilizers for crop productivity in Pakistan, which is not only expensive but also non-environmental friendly. The farmyard manure (FYM) and soybean residue (SR) contain sufficient amount of minerals particularly nitrogen (N). Using FYM can substitute the nitrogenous commercial fertilizer, and will minimize the concerns about its contamination in surface- and groundwater.

Objectives

To evaluate the effects of minimum (MT), conventional (CT) and deep tillage (DT), urea N fertilization, FYM and SR incorporation on soil bulk density, SOC, and STN in the north western Pakistan and to quantify their effects on soil C and N sequestration rates.

Methods and materials

We evaluated the effects of tillage and N fertilizer sources on soil bulk density, soil organic C (SOC) and soil total N (STN) in silty clay loam soil in north western Pakistan during 2005-2007. Treatments included three tillage practices [MT, CT, and DT], and twelve N fertilization sources treatments [(60 and 120 kg urea N ha^{-1}, 10 and 20 tons FYM ha^{-1}, 10 tons SR ha^{-1}, the FYM and SR were incorporated as sole and also augmented with half of urea N, and control treatment] in split plot design with three replications. Tillage system were allotted to main plots, whereas N fertilization to subplots. The cropping system was wheat-maize-wheat.

Results

Deep tillage had significantly increased the soil bulk density toward the end of the experiment compared to CT and MT. The STN was higher for MT than DT and/or CT, whereas SOC was higher for MT than DT. MT had accounted for 22% higher SOC and 28% higher STN sequestration rates than DT. Control and urea N application had higher bulk density than FYM and SR incorporated plots. Similarly, FYM incorporated plots had lower bulk density than plots receiving SR. Generally, SOC and STN returned to the soil from 2005 to 2007 were greater with FYM and SR than urea and control. More specifically, STN was higher when SR was used, whereas SOC was not different in both FYM and SR incorporated plots. The SOC concentration was greater with 10 tons FYM ha^{-1} along with 30 kg urea N ha^{-1} in CT, followed by 20 tons FYM ha^{-1} in MT. However, the STN was greater with 10 tons SR + 60 kg urea N ha^{-1} in CT and MT compared to other treatments. The FYM sequestration rate of C and N was lower than SR, but higher than urea N/Control.

Conclusions

Organic sources of N fertilization increased soil C and N sequestration compared to inorganic fertilization in MT over DT. The application of FYM had increased the SOC compared to SR, whereas SR had increased the STN compared to FYM. FYM augmented with urea N increased SOC sequestration rate of about 4-5 times more than control. STN sequestration rate was higher for SR plots over control, urea N and FYM. Thus the application of FYM as well as SR had sequestered more C and N principally in MT plots, and thereby has the potential to increase soil quality and productivity couple with reducing N leaching and greenhouse gas emission.

P 3.1.62

Relevance of bias-free estimation of the organic carbon stock in soils

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It has been well known that land use change (e.g. from plowing to no-till or from arable land to pasture) alters the soil bulk density and the SOC concentration as well as the stratification of both. Enhanced SOC concentration and bulk density account to a larger SOC stock in the upper soil layer. In many cases this increase was interpreted as carbon sequestration thanks to reduced tillage intensity. However, reasonable doubt came up whether this interpretation was just an artifact of the calculation. Soil mass related SOC stock estimations became, therefore, state of the art. It was the objective of our study (i) to present a new method of mass related SOC stock estimation and (ii) to analyze the biases of different methods of mass related SOC stock estimations using a generated theoretical data set and the data of a real tillage experiment.

All methods biased significantly, if the sampling depth was not substantially deeper than the humus rich top soil. The conventional method corrects the thickness of each layer of a profile to match reference soil mass unique for each layer. This method biased positively when just the topsoil was considered and it biased negatively, if also the subsoil was taken into account (Fig. 1).

Figure 1: Differences in SOC stock estimation no-till minus plowing (Δ SOC) by means of a conventional mass relating estimation as related to the depth of the considered profile

The new estimation method presented here corrects the thickness only of the deepest soil layer of a soil profile matching the reference soil mass of the entire soil profile. This method provided reliable bias-free results, if the subsoil is taken into account (Fig. 2).

Figure 2: Differences in SOC stock estimation no-till minus plowing (Δ SOC) by means of a new bias-free estimation method as related to the depth of the considered

Applying the new method on a real tillage experiment, we observed a highly significant positive relationship between the tillage intensity and the SOC stock. We conclude from this observation that using bias-free estimation methods is extremely relevant to interpret the effect of land use change on SOC sequestration correctly.

Figure 1

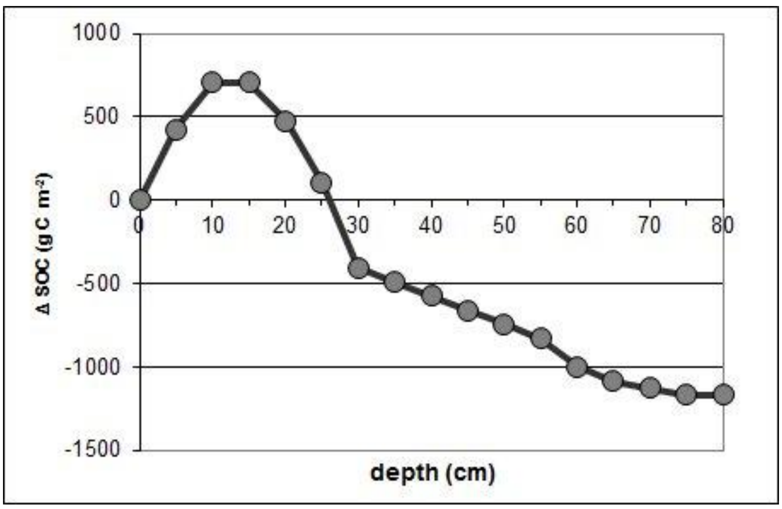
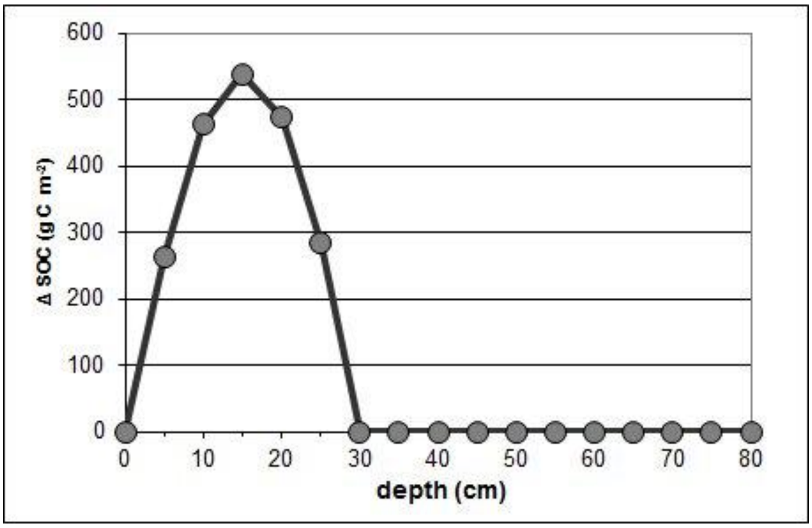


Figure 2



600
500
400
300
200
100
0
Δ SOC (g C m⁻²)
0
10
20
30
40
50
60
70
80
depth (cm)

P 3.1.63

Modelling vertical soil carbon stocks to 1m depth as a function of land use

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Decisions on land use and land use change increasingly include consideration of potential changes in soil carbon stocks. Predicting or modelling such soil carbon changes as a function of land use change necessitates the understanding of soil carbon distribution in the soil profile under different land uses.

We propose that the depth distribution of soil carbon stock under different land uses can be modelled and predicted using appropriate mathematical equations and related to a value close to the soil surface. This approach assumes that SOC stocks to a depth of 1 m can be functionally related to the concentration at the surface in the absence of large volumes of material transport. In addition, physical fractionation of soil organic matter to 1 m would yield important information on what proportion of the organic matter would be most vulnerable to changes in land use.

This approach was tested in a quaternary catchment in the Midlands area of KwaZulu-Natal, South Africa. Roughly 500 samples were collected from 64 profiles under forestry, grassland and cultivated land (including conventional tillage, reduced tillage and minimum tillage practices). Samples were taken in triplicate using 5 cm steel cores at depths of2.5, 7.5, 12.5, 17.5, 30, 40, 50, 75 and 100 cm (unless restricted by rock) for bulk density and soil organic carbon determination.

Vertical carbon stock distribution functions were developed for 5 different land uses (cultivated land was divided into 3 separate land uses based on tillage practices). Exponential decline functions were used to model carbon distribution under forestry, grassland and cultivated land using minimum tillage and subsequently normalized using the value observed close to the surface. Normalization reduces the number of model parameters needed to predict soil carbon stocks and enables the multiplication of the exponential decline curve characteristics with a soil carbon stock value observed close to the soil surface to represent an estimated value of soil carbon distribution to 1 m at that observation point. The integral of the exponential function was used to calculate the soil carbon storage.

Under conventional and reduced tillage practices, the levels of soil disturbance in the top 20 to 40 cm of soil rendered the use of exponential decline functions inappropriate unless an average carbon value was calculated for the top 30 cm and used as surface value. Alternatively, 3^{rd} and 4^{th} order polynomial functions were better able to capture the high variation in soil carbon in the upper 40 cm.

This methodology proved useful not only to model the vertical distribution of soil carbon stocks, but also to calculate the cumulative carbon stocks to 1 m soil depth as a function of land use. Soils under forestry showed distinctly higher carbon values compared to grasslands and cultivated land, with a large proportion of this carbon occurring in the form of particulate organic matter in the top 5 to 10 cm. When considering land use change, changing from forestry to cultivation, for example, is expected to result in initial rapid loss of soil carbon through organic matter breakdown in the top 10 cm, especially under heavy soil disturbance. Conversely, it could be expected that a change from cultivated land or grassland to forestry may result in a gradual increase in soil carbon under the same climatic regime.

Keywords: soil organic carbon, vertical carbon distribution, land use

P 3.1.64

Abiotic and biologically-driven basalt weathering and C sequestration under changing climate

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Weathering of primary silicates is one of the mechanisms involved in carbon removal from the atmosphere, affecting the carbon cycle at geologic timescales. Basalt represents between 30% and 35% of the global chemical silicate weathering CO_2 flux. Mineral weathering can be enhanced through contribution of biota, both microbes and plants. Biota increase soil CO_2 concentrations through root and microbial respiration; release of organic acids, uptake of dissolution products, and redistribution of water in soil profile. These mechanisms are complex and depend on plant growth and microbial abundance that are in turn dependent on temperature, precipitation, light, and atmospheric CO_2. World is experiencing increase in both temperature and atmospheric CO_2. Precipitation patterns are also changing. Laboratory experiments indicate that increase in temperature would increase rates of abiotic silicate mineral weathering. Relationship between climate and weathering is more difficult to demonstrate in natural environments because of the effect of temperature on biotic processes, such as plant and bacterial growth and activity. Increased atmospheric CO_2 concentrations potentially affect weathering rates directly through increase in soil CO_2 concentrations by lowering pH of soil solution and increasing proton-promoted dissolution of soil minerals and indirectly through enhanced biological activity. Direct effect has been shown in laboratory experiments where, when pH was not controlled, CO_2 increased mineral dissolution. In practice, relationship between weathering and atmospheric CO_2 is more complex, since soil concentrations of CO_2 are usually significantly higher than atmospheric CO_2 and are influenced by biotic respiration. Effect of elevated CO_2 on biological weathering has not been demonstrated before. The goal of our study is:

1) to quantify abiotic and biotic contributions to weathering and CO_2 flux during early colonization of the landscape by biota;

2) to determine effect of elevated temperature on abiotic and biotic weathering of basalt;

3) to determine effect of elevated CO_2 concentrations on biotic and biotic weathering.

In order to achieve these goals we would like to conduct following experiments in controlled environments at ECOTRON Ile-De-France employing basalt used in The Landscape Evolution Observatory (Arizona, USA): mesocosm studies, where basalt is exposed to rainfall at equilibrium with two different CO_2 concentrations in the air, ambient and elevated and kept at two temperature regimes. At the proposed design, eight mesocosms would be needed. Four will be maintained at ambient CO_2 and four at elevated CO_2 (800 ppm); with a pair of mesocosms in each CO_2 treatment maintained at control temperature regime and a pair at elevated temperature regime. Each mesocosms would be split into 4 sections, corresponding to 4 plant treatments: one with a grass, one with an herbaceous legume, one with a woody legume and one control without plant. Replication will be ensured by repeating the same treatment in the two mesocosms concurrently and by repeating experiment in time using new sample basalt samples. Mesocosms will be equipped with temperature and humidity sensors, and with solution and gas samplers at three different depths, which would allow collection of these samples as experiment progresses. These solution samples will be analyzed to determine pH, conductivity, alkalinity, major (ICP-AES), trace and rare earth elements (ICP-MS) concentrations, anions concentrations (Ionic chromatography) and total organic carbon (TOC) concentration. Soil CO_2 concentrations will be monitored using porous Teflon tubes connectedto Vaisala probes. Moreover soil samples will be collected during the experiment in order to determine the evolution of soil microbial community composition.

P 3.1.65

The evaluation of biochar effects at both the field and laboratory scale; soil carbon, microbial community composition and carbon dioxide efflux

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The use of biochar, a recalcitrant and carbonaceous material that is produced when organic matter undergoes pyrolysis, to ameliorate soil may increase soil pH, the ability to exchange nutrients and water holding capacity of soils over time. However, the benefits of increased soil carbon (C) and decreased greenhouse gas (GHG) emissions may be more immediate. To examine the effects of an anaerobic digester biochar in two different tropical Hawaii soils, a highly weathered Oxisol and a fertile Mollisol, a two-year field trial is underway growing sweet corn (conventional tillage with winter cover crop) and Napier grass (ratoon harvest, no-till management). As expected, immediately after amendment soil C was higher in the biochar plots compared to the control plots (2.15 versus 1.45 and 1.88 versus 1.41%) for the Mollisol and Oxisol, respectively ($p<0.001$). Further, diversity indices obtained by Illumina 16s sequencing showed that even just a few days post-biochar amendment, soil bacterial community composition shifted as a result of biochar amendment (PERMANOVA $p=0.043$). After year one of the field trial, there was no change in soil pH, moisture content, cation exchange capacity, or crop yield in response to biochar for either soil ($\alpha=0.05$). However, patterns in soil CO_2 efflux emerged during that time, indicating that while there was no difference between the control and biochar within the corn plots, the Napier plots showed a biochar treatment difference. For the Mollisol Napier plots, the presence of biochar seems to decrease CO_2 efflux whereas in the Oxisol Napier plots, biochar increases the CO_2 efflux. These patterns partially support the findings of a laboratory incubation study over a temperature gradient using year one field soils which indicated there was not a treatment difference at 29ºC at either site for corn or in the Oxisol Napier plots, but the Mollisol Napier did have a significant trend ($p=0.096$) with control plots having increased cumulative CO_2 emissions, consistent with what is being found *in situ*. The examination of microbial communities, which likely differ between field and laboratory conditions, may be a more sensitive measurement of change and therefore may be seeing differences at the field scale more rapidly in terms of CO_2 efflux as well as compared to measurements such as soil cation exchange capacity at a field scale. While there are little significant changes occurring due to biochar in the field after one year, there may be benefits due to increased soil C and changes in bacterial communities and nutrient cycling, which may be seen in the field trials on a longer time scale.

P 3.1.66

Impact of logging-associated compaction on forest soil microbial community structure and activities

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Heavy traffic can cause drastic changes in soil porosity and structure, but we lack a fundamental understanding of how this affects the soil microbiome (Hartmann et al., 2014). The optimal soil water content for aerobic microbial activity depends significantly on soil bulk density among others soil parameters (Schjønning et al., 2003). Thus, alterations in soil porosity after compaction may strongly affect microbial community structure and activities. Here, we assessed those parameters after 7 years of soil compaction following heavy traffic. The site studied is located in a state-owned forest in northeast France (Azerailles, Meurthe et Moselle). The soil is a Luvisol developed on a silt loam layer approximately 50 cm thick laying on a clayey layer; this strong textural discontinuity causing limited temporary water logging (Goutal et al. 2012). In May 2007, a 8-wheel drive forwarder (25T) drove for an equivalent of one pass back and forth. In September 2014, soil samples were collected in the trafficked and undisturbed plots and gas emissions were measured in the field. The quantification and diversity of different microbial groups were studied by combining q-PCR and terminal restriction fragment length polymorphism (TRFLP), respectively targeting 16S rDNA and ITS genes for bacterial, fungal and archae communities (Osborn et al., 2000; Fierer et al., 2005). Microbial functions were monitored by measuring enzymatic activities, catabolic profiling using MicroResp™ technique (Campbell et al. 2003) and gas measurements. Field measurements first showed significant changes in soil processes, resulting in reduced CO_2, and increased CH_4 emissions from compacted soils. Compactions significantly reduced abundance of microorganisms and to a less extend microbial activities. It also persistently altered the structure of the microbiota. This study demonstrates that physical soil disturbance induces profound and long-lasting changes in the soil microbiome and associated soil functions.

P 3.1.67

Soil nitrous oxide, carbon dioxide and methane emissions from oil palm cultivation in the Brazilian Amazon

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Introduction

Biodiesel production expands in Brazil and oil palm has been cited as an important raw material. Besides a greenhouse gas (GHG) emissions comparative analysis between biodiesel from palm oil and fossil diesel, is also necessary to consider the GHG emissions in the agricultural cultivation of oil palm. So, the objective of this study was to evaluate the soil emissions of nitrous oxide (N_2O), carbon dioxide (CO_2) and methane (CH_4) after fertilizer application and from decomposition of crop residues in mature stands of oil palm.

Material and Methods

The study was carried out at Agropalma Farm (48°46'W, 2°27'S) located at Para State, Brazil. The experiment was conducted in an oil palm area with 25 years old. We tested three representative doses of nitrogen (N) fertilization with ammonium sulfate (24, 51 and 69 kg N ha^{-1}) and compared to a control (without N fertilization). We collected GHG samples once a day during 25 days in August 2010. In order to measure the GHG emissions from decomposition of crop residue deposited in inter rows of oil palm, we also collected GHG samples in the frond piles during 10 consecutive days. Measurements of GHG emissions were performed using the static chamber technique with two-piece that were inserted 5 cm into the soil. The gas samples were manually taken from closed flux chamber. The N_2O, CO_2 and CH_4 concentrations were determined by a gas chromatography (GC - Shimadzu 2014). The fluxes of each gas were calculated by measuring alteration in concentration as a function of incubation time. Data were submitted to analysis of variance and the means of treatments were compared by Tukey test ($p \leq 0.01$) using the Statistical Analysis System (SAS), version 9.2.

Results

The soil N_2O emissions after N fertilization were higher than in the control, but we didn't found differences between the N doses applied (p2O ha^{-1} for Doses 1, 2, 3 and control, respectively. The ammonium sulfate applied in the soil showed an emission factor ranging between 0.21 and 0.50 %, lower than 1% proposed by IPCC. We didn't find difference in CO_2 emissions between the doses of N applied (p2 emissions rates. The cumulative values were 198.100, 203.175, 167.003 and 200.136 kg CO_2 ha^{-1} for Doses 1, 2, 3 and control, respectively. The soil CH_4 cumulative emissions after fertilization were lower in Dose 2 (0.012 kg CH_4 ha^{-1}) than in the others treatments (0.141, 0.103 and 0.131 kg CH_4 ha^{-1} for Doses 1, 3 and control, respectively). The CH_4 emissions reported in our results was positive for the evaluated period, agreeing with others studies with N fertilization (Metay et al. 2007). Considering that the N application is done twice a year, the maximum annual GHG emissions in oil palm plantations for this agricultural operation is 0.192 kg N_2O ha^{-1}, 406.349 kg CO_2 ha^{-1} and 0.282 kg CH_4 ha^{-1} (Table 1). The frond piles represent 20% of the total area cultivated with oil palm. Our results showed that the annual GHG emissions from decomposition of crop residues were 0.387 kg N_2O ha^{-1}, 1,462.146 kg CO_2 ha^{-1} and 0.433 kg CH_4 ha^{-1} (Table 1). The constant input of fresh residues from the harvest operations every 22 days associated to the soil and climate conditions observed in the study site promotes the intense GHG emissions to the atmosphere.

Table 1. Annual emissions of N_2O, CO_2 and CH_4 from nitrogen fertilization and decomposition of crop residues at oil palm plantations in Brazilian Amazon.

Treatment	N_2O	CO_2	CH_4
	------------------------------kg ha^{-1} $year^{-1}$------------------------------		
Control	0.068	400.273	0.262
Dose 1 (24 kg N ha^{-1})	0.186	396.201	0.282
Dose 2 (51 kg N ha^{-1})	0.192	406.349	0.024
Dose 3 (69 kg N ha^{-1})	0.188	334.006	0.207
Frond piles	0.387	1,462.146	0.433

Conclusion

Our results indicate that fertilizer application in mature stands represent low GHG emissions associated to oil palm production. However, is important to evaluate the fertilization during the 25 years of plant life cycle. Our results suggest that decomposition of frond piles is an important compartment to be considered in studies including all the life cycle of oil palm. This insight about GHG emissions in oil palm production in Brazil provides valuable information to be used in life cycle assessments of biodiesel production using this oilseed as raw material.

Reference

Metay, A., Oliver, R., Scopel, E., Douzet, J.M., Moreira, J.A.A.M., Maraux, F., Feigl, B.J., Feller, C., 2007. N_2O and CH_4 from soils under conventional and no-till management practices in Goiânia (Cerrados, Brazil). Geoderma 141 77-88.

P 3.1.68

Alteration of soil organic matter composition during mineralization as affected by charcoal amendment

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Introduction Biochar is increasingly being proposed as a strategy to promote carbon (C) sequestration into the soil. Brazil is the world's greatest charcoal producer (approximately 10 million tons year^{-1}), supplying mainly the national steel industry. However, 15% of this amount is lost as charcoal fines because they are suitable for the steel industry due to clogging of the gas flow, which reduces the efficiency of the blast furnaces. In this context, charcoal fines could be possibly tested as a mean to enhance C sequestration when applied to the soil.

Objectives The objective of this study was to investigate the impact of charcoal fines on the soil organic matter (SOM) composition and to elucidate how the SOM composition of a charcoal amended soil changes as a result of the microbial activity.

Materials and Methods. Charcoal was originated from the pyrolysis (approximately 350°C) of *Mimosa scabrella* (a hardwood Brazilian specie). About 45% of the charcoal particles were smaller than 2mm. In this experiment two treatments were evaluated: Cambisol without charcoal - control treatment (T1) and Cambisol amended with 40 Mg ha^{-1} of charcoal (T4). Firstly, the charcoal was spread on the soil surface and thereafter it was incorporated to the soil up to 10 cm. The soil samples were collected at 0 - 5 and 10 - 20 cm depths 20 months after charcoal application. The soil samples and the pure charcoal samples were incubated in an aerobic environment during 165 days and the temperature was maintained at 20°C. Before and after the incubation, the SOM and the charcoal were analyzed by solid-state ^{13}C nuclear magnetic resonance spectroscopy (^{13}C NMR). The charcoal specific contribution to each C group was estimated in T4 samples by virtual NMR fractionation.

Results The main alteration of SOM composition was observed at 0 - 5 cm depth. The charcoal increased the SOM aryl C contribution from 12% to 18% (Table 1) and that was assigned to the high charcoal aromaticity (Table 1) and to its greater concentration at 0 - 5 cm depth, despite being incorporated down to 10 cm. At 10 - 20 cm depth the SOM composition showed no remarkable differences between T1 and T4. The virtual fractionation of the NMR spectra indicated that the aryl C compounds from the charcoal were preferentially preserved in T4 during the SOM decomposition. Before the incubation the charcoal specific contribution to the aryl C intensity at 0 - 5 cm depth was estimated as 8%, and after the incubation it increased to 13% (Figure 1).

Conclusions The charcoal shifted the SOM composition towards a higher aromaticity and the preferential preservation of charcoal aromatic compounds during mineralization indicates that the charcoal has a potential to be used as a mean to enhance C sequestration into the soil. However, further experiments mainly at a long-term scale are strongly recommended to consolidate the potential use of the charcoal fine residues as a mean to increase the slow soil organic matter pool.

Figure 1

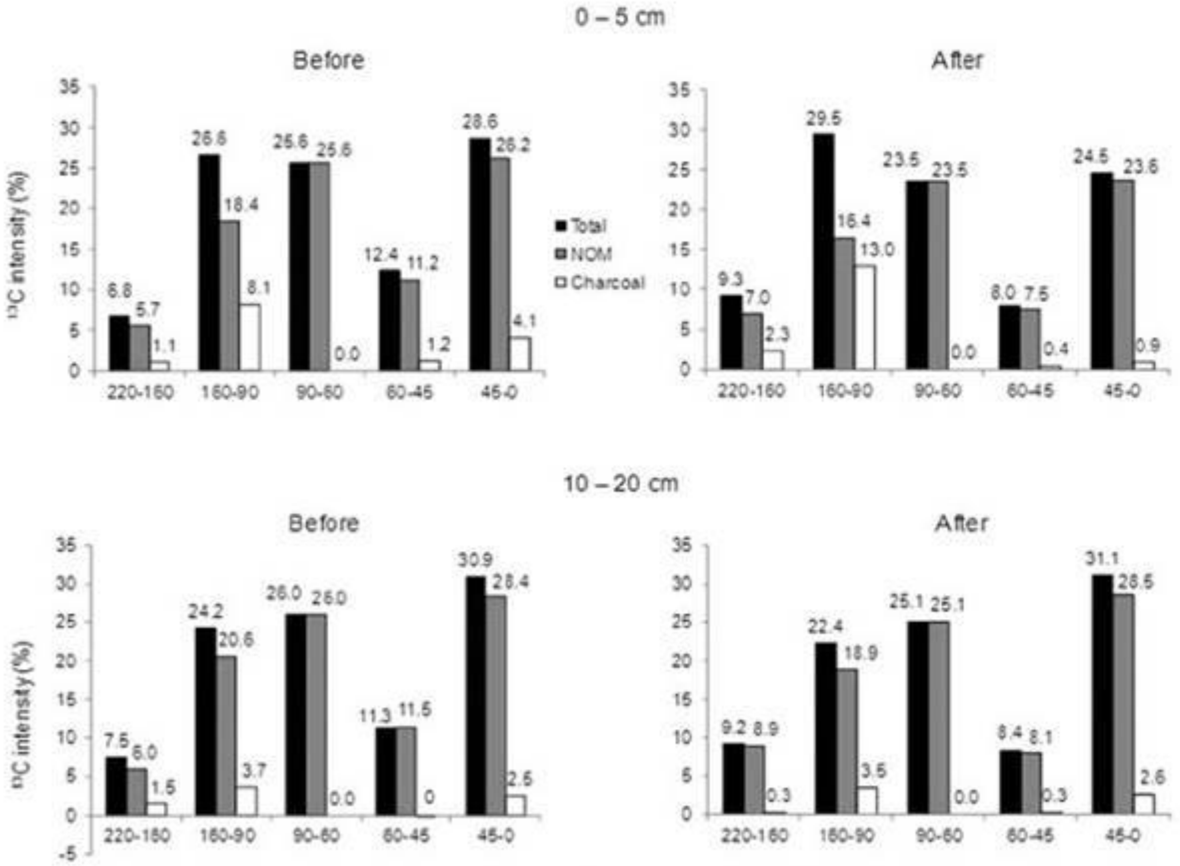

Figure 1. Specific contribution of the charcoal in T4 at 0 - 5 and 10 - 20 cm depths, before and after the incubation experiment, to the different chemical shift regions of the ^{13}C NMR spectra. Black bars indicate the total organic matter (native organic matter + charcoal). Gray bars indicate the contribution of the native organic matter and white bars indicate the contribution of the charcoal to the total signal intensities.

Figure 2

Table 1. Comparison of the relative intensity distribution (%) of solid-state ^{13}C NMR spectra, before and after 165 days of incubation, of the charcoal and of the Cambisol samples collected at 0 - 5 and 10 - 20 cm depth after charcoal application.

Soil depth	Treatments[a]	Incubation	Carboxyl C 220-160 Ppm	Aryl C 160-110 ppm	O-Alkyl C 110-60 ppm	N-Alkyl C 60-45 ppm	Alkyl C 45-0 ppm
cm					%		
0 - 5	T1	Before	6.5	12.3	38.3	12.9	30.0
		After	8.4	12.7	35.2	9.0	28.3
		Before - after	-2	0	3	4	2
0 - 5	T4	Before	6.8	17.9	34.3	12.4	28.6
		After	9.3	23.1	29.9	8.0	24.5
		Before - after	-3	-5	4	4	4
10 - 20	T1	Before	6.5	13.4	37.0	12.4	30.7
		After	9.5	13.4	33.8	8.7	30.5
		Before - after	-3	0	3	4	0
10 - 20	T4	Before	7.5	15.4	34.8	11.3	30.9
		After	9.2	15.5	32.0	8.4	31.1
		Before - after	-2	0	3	3	0
-	Charcoal	Before	6.1	78.3	8.0	2.7	4.9
		After	6.7	66.6	11.6	3.8	10.5
		Before - after	-1	12	-4	-1	-6

[a] T1 = 0 Mg ha^{-1} (control); T4 = 40 Mg ha^{-1}.

P 3.1.69

On Quantifying Active Soil Carbon using Mid-Infrared Spectroscopy

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Soil organic matter (SOM) is derived from plant or animal residues deposited on or in soil and is in various stages of decomposition and mineralization. While total SOM is a measure of soil quality, it is very a very general measure since SOM consists of many constituents having a range of residence times, which depend upon a number of factors. One operationally defined SOM fraction is “active soil carbon” (ASC) and is thought to consist of readily oxidizable SOM that is responsive to management practices and may provide one measure of “soil health” closely associated with soil biological activity. ASC can be a useful indicator to assist farmers and land managers in their selection of soil management practices to maintain ASC or to build total SOM. ASC has generally been measured using permangate oxidation. However, others have used mid-infrared spectroscopy (MIR) to develop partial least squares (PLS) regression models to estimate total organic carbon (TOC), particulate organic carbon (POC) and other soil characteristics with good success. Consequently, we hypothesized that we could use MIR to estimate ASC. Here we report on a method that uses MIR and chemometric signal processing to quantify TOC and ASC on a variety of soils collected serially and seasonally from across the United States. High temperature oxidation was used on the samples to quantify TOC and permanganate-oxidizable carbon was as a measure of ASC. These data were used to calibrate and validate MIR-based regression models to estimate TOC and ASC using MIR alone. Signal processing included 1st or 2nd derivatives of the spectra with various gaps in the data and continuum removal. We used a goodness of fit statistic (R^2) and the lowest root mean square error of prediction (RMSEP) to select the most robust models. The best predictive model for TOC was built on spectral data following continuum removal with 9 components, and had an R^2 of 0.95 and RMSEP of 0.18. For ASC, the model was built on a 1st derivative of the spectral data with a gap of 8, and had an R^2 of 0.86 and RMSEP of 0.22. We conclude that ASC can be reasonably estimated with MIR. When combined simultaneously to estimate ASC and other soil properties (e.g., TOC, POC), MIR becomes a cost effective means of characterizing large numbers of samples and could easily provide repeatable measures of the status and condition of soil carbon due to land management practices. Our presentation will describe the details of developing these models and the utility of ASC as one metric for quantifying “soil health”.

P 3.1.70

Organic carbon variation with depth along a toposequence under sub-humid climate: a case study in Zeramna valley, Skikda area, Algeria

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Introduction

In Algeria, few studies investigated organic matter status and its evolution according to ecological factors. This work aimed to study carbon variation in depth in comparison to carbon content in top soil, both its distribution in in particle-size fractions and its susceptibility to mineralisation.To capture the variability induced by land use effect and soil types, this study was carried out on atoposequence under sub-humid climate, Zeramna valley in Skikda area, Algeria.

Methods

Four pedological profiles were characterized along the toposequence (NothWest -NothEast): P1 under oak trees in the middle of slope, horizons 0-30/30-90 cm/source rock; P8 under olive trees, located on piedmont, horizons 0-30 cm/30-85 cm/ source rock ; P13 under citrus trees, located on the alluvial plain,(horizons 0-30 cm tillage/30-55/55-80/80-100 cm); P17 under citrus trees, near to the river in the alluvial plain, horizons 0-30 /30-70 /70-100 cm. According USDA classification, these soils are Inceptisol (P1 and P8), Mollisol (P13) and Entisol (P17).Soil organic matter (SOM) was characterized by measuring both carbon content and carbon stock. To determine the different forms of the SOM, physical SOM fractionation was performed in top soil and sub-soil. Soil carbon mineralisation was also studied in control condition (28°C, -0.03 MPa) at all soil horizons.

Results

In term of C content in depth, the results showed that total organic carbon (TOC) content decreased with depth (R^2=0.54, n=33, p<0.001) for all soil profiles, but these variations differed according to soil profile position within the toposequence. TOC drastically decreased with depth in mountain soil Inceptisol profiles (P1 and P8), while gradually decreased in alluvial plain soil profiles (Mollisol P13 and Entisol P17). P1 presented highest TOC content in top soil (26.7±1.97g C kg-^{1} sol) and most drastically decrease in sub-soil (5.4±0.5 g kg-1 sol). However, in the P13 profile, TOC decreased gradually with depth, ranging from 14.5±1.29g kg^{-1} soil in top soil to 9.3g kg-^{1} soil in the deepest horizon (p <0.021).TOC content in P17 profile decreased less gradually with depth than P13.This results underlined soil type effects (shallow soils with A/C/R horizons in mountain profiles and deep soils in alluvial plain). In top soil horizon (0-30cm), carbon content is important in P1 and decreased gradually with toposequence.

In addition, C stock in 0-100 cm deep showed that a highest soil C stock is in the Mollisol alluvial plain (P13), with 168±11 tha-^{1}, the lowest C stock is recording in P1. This result confirmed the contribution of organic and inorganic materials inputs from the river to the soil. This accumulation may act as a carbon sink. However, the C stock in 0-30 cm is highest in P1 mountain profile with 73±10 t C ha^{-1} soil, and decreased gradually with the toposequence in alluvial plain. These carbon richness observed in top soil mountain profiles is due to trees forest effect and a large installation for herbaceous vegetation

Moreover, physical SOM fractionation showed a few C content of SOM particle size fraction in sub soil comparing to topsoil. In mountain profiles (P1, P8) and in sub soil horizons, C content accumulated in fraction < 2µm with 6.9 g kg-1 sol in P8 and 3.54 g kg^{-1}in P1, whether more than 60 % of TOC. Against, in the plain alluvial profiles (Mollisol P13 and Inceptisol P 17), C content accumulated in 2-20 µm fraction recording respectively 6 and 3.9 g C kg-1 soil, whether 47% and 58% of TOC. However, in top soil horizons, C content are important in mountain profiles, whose its accumulated in > 50 µm fraction recording the highest content in P1 and P8 with 10 and 5 g kg-1 soil, against 2 to 3 g kg-1 soil are observed in alluvial plain. C content in fine fraction (< 2µm) is stable in all sub soil profiles.

Carbone mineralization declined rapidly with soil depth (R^2 = 0.43, n = 33, p<0.05). On 0-100 cm deep, C mineralized of all C stock is important in Mollisol P13 among profiles, recording 4.23 t C-CO_2 ha-^{1}, whether 2.52 % of C stock total. The lowest C mineralized is observed in mountain profile P1 with 1.87 t C-CO2 ha-1 soil.

Conclusion

Alluvial plain Mollisol presented a veritable C sink, whose C content accumulated in 2-20 µm fractions. This stock is exposed more for less with C mineralization.

P 3.1.71

Soil carbon turnover under biofuel crop treatments on fine and coarse-textured soils

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Predictions of land use change effects on soil carbon dynamics are limited by interactions between vegetation, management activities, and soil properties. Biofuel production is being pursued in the U.S. as an alternative source of energy to fossil fuels, with the dual goal of achieving energy independence and reducing carbon emissions from fossil fuel combustion. In order to satisfy the second goal, biofuel crop production should be managed more sustainably than conventional industrial agriculture, which has contributed to large soil carbon and nutrient losses, release of greenhouse gases, and pollution of aquatic ecosystems. The type of biofuel crop (monoculture vs diverse species, annual vs perennial plants) and management practices (tillage vs reduced or no-till, residue harvest) can affect the amount and spatial distribution of carbon inputs into the soil profile. Root biomass and depth can affect microbial activity and the stabilization of soil C.

We studied the effects of five years of biofuel crop treatments on soil carbon stock, microbial respiration rates, and C turnover in surface (0-10 cm) and deeper soils (25-50 cm). The four vegetation treatments measured include some of the most common bioenergy crops in the U.S.: continuous corn (an annual grass), switchgrass (a perennial monocrop), native prairie (perennial multiple species) and poplar (woody species). To better understand how soil-specific properties, such as texture, affect the response of soil C pools to different crop management, we compared the same cropping systems on two different soils, Mollisols at the University of Wisconsin- Madison's Arlington Agricultural Research Station and Alfisols at Michigan State University's Kellogg Biological Station. We took advantage of the availability of archived soils collected in 2008 at the start of the biofuel field experiment and five years later in 2013 to measure changes in bulk soil carbon content and its residence time using radiocarbon. In addition, we conducted a one-year laboratory incubation at ambient temperature of 2008 and 2013 soils to estimate potential changes in the size and turnover rate of microbially-available C pools using biological fractionation. To determine whether microbes were accessing different pools after five years of management, we measured ^{14}C-CO_2 for two of the four treatments at one time period during the incubation.

Corn, switchgrass, and native prairie treatments had smaller total carbon stocks in surface soils at both sites after five years of management, which included no till. The biologically available or active pool, was more sensitive to management and an earlier indicator of changes to soil carbon dynamics compared to other pools or bulk soil. The size of the active C fraction was greater in the coarser-textured soil whereas the fine-textured soil contained more C associated with the slow-cycling pool. Preliminary analyses of the radiocarbon data suggest that microbes are accessing different pools of C under the different biofuel crops, especially after five years. The response of soil C pools differed between the two sites on very different soil types, suggesting that predictions of the sustainability of biofuel crop production may vary from site to site. This research highlights the importance of long-term monitoring to better understand mechanisms underlying soil carbon dynamics and their response to land management, especially on different soils.

P 3.1.72

Cummulative effect of long-term soil management on quality of humus as a source for soil respiration

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Approximately 8.7 Gt of carbon (C) are emitted to the atmosphere each year on a global scale by anthropogenic sources. In this context, soil organic carbon (SOC) and it's potential to become a 'managed' sink for atmospheric carbon dioxide (CO_2) has been widely discussed in the scientific literature. Agronomists have long recognized the benefits of maintaining and increasing SOC, including labile and humic acid (HA) fractions of soil organic matter (SOM). The aim of this study was to assess the impact of contrasting long-term soil managements on soil humus quantity status and soil respiration intensity.

A long-term field experiment was set up at the Institute of Agriculture, Lithuanian Research Centre for Agriculture and Forestry, on *Endocalcari-Epihypogleyic Cambisol (CMg-p-w-can)* (55°23'50'' N and 23°51'40'' E). Trial was established in 1999 and it is running till now. Soil texture was loam (sand 53.7%, silt 32.6%, clay 13.7%). Field experiment had a split-plot design in four replications. Residue management (with and without straw) was as main plot, while tillage (conventional - CT, and no-tillage - NT) was as sub-plot. Since trial establishment the rates of mineral NPK fertilizers were calculated according to soil properties and projected yield of the crops grown.

A composite soil samples for chemical analyses were prepared from six samples collected per each treatment from the 0-10 and 10-20 cm soil depth. Humus carbon content was determined by Tyurin titirimetric method modified by Nikitin. Soil organic matter (SOM) was fractionated into 3 humic acid (HA) and 4 fulvic acid (FA) fractions by Ponomariova and Plotnikova version of classical Tyurin method. CO_2 fluxes were measured with a portable infrared CO_2 analyzer (IRGA) attached to data logger (Li-6400-09).

Straw returning significantly increased soil SOC content in 0-10 cm layer under both CT and NT compared with straw removing. NT resulted in significantly higher ($P \le 0.01$) SOC contents in 0-10 cm soil layer than CT. More favourable ratio of HA and FA fractions within the whole plough layer was under NT than CT. In addition, SOM in general was richer in HA under NT than under CT. This means that the quality of humus under NT has improved. Soil CO_2 e-flux significantly responded to measurement date and residues management practices and their interaction (P2 was by 32% higher from the soil without crop residues than with them. CO_2 e-flux averaged across residues handling under NT was 18 % lower than in CT.

P 3.1.73

Green manure combined with reduce tillage improves soil structure and promotes physical-chemical stabilization of OC

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Introduction

Soil CO_2 emission is influenced by different mechanisms of stabilization of soil organic matter: physical inaccessibility, chemical recalcitrance and biotic mechanisms. Decomposition and mineralization of SOC depends on the frequency and intensity of soil disturbance by tillage practices. In this sense, agricultural management practices that improve soil structure have the potential to favor the OC physical-chemical protection and the subsequent reduction of CO_2 emissions. In addition, the improvement in soil structure is strong linked to the incorporation of easily decomposable OC which might cause a rapid stimulation of the soil microorganisms accompanied by significant increase in aggregate stability (Helfrich et al., 2008). The objective of this study was to stablish the effect of different management practices on several soil physical properties related to soil structure, and its relations with changes in the stock of several functional SOC pools.

Material and Methods

The experiment was carried out under an organic, rain-fed almond orchard located in a semi-arid area of Southeast Spain. For 14 years the habitual soil management in the study area was reduced tillage (RT) to control weeds. In 2008, two different SLM practices were applied: i) reduced tillage plus green manure (*Vicia sativa* L. + *Avena sativa*) (RTG) and ii) no-tillage (NT). The experimental design consisted of nine plots (49 m length and 7 m width) in a randomized-block design, with three replicates for each treatment. Soil samples were collected in 2012 from 0-5, 5-15 and 15-30 cm depth. The following soil physical properties were analyzed: Bulk density (BD), total porosity (TP), distribution of soil pores and mean weight diameter, as an indicator of soil aggregate stability (MWD). Five OC fractions were obtained with the method proposed by Zimmermann et al. (2007): dissolved organic carbon (DOC), particulate organic matter (POM), sand and stable aggregate (S+A), silt plus clay sized (S+C) and chemically-resistant carbon fraction (rSOC) to calculate SOC stocks.

Results

The conversion from RT to RTG lead to an improvement in soil structure: slight decrease of BD and an increase of about 30% in the MWD values. In addition, in RTG the stock of the sensitive pools (DOC + POM) increased about 30% respect to RT at 0-15 cm depth (2.4 and 1.8 Mg C ha^{-1} for RTG and RT, respectively), while the OC stock in the slow pools (S+A and S+C) increased about 55% respect to RT at 5-15 cm depth (11.1 ± 0.6 Mg C ha^{-1}, 7.1 ± 0.4 Mg C ha^{-} for RTG and RT, respectively). The conversion from RT to NT, lead to a significant increase in BD and reduction in total soil porosity and macro-porosity (pores > 30 µm) together with an increase of about 30% in the MWD values. However, the stock of the sensitive, slow and passive pools did not experience any change respect to those obtained in RT through the soil profile.

Conclusions

The combination of reduced tillage and green manure incorporation was shown as a good option for improving soil structure and increase SOC stocks due, basically, to: i) green manure suppose a continuous and decomposable energy source to microorganism which contributes to physical-chemical stabilization through physical protection by occlusion in aggregates, and chemical stabilization by interaction with mineral particles; and ii) minimum tillage favors the OC stabilization in deeper layers due to the incorporation of plant material. Cessation of tillage was not a good strategy in order to improve soil structure and promotes OC stabilization at the short-term.

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P 3.1.74

Monitoring Changes of Organic Carbon Pool in Arid Region using Remote Sensing Case Study, Middle Nile Delta

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The current work studies spatial and temporal variation of soil carbon pool and their affective factors in middle Nile Delta, using remote sensing data (Landsat , ETM 1990 and Landsat8 , 2015). 26 soil samples have been collected from different soil types of the investigated area.This study was conducted to clarify relationships between the SOCP in the upper 30-cm mineral soil and site variables soil texture under different land-uses in Mediterranean region. Linear correlations and regressions were computed between NDVI and organic matter where the results showed a strong relationship (r2 = 0.62) between NDVI and organic matter .The overall average of SOCPs at cropland is equal to 53.85 t/ha. The result showed also decreasing of SOCPs by 285421.16 Mg C with decreasing of cropland area by 5300 ha.

Keywords:

NDVI , Remote sensing, SOCPs, GIS

P 3.1.75

The influence of deciduous tree species on soil carbon dynamics and sequestration in temperate forests

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1. Introduction

Temperate forests store 300 billion tons of organic carbon (C). In Europe, 800 million tons of C are fixed annually in the forest, ~40% in the soil and ~60% in the living biomass. One goal of sustainable forestry is to ensure and increase the C sink function of the forest ecosystem. While the tree species effect on soil C stocks is well documented, the change in soil C stocks over time, i.e. the carbon sequestration, remains largely unknown. The factors controlling this process are not yet fully understood. A new DFG-project started in June 2015 that will address these open questions. The objectives and the experimental design of this project will be presented.

2. Objectives

The main objective of the study is to detect the effect of important tree species (*Fagus sylvatica* L., *Quercus* spec., *Fraxinus excelsior* L., *Acer pseudoplatanus* L., *Tilia* spec and *Picea abies* L. Karst.) on (1) soil C-sequestration and (2) C dynamics in forest soils.

3. Materials & methods

(1) In the present study, the forest soil under the four tree species in six Danish common garden experimental sites (Kragelund, Mattrup, Wedellsborg, Vallø, Viemose and Odsherred) which had been analyzed for its topsoil C stocks in 2004/2005 by Vesterdal and colleagues will be re-sampled in fall 2015 and spring 2016 (n=15 per species plot). Thus, possible changes in soil C stocks can be directly quantified.

(2) In order to disentangle mechanisms responsible for the tree species effect on forest soil C stocks and stock changes, intensive studies will be conducted at the experimental site “Mattrup”. Climate parameters, topsoil moisture and topsoil temperature will be continuously measured for two years. Soil respiration will be measured every second week for two years using a LI8100 survey chamber. Trenched areas will allow differentiating between rhizosphere respiration and basal respiration of soil organic matter. It will be checked whether the relative proportions of these sources to the total soil respiration are dependent on tree species and thus contribute to different carbon stocks in the forest floor. Soil moisture, temperature and respiration will be repeated five times in each species plot.

4. Results

Initial results from the first two month (July-Sept 2015) of respiration measurements will be presented on a species level.

5. Conclusion

Since the quality of C input to the soil (root deposition, litterfall), topsoil C stocks and soil chemical properties (pH, nutrients) were found to differ between species in previous studies, species related differences on soil C dynamics and sequestration are expected. A gain of knowledge on the processes responsible for tree species related differences on soil C stocks and sequestration is expected.

P 3.1.76

Effects of soil erosion on soil organic carbon dynamics under low input /low productivity farming fields of Indian Himalaya: Experimental study of the effect of vertical soil mixing on soil respiration rates

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Introduction

Soil erosion-induced redistribution of soil organic carbon (SOC) alters the lateral and vertical distribution of SOC stocks and this has been shown to perturb the net exchange of C between soil and atmosphere (Dungait et al, 2013), although there remains debate concerning the net direction of C exchange. Retrospective studies, using caesium-137 (^{137}Cs) and SOC inventories have found that long-term (half-century) erosion-induced SOC redistribution on agricultural land has driven a carbon sink (Van Oost et al, 2007). Furthermore, in a recent study of *in situ* spatial variation in soil respiration in a landscape subject to sustained high magnitude erosional forcing, Li et al. (2015) demonstrated that SOC stocks in the eroding landscape were in equilibrium and, therefore, that erosion was driving a sink of atmospheric C (assuming that at least some of the eroded C was sequestered elsewhere in the landscape). The lateral redistribution of SOC stocks appeared to be the main control on spatial variation in respiration rates.

Although attention has focussed on lateral redistribution, vertical redistribution of SOC between the plough and sub-plough layer of agricultural soils as a result of erosion and deposition may also have an important effect on respiration rate and SOC 'stability'. At depositional sites, SOC-rich material transported into deeper horizons may respire at a lower rate due to physical separation from the most biologically active surface environment. On the other hand, incorporation of relatively young SOC into deeper horizons may enhance mineralisation of the pre-existing deeper SOC in a priming effect. At erosion sites, SOC-poor material transported towards the surface may sequester new SOC but mixing with material richer in SOC may again see priming and more rapid consumption of formerly buried SOC. This uncertainty defines the objectives of the study.

Objectives

To study the effect of erosion- and deposition-induced vertical soil mixing on soil respiration rates

Materials and methods

In this study we explore the effect of vertical mixing on respiration in an experimental setting using soil from low input/productivity and highly eroding agricultural fields from the foothills of the Indian Himalaya. The effect of vertical mixing was studied by measuring soil respiration in samples from eroding and depositional profiles collected from near surface (0-0.15m) and at depth (0.45-0.6m) in isolation and as 1:1 mixtures. Samples were incubated at 20^{o}C and 60% water holding capacity for 1 year and 19 respiration measurements (cf. Karhu, 2014) were made over the year (at weekly intervals at first and then increasing intervals through the year). The effect of mixing on respiration rate was determined by comparing the measured rate of respiration from the mixed samples with an expected rate of activity based on the measurements made on individual depths (average respiration rates of 0-0.15m and 0.45-0.6m samples).

Result

After one year of incubation the mixed soils from the depositional profiles released more C than expected based on the respiration rates of the individual layers, although this difference was only statistically significant in one of the two sites (Fig 1). For the other landscape positions, no differences were observed between measured and expected respiration rates for the mixed samples. We interpret these results to indicate that decomposition rates in deeper but organic rich layers within depositional areas are low because of lack of readily decomposable C and that mixing the horizons primed decomposition of the deep layer C. Thus, burial represents a process through which C stocks can accumulate in eroding landscapes by protecting organic matter from priming effects.

Conclusion

Reduced decomposition rates associated with burial in deposition areas may be important in contributing to soil erosion causing a net C sink.

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Figure 1

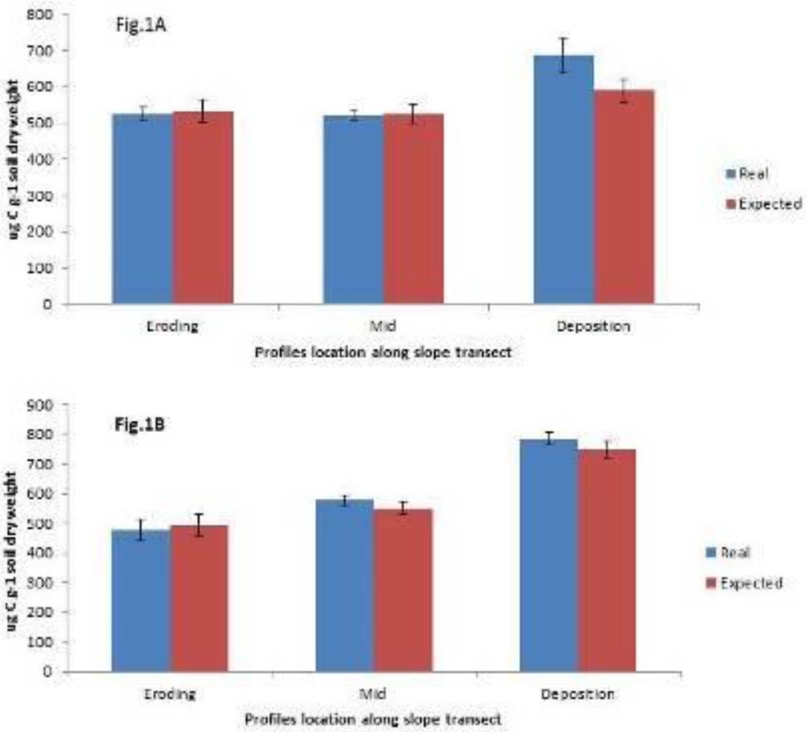

Fig 1. Comparison of total C release real vs expected from one year incubated mix soils of Eroding (E), mid (M), and Deposition (D) profiles (Site1- Fig.1 A and Site 2-Fig 1B). Error Bars are ± SE (n = 5)

P 3.1.77

Effects of soil erosion on soil organic carbon dynamics under low input /low productivity farming fields of Indian Himalaya: retrospective assessment and process investigation

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Introduction

Globally soil erosion is the most widespread form of soil degradation. Soil erosion-induced redistribution of soil organic carbon (SOC) alters the spatial distribution of SOC (Dungait et al, 2013) and this perturbs the net exchange of C between soil and atmosphere. Nevertheless, the direction of net exchange with the atmosphere (source or sink) that results from this perturbation remains a matter of debate (VanOost et al., 2007, 2008; Lal and Pimentel, 2008). Although retrospective studies, using caesium-137 (^{137}Cs) and SOC inventories have found that long-term (half-century) erosion-induced SOC redistribution on agricultural land has driven a carbon sink (Van Oost et al, 2007), it has not yet been determined whether this is a universal phenomenon. The majority of the latter studies have examined temperate and mechanised high input/high productivity agricultural landscapes. Therefore, there is a need to apply the same approach to investigate subtropical and low input/productivity agricultural systems, where net return of biomass is expected to be lower and this may limit sink strength.

Objectives

To quantify erosion-induced soil carbon redistribution and the net effect on carbon exchange with the atmosphere in low input/productivity and highly eroding agricultural fields from the foothills of the Indian Himalaya.

Materials and Methods

The study was conducted in the foothills of the Indian Himalaya, near Dehradun, Uttarakhand. Agricultural sites were selected at 3 elevations (550, 700 and 1600 m.a.s.l.). At the upper 2 sites subsistence agriculture is practiced, with maize and wheat the dominant crops and cultivation by chisel plough and animal traction. At the lowest elevation site, mechanized commercial agriculture is undertaken with maize and wheat again the dominant crops. At each site, 3 fields were selected for sampling; and within each field transects (typical length ca 60 m) were placed to extend from erosional to depositional areas. Due to the lack of stable uncultivated land in the region, level cultivated fields were used as reference sites. Along each transect, 6 soil pits were opened and profiles of depth incremental (0-10, 10-20, 20-30, 30-50, 50-70 & 70-100 cm) soil samples (of known cross-sectional area) were collected from 3 faces of each pit (to provide 3 replicate measurements). The samples were prepared for analysis by drying, grinding and sieving to 2mm. All analysis was undertaken on <2mm fraction. Total C was measured by dry combustion and ^{137}Cs by gamma spectrometry on untreated samples. In addition, total C was measured on sub-samples in which inorganic carbon had been removed by acid fumigation. These data were used to derive total C, SOC and 137Cs inventories (mass or activity per unit area) for all soil pits. These data were used in retrospective assessment of erosion-induced perturbation of C dynamics using the approach of Quine and Van Oost (2007).

Results

The spatial distribution of soil organic carbon is strongly related to the multi-decadal pattern of net soil redistribution as evidenced by ^{137}Cs inventories (Fig. 1). For example, in the field illustrated in Figure 1, the most eroded pit (ca 70% ^{137}Cs loss) is characterised by an SOC inventory of 3 kg C m^{-2}; whereas the pit showing the highest net deposition (ca 75% ^{137}Cs gain) has an SOC inventory of ca 5 kg C m^{-2}. The SOC inventories in the fields appear to be close to equilibrium.

Conclusions

There are consistent and clear patterns of ^{137}Cs and SOC redistribution at the field scale. These demonstrate the significance of erosion for spatial patterns of SOC and the net exchange of C between soil and atmosphere.

Preliminary data suggest that the fields are close to dynamic equilibrium - i.e. little/no additional carbon is found within the fields, which implies that exported C may contribute to a sink.

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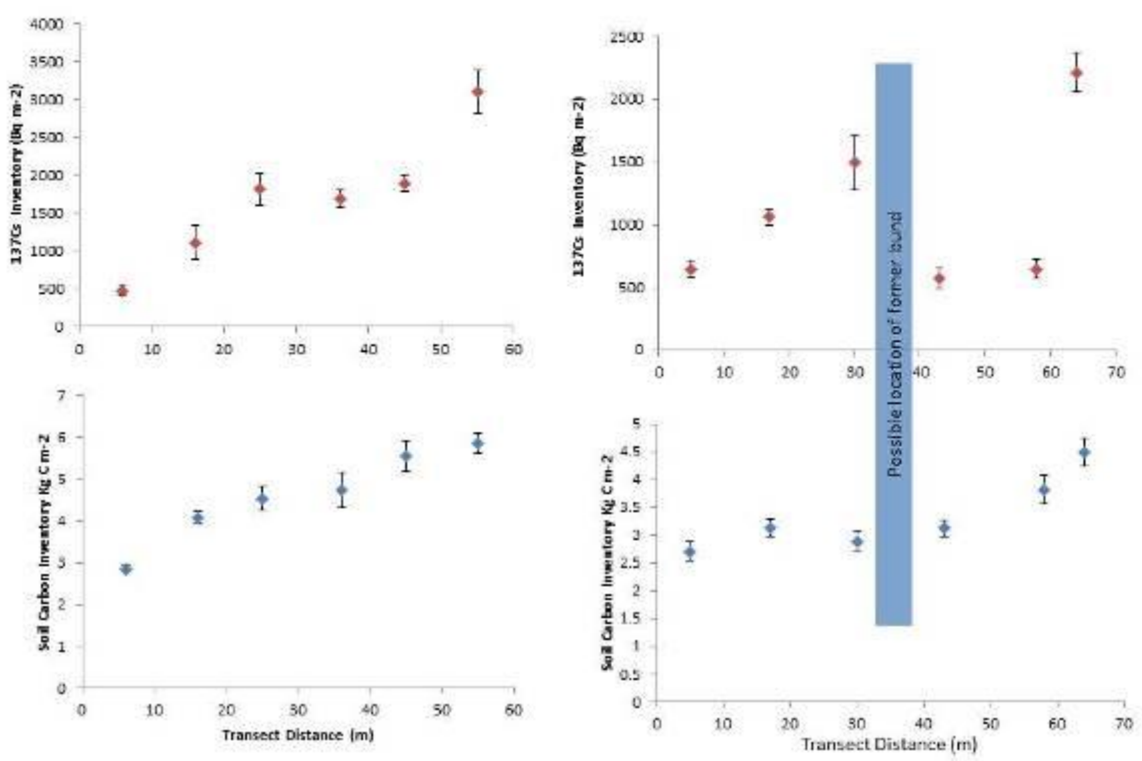
Figure 1

Fig 1. Along transect variation in 137Cs (upper) and C (lower) inventories in Site 2(Left side) and Site 1(Right side). Error Bars are ± SE (n = 3)



P 3.1.78

Soil formation, carbon exchange, and soil metabolite profiles along a vegetation gradient at King George Island, Maritime Antarctica

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1. Introduction

Biota, and particularly, vegetation is one of the state variables of soil formation. In the past decade the paradigm emerged that above- and belowground processes are tightly interconnected, e.g. plant photosynthesis is strongly linked with soil respiration. Chronosequences provide an ideal opportunity to study the impact of vegetation on the processes of soil formation, including weathering and organic matter accumulation.

2. Objectives

At Maritime Antarctica, glacier retreat chronosequences define sites that represent an increasing level of trophic complexity as a result of vegetation development. The objectives of our study were to follow soil horizon formation, quantify soil carbon stocks and exchange with the atmosphere along a vegetation gradient at King George Island, and to link this to the *in vivo* soil biological activity.

3. Materials & methods

We have chosen a rock outcrop (11-71 m asl) of the Collins glacier, representing a deglaciation chronosequence ranging from <200 yr B.P. to ~7200 yr B.P., with pronounced succession from algaea and cyanobacteria (i.e., bare soil) over lichens and mosses to the evolutionary younger vascular plant *Deschampsia antarctica*. Along this chronosequence, soils were described and volume-based soil samples were taken. Net ecosystem exchange and soil CO_2 efflux was measured with a Licor LI-6400 XT using a transparent and opaque chamber, respectively, and soil carbon and nitrogen was determined by dry compustion (Elementar vario MICRO cube). Soil metabolites were extracted by a chloroform/methanol/water mix and measured as TMS derivatives at a Perkin Elmer GC Autosystem XL with TurboMass Gold quadrupole mass spectrometer. Raw data were processes by TurboMass Gold V.4.3 software, followed by data analysis using SIMCA-P+ software package.

4. Results

Along the chronosequence, there was a clear gradient of increasing formation of Fe and Al (hydr)oxides with increasing soil age. The development of a cryptic A horizon to well developed and increasingly thick O and A horizons at the older sites reflected organic matter accumulation. Consequently, the soil organic carbon stock increased from 0.2 kg m^{-2} at the bare soil to 3.6 kg m^{-2} under *D. antarctica*. An increasing photosynthetic activity from algae and cyanobacteria to *D. antarctica* is mirrored by increasing soil CO_2 efflux rates along the chronosequence from 0.2 ± 0.1 to 2.8 ± 0.9 µmol m^{-2} s^{-1}.

Untargeted metabolomics was applied to study the link between the successional stage of soils and its biological activity *in vivo*. The soil metabolome database included 89 samples (observations) and 386 metabolites (variables). Application of multivariate statistics (SIMCA+) allowed selecting 57 metabolites as potential markers discriminating the soil horizons. The relative abundances of almost all sugars, lipids and organic acids decreased with soil depth. However, comparison of the metabolite profiles of different soil horizons along the succession gradient revealed a prominent difference in the composition and relative content of plant and microbial metabolites. The contribution of vascular plants on the soil metabolome could be clearly determined.

5. Conclusions

Our study revealed that even under extreme environmental conditions vascular plants add considerably to soil development, large soil carbon storage and a relatively high rate of CO_2 efflux. Further, metabolomics showed to be a promising tool to assess the biological activity of soil *in vivo* and to distinguish the contribution of plants and microorganisms to soil formation processes.

P 3.1.79

SOM decomposition *vs*. stabilization in permafrost soils - First results of a long-term incubated microcosm experiment

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In times of global climate change the possible transition of permafrost soils from an important terrestrial carbon sink to a source has become a major scientific focus. In these soils, global warming could not only lead to an enhanced degradation of soil organic matter (SOM) due to increased microbial activity. In contrast, the new formation of mineral surfaces and increased soil aggregation resulting from increased soil aeration may also stabilize SOM in the midterm.

To address SOM decomposition *vs*. stabilization in its temporal dynamic we conduct a long-term incubating microcosm experiment. Under controlled temperature and soil water contents we evaluated processes of SOM-mineral interactions at aggregate surfaces, e.g. SOM mediated aggregation of newly formed mineral surfaces on primary particles. These processes considerably influence further soil-architecture development presumably triggering the response of SOM mineralization in different soil compartments to increasing temperatures. The chosen experimental setup and the use of stable isotope labelling (^{13}C and ^{15}N) enables us to differentiate between degradation of freshly added *vs.* old organic matter.

To evaluate these processes, topsoil (Ah) and permafrost (PF) material from a well described Yenissej tributary catchment in Siberia (67°28.933' N, 86°25.682' E) were collected during a field campaign in August 2013. This catchment is part of the high latitude forest tundra ecotone, representing wide areas of northern Russia and is typically characterized by non-continuous permafrost. For this, it is highly vulnerable to SOM losses due to climatic change.

The two contrasting soil horizons are incubated after an amendment with homogenously ^{13}C and ^{15}N labelled grass material at 5 and 15 °C with field equivalent bulk density and a water holding capacity of 60%. The small-scale spatial distribution of ^{13}C labelled organic material on micro aggregate surfaces and primary particles is currently investigated by NanoSIMS. To assess microbial biomass C chloroform fumigation extraction (CFE) was applied, and subsequently the amount of ^{13}C of the extracts will be determined to trace the fresh added OC from the litter to the microbial biomass. Furthermore, regularly taken CO_2 gas samples from the headspace have been measured to evaluate degradation kinetics of old and fresh SOM.

After 90 days of incubation a first comparison of the two substrates reveals that microbial C (C_{mic}) values of the Ah material incubated at 5 °C were higher as for PF at the same temperature. This trend was also observed at 15 °C. In both soil horizons, there was no temperature dependency of C_{mic}. In contrast, CO_2 efflux was larger at the higher temperature. Q_{10} values of soil and grass born C differed between the different substrates; PF showed a higher temperature dependency for grass born C (grass: 2.09; soil: 1.27) than Ah material (grass: 1.55; soil: 1.64).

Our results on degradation kinetics indicate that the potential of PF to stabilize fresh organic carbon (OC) is more limited as compared to Ah horizons and that this freshly incorporated OC is very sensitive to temperature increase in these horizons. This could be due to the fact that both horizons differ in the quality and thus degradability of their SOM pools. Both effects could also be explained by microbial communities differing in their reaction on temperature and composition. For this we will investigate the phospholipid fatty acid (PLFA) finger print of both horizons. We conclude that even though old SOM in permafrost is not as vulnerably to temperature increase as SOM in Ah horizons, this effect is overcompensated by their very limited potential to stabilize new OC.

P 3.1.80

Land-use change effect on soil carbon, nitrogen and microbial biomass carbon in Chitwan, Nepal

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Land use change especially from forest to intensive agriculture for sustaining livelihood causing severe consequence like soil erosion, land slide, flood etc. Focusing on agriculture production completely ignore soil as well human health. However, organic farming system is emerging as a new hope which will be the good soil management alternative to manage current land use change crisis as well as soil degradation problem. We examined the effect of three land use i.e. forest, organic and conventional farming on carbon, nitrogen and microbial biomass carbon in different depth (0-100 cm with 10 cm in interval) of soil in Chitwan, Nepal. Our results showed that both carbon and nitrogen content (%) was high in organic farming than conventional farming and forest. However, the trend decreased in lower depth. Significantly high microbial biomass carbon (µg C g^{-1} soil) was found in organic farming than conventional farming and forest but the trend was inconsistent in lower depth. Carbon stock was higher in upper depth (0-10 cm) than lower depth (10-20 cm). Moreover, organic farming was significantly higher than conventional farming and forest in both depth (P

P 3.1.81

Future changes of soil carbon stocks in forests on a landscape scale: Coupled simulations of carbon dynamics evaluated with the second National Forest Soil Inventory in northern Germany

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Models of C dynamics are rarely validated at the landscape scale, since the number of repetitions of soil organic matter inventories on this scale is still not very high. The German National Forest Soil Inventory (NFSI) in the federal states of Lower Saxony, Saxony-Anhalt, Brandenburg, and Hesse from the years 1990 - 1993 and 2006 - 2008 provides the occasion to compare model predictions with independent observations.

We used the dataset of 185 variables from a systematic 8 by 8 km grid of 648 forest plots from the NFSI in subsequent steps:

1. Identification of the statistically most significant variables determining soil carbon stocks (SCS, forest floor + 0-90 cm) in a maximum likelihood based approach: Only eight of the variables related to regional attribution, environmental conditions, climate, soil type, hydraulic properties, tree properties, geology, and physicochemical soil properties were considered significant. The resulting Generalized Additive Model (GAM) of soil carbon stocks (r^2 = 0.7 for 1990 - 1993 and 0.8 for 2006 - 2008) was used for a regionalization of the observations for the North German lowlands (project "Sustainable land-use management in the North German lowlands").

2. In order to reduce uncertainty of model predictions, the SCS-GAM was subsequently used to initialize and test two independent dynamic soil carbon models: Yasso07 (Tuomi et al. 2009 and 2011) and the RothC-26.3 model (Coleman & Jenkinson 2005). These models were applied to a transect of 4 model regions in the North German lowlands reflecting the West-East gradient of atmospheric deposition and climate. The results of both models were compared with the results of the SCS-GAM in these regions for the years 2006 - 2008.

3. Both verified models were applied to land use change scenarios and a climate projection from 1991 to 2070 to take into account the uncertainty from selected models. The climate projection used is based on the emission scenario RCP 8.5 and the median runs of three global circulation models (INM-CM4, ECHAM6, and ACCESS 1.0) that were downscaled with the regional model STARS II (Orlowsky et al. 2008). The land use scenarios for the forest sector reflect three different political goals: near-natural silviculture, conservation of biodiversity, and climate protection.

Simulation results over 80 years show spatially different patterns of SCS trends in the four model regions. While a general tendency of decreasing SCS is visible in all scenarios, the biodiversity oriented scenarios had slight advantages when compared to the others.

P 3.1.82

Stand scale spatial distribution of soil organic carbon stocks and macronutrients in permafrost-affected soils with different active layer depths

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Introduction

Permafrost thaw, as a result of global warming, influences soil organic carbon (SOC) stocks, decomposition rates and nutrient availability by increasing soil temperature and microbial activity, and by altering soil aeration and interactions between soil organic matter and mineral surfaces. Therefore, permafrost thawing increases the release of carbon into the atmosphere and macronutrients, such as nitrogen (N) and phosphorus (P), into the ecosystem. Consequently, leading to the changes in spatial distribution and variability of SOC and N stocks and soil P fractions.

Objectives

This research focused on the influence of permafrost thawing on spatial distribution and variability of SOC and N stocks and soil inorganic P fractions in permafrost-affected soils with various active layer depths and under different vegetation communities in the forest tundra zone of the northern Siberia. Moreover, soil moisture, bulk density, organic layer thickness, pH and soil structure were used to define their influence on the distribution of SOC and N stocks, and soil inorganic P fractions at studied sites.

Materials & methods

In total, 732 spatially referenced soil samples were taken with a soil corer (50 mm Ø, 34 cm long) at six sites with different active layer depths at the Little Grawijka Creek catchment (67°28.933’ N, 86°25.682’ E), Krasnoyarsk Krai, Russian Federation. For obtaining a high spatial resolution, 122 soil samples were collected at the main, centered and nested locations at each site from two depth increments, 0-10 cm and 10-30 cm (Fig. 1).

Figure 1. Sampling design, showing main (red squares), centered (yellow circles) and nested (green triangles) sample locations.

The SOC and total N concentrations were measured using a dry combustion method on the Vario EL cube (CHN mode) analyzer. Four P fractions, precisely $NaHCO_3$-P_i; NaOH-P_i; HCl-P_i and H_2SO_4-P_i fractions, and the total P were measured using the sequential P fractionation method, based on the Hedley et al. (1982) and modified by Kuo (1996), on a continuous-flow analyzer. The geostatistical approaches applied in R program (R version 3.1.3) were used to calculate the spatial distribution and variability of OC and N stocks, and soil inorganic P fractions.

Results

First results of our study showed that the C:N ratios and SOC and N stocks decrease with an increase in active layer depth. Likewise, we found significantly higher plant-available P concentrations in permafrost soils with a deeper active layer in contrast to shallow permafrost soils (Fig. 2). However, the total P concentrations were lower in soils with a deeper active layer (170-525 mg/kg) than with a shallow active layer (209-668 mg/kg). Moreover, permafrost thawing leads to a decrease in spatial variability of SOC and N stocks, and soil inorganic P fractions. Soil moisture and organic layer thickness have strong positive correlations with SOC and N stocks.

Fig.2. $NaHCO_3$-P_i concentrations in mg/kg at two studied sites with a shallow active layer and with no presence of permafrost (NP): 1) within the soil profile; 2) within 0-10 cm; 3) within 10-30 cm

Conclusion

In conclusion, permafrost thawing leads to an increase in availability of macronutrients, resulting in increased site-specific vascular species abundance at sites with a deeper active layer. Furthermore, an alteration in concentrations of the certain soil inorganic P fractions occurs due to permafrost thaw.

Figure 1

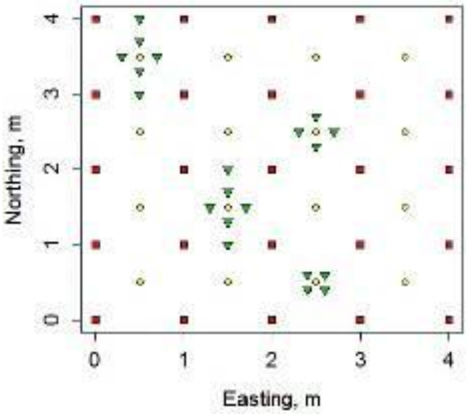
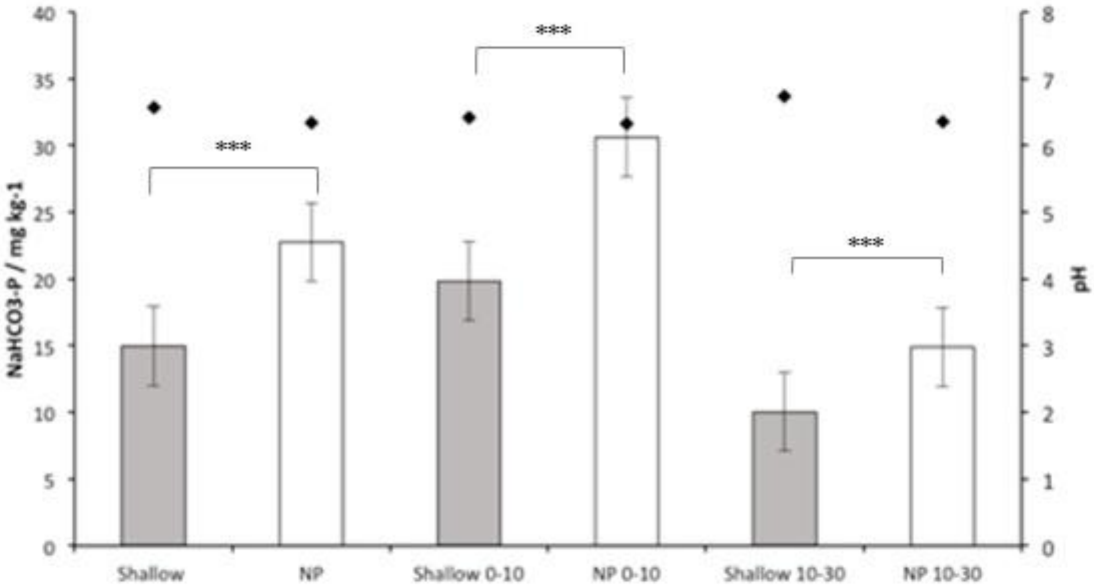


Figure 2



P 3.1.83

Agricultural Soils as Potential Sink of Soil Organic Carbon

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SOC is lost through cultivation at a current rate of loss of approximately 0.8 Pg C yr-1. However, C losses from agricultural soils can be reduced by 0.01 - 0.05 Pg C yr-1 and 0.025-0.037 Pg C yr−1 can be potentially fixed in soil through proper soil and land management. The objective of this study is, therefore, to determine the effect of years of crop cultivation vis-à-vis forest and plantation, on the SOC pool in the Irga watershed of Jharkhand, India.

The area is represented by two soil subgroups - Typic Haplustalfs and Typic Paleustalfs. 3 sites were chosen for each soil subgroup to represent 3 land uses (forest, plantation and mono-cropped area). The plantation and cultivated sites ranged in approximate age from 50-100 years since conversion to these land uses. Soil samples of each site was collected from depths of 0-10 cm and 10-20 cm. Particle size analysis was done by dry sieving; SOC content was measured using the Walkley and Black method; bulk density measurements were made by the core method for every 10-cm layer.

The highest SOC content was measured in the mango orchard in Dhanwar (226 Mg C ha-1). In Birni, however, cultivated land under paddy-fallow rotation recorded the highest SOC content (242 Mg C ha-1). Eucalyptus plantation recorded the least amount of SOC content. In the 0-20 cm depth, cultivated land in both the sites and mango orchard in Dhanwar showed an increase in SOC pool in comparison to forests (89.93-102.76 Mg C ha-1 and 135.11 Mg C ha-1, respectively).

The practice paddy-fallow rotation and the application of manure have led to an increase in the SOC pool in the plough layer of agricultural soils in the SOC-poor area. Thus the agricultural soils in the Irga watershed have the potential to sequester C through proper soil and land management.

Fig 1: SOC at 0-20 cm depth

Fig 2: SOC losses and gains from long-term plantation and cultivated land at 0-20 cm depth. Native forest has been used as a baseline.

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Figure 1

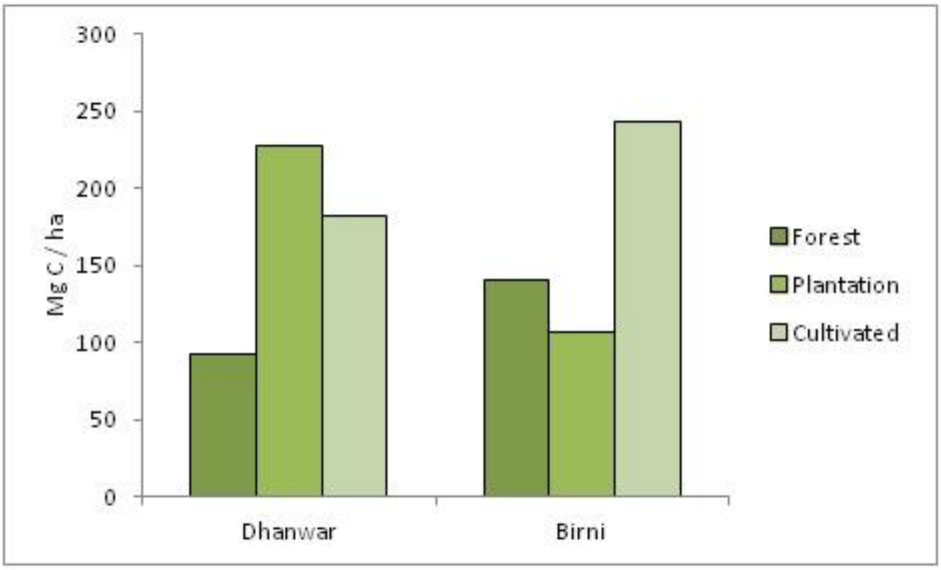
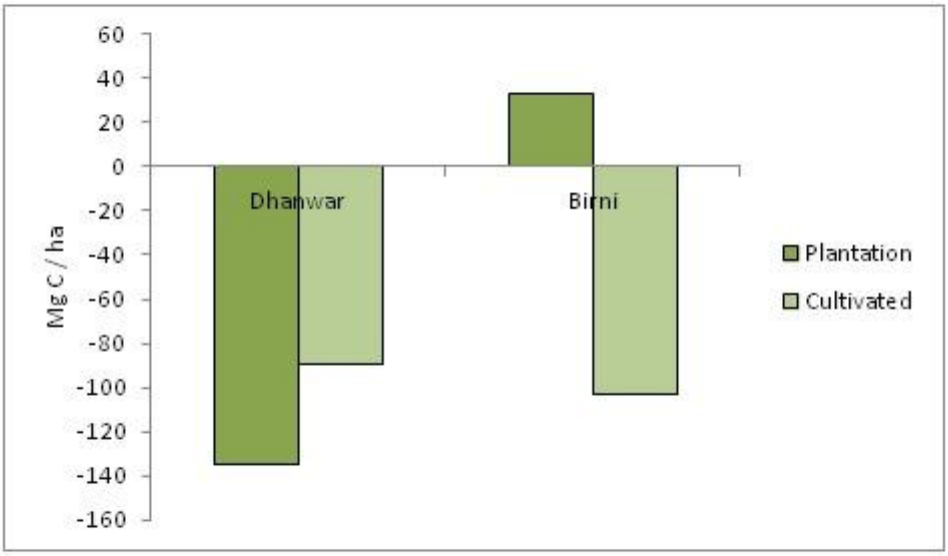


Figure 2



P 3.1.84

Influence of non-extreme and extreme changes in temperature and moisture on C mineralization in peats and peat soils

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Introduction

Peat and peat soils contain up to one-third of World Soil Carbon. About 8% of Russian territory is occupied by peats; about 42% of this is in the Western Siberia. About 14% of territory of Belarus is occupied by drained and non-drained peatlands. Climatic changes in the Northern Latitudes can promote mineralization of organic matter in peats and peat soils and CO_2 emission into the atmosphere. Extreme changes in temperature and moisture due to weather and seasonal changes and anthropogenic activity can stimulate mineralization as well. Mineralization increase can appear under thawing of frozen peats or as a consequence of peats drainage and flooding of drained peat soils. Due to fires huge amounts of CO_2 come to the atmosphere. Ash remaining above can provoke mineralization too.

Objectives

We aimed to evaluate sensitivity of C mineralizable pool of series of peats and peat soils to non-extreme changes in temperature and moisture, and to extreme changes: to frozen-thawing, to drying-rewetting, to thermal ashing.

Materials & methods

We performed our study with samples of non-drained high-moor sphagnum peat sampled in Tomsk region, Russia, under trees, shrubs and on swamp with organic carbon (OC) of 43.1, 40.9 and 43.4%, respectively, and water-holding capacity (WHC) of 910-1280 mass %, and on non-drained valley carex-cane peat sampled in Belarus Polesie under tree flora with OC of 35.1%, and on drained arable peat soils (OC= 31.2, 28.6, 22.2, 13.5 and 7.8%), WHC of 67-113 mass % as well. **1:** The samples were incubated for 150 days under 8 and 22°C and moistening of 10, 60 and 110% of WHC. Potentially mineralizable carbon pool (Cpm) was determined using data of cumulative C-CO_2 production by biokinetic organic matter fractionation technique. To assess influence of change in temperature by 10°C and moisture by 10 mass % on change in mineralizable SOC pool size we calculated temperature (Q_{10}) and moisture (W_{10}) coefficients. We used Q_{10} and W_{10} to predict Cpm mineralization in the studied peats and peat soils under different hydrothermal conditions. **2:** The samples were incubated for 12 days under 22°C and 60% of WHC, then were frozen under -15°C or drying under 65°C and next incubated for another 12 days under 22°C and 60% of WHC, evaluating C-CO_2 production. Four cycles of frozen-thawing and drying-rewetting were carried out. **3:** To imitate conditions of crowning fire the samples were thermally ashed under 700°C and oxygenation. Then initial (control) samples, ashed samples and samples with ash were incubated for 150 days under 22°C and 60 % of WHC, evaluating C-CO_2 production. **4:** Extractability of C from the samples by 0.5n K_2SO_4 and 0.1n NaOH was evaluated. **5:** CO_2 emission into atmosphere from surfaces of the peats and peat soils was assessed.

Results

We found that Cpm of high-moor peats was sensitive to temperature and non-sensitive to moisture (Q_{10}=2.0±0.6, W_{10}=1.0±0.0; Cpm increased in 1.2±0.4 times in 10-110 % of WHC diapason). Cpm of valley peat and peat soils was sensitive to temperature and moisture (Q_{10}=2.3±0.5, W_{10}=1.5±0.4, Cpm increased in 6.9±3.5 times in 10-110 of WHC % diapason). Prognostic potential C mineralization in the peat and peat soils for non-frost period under average long-term weather conditions agree with field CO_2 emission. Extractable C can agree quantitatively with prognostic potential C mineralization under different hydrothermal conditions. CO_2 production during repeated cycles of drying-rewetting was more than during cycles of frozen-thawing. Temperature oscillations during frozen-thawing decreased microbial biomass and promote C substrate utilization similar in high-moor and valley peats. Due to the drainage and plowing of valley peat soils decrease in C content was accompanied with increase in percentage of extractable C, Cpm and microbial biomass.

Thermal sensitivity of drained soils Cpm related positively with OC content (r=0.837), Q_{10} in diapason 8-22°C changed from 1.5 to 2.6. Ashed samples absorbed CO_2, mixed samples produced less CO_2 than initial (control) samples, with exception of high-moor peat from swamp.

Conclusion

We conclude that due to warming C mineralization in non-drained high-moor and valley peat can be increased. Mineralization of drained valley peat soils due to increase in moisture content can be increased manifold. After crowning fireessential decrease in CO_2 production by valley peat and unessential decrease or increase in CO_2 production by high-moor peats is possible.

Acknowledgment

This work was supported by the Russian Foundation for Basic Research, project nos. 12-04-90023-Bel_a, 14-04-90025-Bel_a, 14-04-01575_a and RF President Grant for Leading Scientific Schools State Support no. 6123.2014.4.

P 3.1.85

Effect of Tillage and Crop Rotation on Soil Organic Carbon on the Shale Derived Soils of the Western Cape, South Africa

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INTRODUCTION

Minimum soil disturbance, crop rotation with diverse crops and stubble retention are important management strategies that will ensure the success of conservation agriculture (CA). Adoption of CA practices will normally increase soil productivity and crop performance, however not instantaneously. The aim of this study was to quantify the effect of soil disturbance and crop rotation on soil organic carbon, active carbon and C:N relations in the soil.

MATERIALS AND METHODS

Three crop rotations namely: continuous wheat (WWWW), medic-clover/wheat/medic-clover/wheat (McWMcW) and lupin/wheat/canola/wheat (LWCW) were allocated to main plots and replicated four times at the Langgewens (Moorreesburg) Research Farm (-33.276822 18.703171) near Moorreesburg and Tygerhoek (-34.148100 19.902800) near Riviersonderend. Each main plot was subdivided into four sub-plots allocated to four tillage treatments, namely: zero-till (CT) - soil left undisturbed then planted with star-wheel planter, no-till (NT) - soil left undisturbed until planting and then planted with a tined, no-till planter, minimum till (MT) - soil scarified March/April and then planted with a no-till planter and conventional tillage (CT) - soil scarified late March/early April, then ploughed and planted with a no-till planter. Soil organic carbon, active carbon and C:N as influenced by the treatment combinations were recorded. Depth distribution of organic carbon was determined at 0-5, 5-10, 10-15 and 15-20 cm soil depth.

RESULTS AND DISCUSSION

No significant differences between parameters tested were recorded at Tygerhoek. At Langgewens however, organic carbon content in the no-till in the WMcWMc system decreased from 2.14 % in the 0-5cm soil layer to 0.54% in the 15-20cm layer. The mixing effect of the tine- and plough treatments in the conventional tillage treatment is clear as mean soil organic carbon content in the conventional-till treatment decreased from 1.38 % (0-5cm) to 0.67 % (15-20 cm). Active C was higher in McWMcW and WWWW compared to WCWL. Significantly lower active C was recorded for CT with no differences between other tillage treatments tested. McWMcW (13.1) and CWLW (14.1) resulted in lower ($P=0.05$) C:N than WWWW (23.7). Tillage did not influence soil C:N at Langgewens.

CONCLUSIONS

Study showed that soil carbon dynamics differs between sites. At the Langgewens site the detrimental effects of soil disturbance manifested itself in lower organic and active carbon content, an observation not recorded for Tygerhoek.

P 3.1.86

C, N, P content in peat soils of oligotrophic bog (West Siberia)

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Peat soils due to the very slow organic matter transformation may use as indicators of climate change throughout its development during the Holocene. Peat soils contain a large amount of organic matter, which on 50 % is consist of C. Content of N and P are significantly lower, however, these elements play an important role in the primary productivity and transformation of organic matter.

The purpose of research was to examine the C, N and P content and its behavior in organic matter of peat soils in the process of transformation of plant residuals.

Objects and methods

The **objects** of the study were two peat soil profiles collected from ridge-hollow complex (RHC) (Bakcharskoe bog, Vasugan Mire, West Siberia). One of the peat soils was formed at the ridge while the second at the hollow. According to age-dating the soil at the hollow record at 5439 ca yr BP and at the ridge one - 2591 ca yr BP. The complete peat soil profiles of RHC are drilled underneath with 10 cm intervals. Each soil sample was subjected to the following analysis: measured the dry bulk density; determined the macrofossil plant remains; analyzed the content of carbon, nitrogen and phosphorus . Also the C, N, P content was analyzed in the plant tissues (*Carex rostrata, Scheuchzeria palustris, Sphagnum fuscum and Sphagnum magellanicum*) at the living plants and after three years of decomposition. The rate of decomposition of plants was studied using the litterbag technique. The age of the soil layers was estimated by radiocarbon dating at the Trofimuk Institute of Petroleum-Gas Geology and Geophysics SB RAS (Novosibirsk, Russia) and at the Institute of Monitoring of Climatic and Ecological Systems SB RAS (Tomsk, Russia). Also we calculated the next parameters:

the peat accumulation rate (PAR, mm yr^{-1})= H/T, where: H - the thickness of layer, mm; T - age of layer, yr;

the C (N, P) accumulation rate (g $m^{-2}yr^{-1}$) = ρ* PAR*C*10, where ρ - the dry bulk density (g cm^{-3}), C - element concentration (%), 10 - thickness of layer.

Results

Depth of peat soil at the hollow is 280 cm thick and at ridge one is 230 cm thick. According to soil stratigraphy, the both soil profiles more than 1 meter in depth are formed by oligotrophic with *Sphagnum species dominated* bog peat. Mineratrophic peat layers between 280 and 200 cm are presented by *Equisetum* and *Menyanthes trifoliate;* next is followed by layers consisting mainly of *Carex lasiocarpa*. Soil profile of ridge, between 0 and 90 cm consists *of Sph. fuscum,* next layers to 140 cm depth are deposited by *Sph. Magellanicum* peats, the bottom layers are presented by *woody* peats.

The average PAR of studied soils is 1.6 and 1.0 mm yr^{-1} at ridge and hollow respectively and varied from 0.2 to 2.2 mm yr^{-1} at ridge and from 0.19 to 2 mm yr^{-1} at hollow. The C, N, P accumulation rates in the studied soils at ridge and hollow were 54 and 30 $gCm^{-2}yr^{-1}$, 1.2 and 0.77 $gNm^{-2}yr^{-1}$ and 0.038 and 0.040 $gPm^{-2}yr^{-1}$ at ridge and hollow respectively. The C accumulation rates ware correlated with N and P accumulation rates in both soil profiles. The strong correlation between C and N accumulation rates in the soil at the ridge and between C and P accumulation rate in the hollow are observed. The average C:N:P ratio in the soils are 1322:29:1 (at ridge) and 825:25:1 (at hollow) these ratios are increased with depth in the both soil profiles.

The C, N, P contents in the peat-forming plants are different and changing during decay. All plant samples, C and N contents increase during three year decay an average by 13% and 40%, respectively with highest values in the sedge (19 and 65%) and lowest one - in the *Sph. magellanicum* (4 and 12%). The P content is reduced (from 42 to 72%) in all plant samples except of *Sph. fuscum* where the P content is increased.

The average C:N:P ratio in studied plants (except for *Sph. fuscum*) is 516:9:1 in an initial stage and is 965:23:1 after 3 years of decomposition that is significant lower than in corresponding peat layers in the soils.

Conclusion

We received the data C, N, P content and accumulation rates in the two peat soil profiles. The C, N, P accumulation rates in the studied soils at ridge and hollow were 54 and 30 $gCm^{-2}yr^{-1}$, 1.2 and 0.77 $gNm^{-2}yr^{-1}$ and 0.038 and 0.040 $gPm^{-2}yr^{-1}$ at ridge and hollow, respectively. In the both soil profiles, the C:N:P ratio is increased with depth. The significant correlation between the accumulation rates of N, P and C in both soil profiles are observed and suggested the role of N and P in controlling C accumulation. The C:N:P ratios in the peat-forming plants is always lower than the correspondence of peat layers in the soil profiles.

This work was supported by the Russian Foundation for Basic Research, project nos.15-05-06775/a

P 3.1.87

Effects of cover crops and no-till system on soil carbon sequestration and microbial activities under two nitrogen fertilization rates in Northern France

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Known for decades for its agronomic benefits, and widely used by farmers throughout the world, conservation agriculture struggles to be installed definitely in Europe. It was shown that tillage was responsible for the overall erosion of soil fertility. However, there is still a large debate about the real role of no-till in soil carbon sequestration. The aim of this study is to bring more knowledge in order to predict the responses of soil fertility to changes in soil management. An experimental design was established in 2010 in Northern France. Here, we measured soil organic carbon (SOC), soil total nitrogen (STN), microbial biomass carbon (MBC), community level physiological profiling (CLPP), CO_2 efflux and plant productivity. These parameters were measured in six treatments: no-till without cover crops (NT), no-till with cover crops 1 (NT CC1), no-till with cover crops 2 (NT CC2), conventional tillage without cover crops (CT), conventional tillage with cover crops 1 (CT CC1) and conventional tillage with cover crops 2 (CT CC2). Each treatment was conducted with nitrogen fertilization (Nx), or without nitrogen fertilization (N0) since the beginning of the experiment. In the treatments NT CC1 and NT CC2, SOC increased by 4 to 5 t.ha-1 while SOC decreased by 2 to 5 t.ha-1 in CT CC1 and CT over a five-year period. STN analyses show a significant difference between NT CC2 and CT CC1 both in Nx and in N0. For MBC, there is no significant difference between all the 6 treatments in Nx, while CT CC2 is significantly higher than CT in N0. CLPP results show that soils from NT CC1 and NT CC2 had a significant increase of carbon degradation activities, diversity and evenness. First results obtained from CO_2 efflux measurements suggest periodic increases of soil CO_2 content that are higher in NT CC1, NT CC2, CT CC1 and CT CC2 than in NT and CT. There is no significant effect of soil tillage and cover crops on yield and total biomass in Nx, but yields and total biomass are significantly higher in CT CC1 and CT CC2 than in NT without cover crop in N0. We can conclude that no-till allows to maintain a stable SOC content, and provides a protection against the erosion of soil fertility in Northern France. But, no-till needs to be associated with cover crops that allow a carbon sequestration and improve the functional microbial diversity.

Keywords: Agrosystem, Carbon sequestration, Microbial activities, CO_2 efflux, Productivity

Figure 1. Changes in SOC and STN contents in the 0-10 cm soil layer of the different treatments over a five-year period without nitrogen fertilization (N0). Values are means ± standard error. Means followed by the same letters do not differ significantly ($P < 0.05$) according to Kruskal-Wallis test.

Figure 2. Categorized substrates utilization pattern (using Biolog Eco plates) of soils sampled from the different treatments after five years of experiment without nitrogen fertilization (N0). Values are means ± standard error. For the total average well color development, values followed by the same letters do not differ significantly ($P < 0.05$) according to Kruskal-Wallis test.

Figure 1

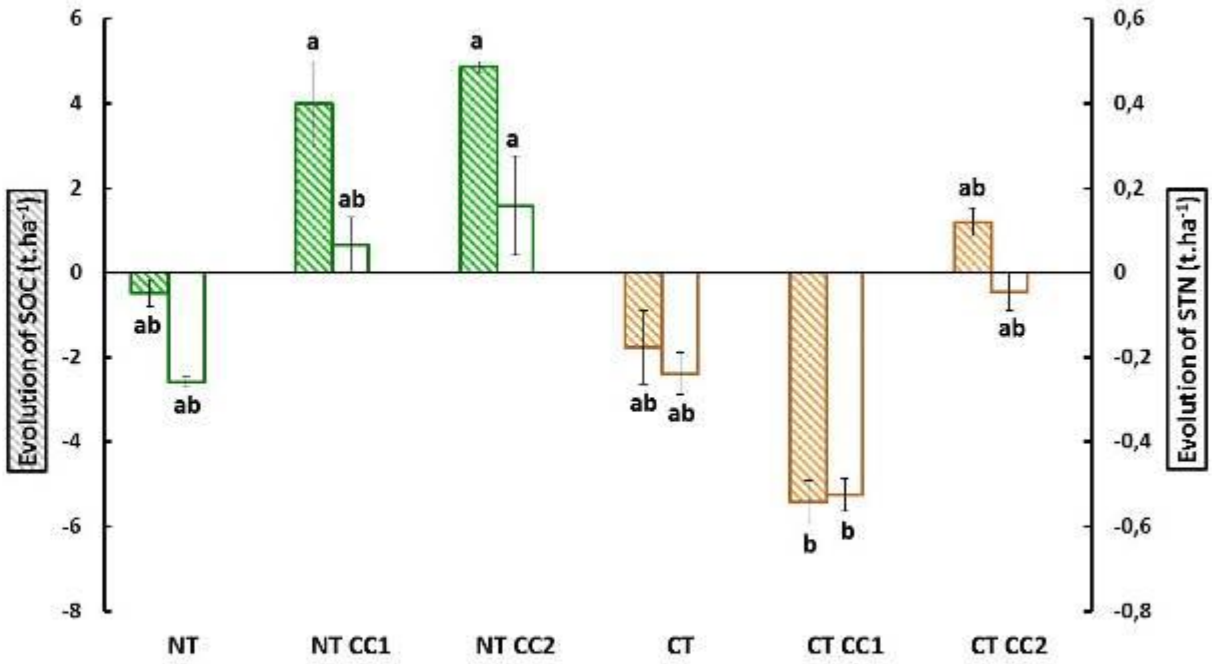
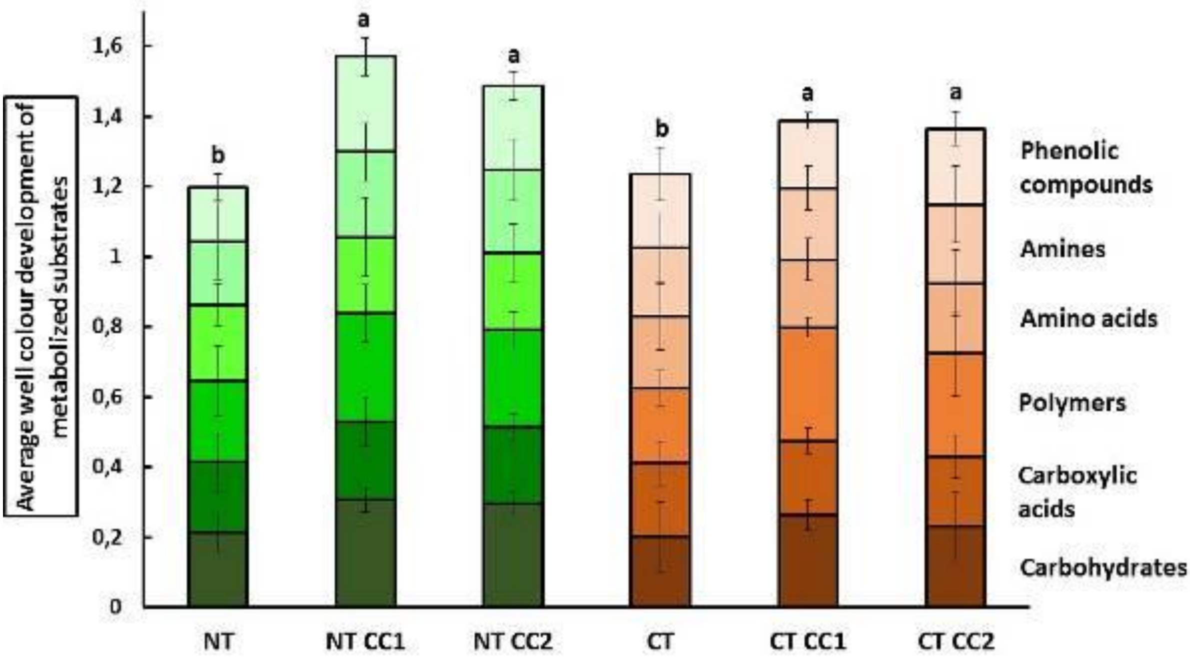


Figure 2



P 3.1.88

Long-term effect of tillage and crop rotation practices on soil organic C in the Swartland, Western Cape, South Africa

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INTRODUCTION

Soil organic C (SOC) can be regarded as one of the most important indicators of soil health, and accumulation of SOC an important component of sustainable agriculture. Little is currently known about the long-term effect of cultivation practises on SOC in the semi-arid Swartland region of South Africa, an important grain production area. Thus the aim of this study was to investigate the effect on commonly used tillage and crop rotation practices on soil organic matter distribution in the Swartland.

MATERIALS AND METHODS

The trials were conducted on the Langgewens Research Farm near Moorreesburg, Western Cape. Two 20-year long-term trials are in progress, one in its 8th year (site A: soil quality study) and another in its 19th year (site B: cropping systems). The Site A trial involves three 4-year crop rotation systems, wheat monoculture (WWWW), wheat-medic/clover-wheat-medic/clover (WMcWMc) and wheat-canola-wheat-lupin (WCWL). Three tillage treatments were studied namely, no-till (NT) - soil left undisturbed until planting, minimum till (MT) - soil scarified late Mar and conventional tillage (CT) - soil scarified late Mar then ploughed. All crops are planted with a no-till planter. The Site B trial consists of four 4-year crop rotations all under no-tillage: wheat monoculture (WWWW), wheat-medic-wheat-medic (WMWM), wheat-medic/clover (WMc) and a wheat-medic/clover with an additional grazing on salt bush (WMcSB). Natural vegetated soil acted as reference SOM content in the area. Soil samples were taken shortly after wheat planting in 2014, at four depths: 0-5 cm, 5-10 cm, 10-20 cm and 20-40 cm. Total soil C and N (%) was determined using dry combustion.

RESULTS AND DISCUSSION

At site A (8th year) at the 0-10 cm depth, the WMWM under NT had the highest %C (1.8%), while WCWL under CT had the lowest (0.6%). The NT and MT treatments had the highest C% at the 0-10 cm depths, whereas, the CT had the highest C% at the 10-20 cm across all crop rotations. This can be attributed to increased physical disturbance in the topsoil but deeper incorporation of residues in CT. The %C differences between tillage systems were most pronounced in 0-5 cm depth. The WMWM rotation generally had the highest C% at all soil depths compared to the WWWW and WCWL systems, across all tillage treatments. This can be attributed to less soil disturbance and denser rooting system of the medics.

At site B (19th year) under NT, WMWM had the highest C content at 0-5 cm (2.7%), but the lowest %C in the 5-40 cm depth (0.4-0.6%), while the WWWW had the lowest %C at the 0-5 cm (1.7%), but the highest %C in the 5-20 cm depth (0.5-1.3%). This can be attributed to greater extent of soil disturbance in the topsoil for WWWW than for WMWM.

CONCLUSION

The greatest differences in %C between tillage and crop rotation treatments occurred between 0-10 cm. At these depths MT and NT treatments were found to have the highest C contents. However, at 10-20 cm depth, CT had the highest C content. Systems containing medics tended to have the highest C contents. Extent of surface disturbance and rooting density appear to have the strongest impact on SOC contents in these soils.

*Keywords: c*onservation agriculture, soil carbon, tillage, crop rotation

P 3.1.89

Changes of organic matter quality and quantity in Bavarian soils

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Climate change will have profound impacts on the organic matter and thus on the functionality of soils. The predicted rising temperatures in Bavaria might lead to an increased decomposition and release of soil carbon into the atmosphere, which would reduce a number of important soil functions. Information about the effect of rising temperatures on different fractions of organic matter is however limited.

In this study we analyse different soil fractions in order to differentiate between functional soil organic matter pools. Sensitive fractions could be used as early warning indicators related to expected changes of total organic matter storage and recommendations of optimised management practices could be made. Furthermore results could be used to verify soil carbon and climate models.

For our approach we use archived soil samples from about 120 long term observation sites with constant management practises. The long term observation sites are distributed over Bavaria and comprise forest, grassland and agricultural systems. These sites have been sampled in the middle of the 80's for the first time and then approximately every 10 years. Potential changes in organic matter quality over the last 30 years can thus be directly related to climate change.

This dataset provides a unique possibility to investigate the effect of rising temperatures on the organic matter storage of soils in different land uses.

P 3.1.90

Explanation of regional long-term changes of SOC content in Poland

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Introduction

Soil organic matter (SOM) determines many soil functions and, depending on the conditions, it can release or sequester carbon dioxide. The changes in soil organic carbon (SOC) stock might become intensive due to climatic and land use changes or simplification of crop rotation. There is a significant knowledge gap on long term SOC changes in agricultural soils as response to agricultural production systems.

Objectives

The paper presents the study aimed at correlating long term changes of SOC with organizational changes occurring in Polish agriculture within lat 50 years. Detailed objectives oft eh stude were: (i) to evaluate changes in SOC stocks in agricultural soils of Dolnoslaskie voivodeship over the last 50 years (1960-2013), (ii) to determine driving forces of SOC evolution, (iii) to forecast SOC responses to agricultural management in future.

Materials & methods

The case study comprise 1800 km^2 of south-east part of Dolnoslaskie province. The area of CS has a very favorable agro-climatic conditions for cropping, especially for most requiring plants such as: wheat, barley, corn, rape, sugar beet, therefore these crops now dominate in the crop rotation. Prevailing soil types are: cambisols and luvisols and the textures are silt and silty loam. The soil organic matter content is not high and oscillates around 2%. Within the area of the Case Study, 94 soil profiles are located measured for SOC contant in 60- and 70-s of the 20 century. Comparative soil analysis in the same profiles have been performed in 2013. The impact of agricultural production systems on SOM was estimated by linking changes in the content of C-org with organizational changes in agriculture and climatic changes over a long time period 1960-2010. Agronomic data were extracted from National Agricultural Census of Poland for specific years (1960, 1969, 1979, 1988, 1996, 2002 and 2010) and it included data on crop rotation, yields, livestock density at resolution of village. Soil and climatic data were then uploaded to Roth-C model along with data on C input to soil calculated from the agronomic data. The Roth-C modelled changes in C stock linked to transformations in agriculture and climate change. Soil profile analizes were used to validate the model outputs through comparison of initial and current SOC content.

Results

Based on the model organic C stock, after slight decreasing in ’80 and ’90, started to increase from the beginning of XXI century. Despite substantial reduction of animal production and manure application, probable reason of OC accumulation can be high input of plant residues, especially straw of cereals, rape and corn grown for grain. The outputs of the model correspond to results of resampling of soil profiles, where in the most of profiles certain increase in SOM content was found after 50 years. The R2 between modelled and measured soil C content was 0,56.

Conclusion

Long term changes in SOC stock can be modelled at regional level if detailed soil, climatic and agricultural data can be collected. Certain limitations for such modelling and further validation of the model are linked to resolution of agronomic data that should be connected to soil and climatic information. In certain regions loss of animal production, resulting in lack of manure, is counteracted by increase in yields and crop residues left in soil.

P 3.1.91

Mitigation potential for carbon sequestration on four British wheat sites

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Introduction

The IPCC report provides emission factors (EF) to estimate mitigation potential for different climate zones and different changes in management. These numbers are based on a wide range of studies and regions and may differ for specific areas. Therefore, the objective of this study is to test the mitigation potential for carbon sequestration on UK wheat sites. The factors are determined over a 20 year period based on simulation results of the biogeochemical model DailyDayCent. In addition the residue management, fertilizer and manure application as well as tillage are considered as possible mitigation options. Model experiments with modified climate data sets (increased and decreased temperature and precipitation) enables to estimate the climate sensitivity of the EF.

Methods

Four different experimental cropland sites, situated in Boxworth, Terrington, Lambfield and Grangefield, all in UK, were considered. The soils of the first two experimental sites were clayey (clay and silty clay loam, respectively), while that of the latter two sites were sandy (both loamy sand). All four experimental sites were wheat fields and the management is assumed to be constant over the study period (20 years) with ploughing, fertilizer applications (three times in spring) and 85 % of the residues were removed from the field (constant over the study period, but different between the four sites). Management practices were modified by, a) replacing fertilizer with manure (same nitrogen content), b) reduced tillage and c) modification of the residue management (50% and 30% removed). Beside the baseline climate, additional climate data with modified temperature (+ 2°,+ 4°,- 2°) and modified precipitation (+50 %, + 25 %, -25 %, -50 %) were used for further simulation runs. The EF were calculated by the ratio between the difference of soil organic carbon (SOC) for the baseline run and the SOC of the modified simulation run and the number of years of the study period.

Results

Residue management (only 30% residues removed from the field) showed the highest impact on SOC for the sandy site of Grangefield and Lambfield, while the residue management on the clayey soils was the best option only for the Terrington site (EF = 0.74), but the manure application showed the highest impact on the Boxworth site (EF=0.81). The lowest impacts for SOC changes show the reduced tillage.

The determined EF for reduced tillage were EF= 0.17, within the range of the IPCC values (0 - 0.28), while the value for Terrington was on the higher end of the range (EF=0.28). The determined EF for sandy soils with a range of 0.2-0.33 was at the the higher end of the IPCC values (0-0.28). The EF for the clayey soils show much higher values (0.65 and 0.74 for Boxworth and Terrington, respectively) than the range provided by the IPCC. Modifications in the fertilizer and manure management show except for Boxworth (EF=-0.14-0.81) also values within the range of the IPCC values (-0.14-0.34 and -0.17-0.25 for IPCC and the experimental site respectively).

The modifications of the temperature showed similar trends for all experimental sites and mitigation options. The impacts of the mitigation options decrease (4-28%) for a temperature increase by 4°C and increase (2-19%) for a temperature decrease by 2°C. The only exception is the low-tillage option on the Boxworth site, which shows the opposite changes. Residue management and the low tillage option show less impacts (11-22%) for higher rainfall and increased impacts (1.5-50%) for less rainfall on all experimental sites. However, except for the Boxworth site, changes are opposite for the manure management the,.

Conclusion

The determined EF in this study support the EF suggested by the IPCC for the different mitigation options in general, but exceeds the suggested EF for residue management. The model experiments for modified weather data show stronger mitigation impacts for the cooler or the drier assumptions, while the impacts decrease for the higher assumptions for rainfall and temperature.

For these modifications Boxworth contradict the trends of the other experimental site for manure management (precipitation) and reduced tillage (temperature). Among different experimental sites lowest yields and the highest initial SOC was recorded at the Boxworth site.

P 3.1.92

Soil carbon in different agroforestry systems and across climate zones in southern India

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Land-use management may influence the soil organic carbon (SOC) stock and thus contribute to climate change mitigation. Tropical agroforestry has the potential of provide high soil carbon stocks yet agreeable yields at the same time. However, the soil carbon content may be influenced by the type of the agroforestry system (AFS), the age of the system and climate. The present study was aiming to assess the influence of type of agroforestry, age of the agroforestry and climate on SOC stocks with comparison to the forest and also to determine the biophysical drivers regulating SOC stock in forest. The study was composed of four AFSs (homegarden, coffee, coconut, mango) of two age classes (30-60 years, >60 years) and assessed agricultural and forest plots as references. Each AFS type was sampled in two of four climatic zones (humid, moist sub-humid, dry sub-humid and semi-arid) based on its relative importance in terms of area, production and income in the region. In total we established 224 plots in 56 plot clusters across four climate zones in southern India. The plots were arranged in clusters (forest, agriculture, medium age AFS, old age AFS) and distributed across climate zones from semi-arid (average rainfall 627 mm yr^{-1}) to humid (average rainfall 3422 mm yr^{-1}). From each plot soil samples were collected from four soil depths (0-10, 10-30, 30-60 and 60-100 cm). The SOC concentration (0-10 cm) and stock (0-100 cm) varied both among the plot clusters and between the AFSs. Among the plot clusters of all systems investigated, SOC concentration (%) and stock (Mg C ha^{-1}) was highest in natural forest and lowest in agriculture, whereby AFS had distinctly higher SOC values than agriculture. Of the AFSs studied, SOC stocks in the top meter of soil were highest in coffee (156±10 Mg C ha^{-1}) followed by homegarden (151±5 Mg C ha^{-1}), coconut (98±7 Mg C ha^{-1}) and lowest in mango AFSs (76±3 Mg C ha^{-1}). The SOC stock on agricultural plots was 63% lower than under forest under dry-sub humid zone, corresponding to 53.3 Mg C ha^{-1}. Under homegarden and coffee AFSs, the SOC stock was much higher than under agriculture and reached near of the forest value but was lower under mango and coconut. In the categories studied, age of the AFS had little influence on soil carbon. The climate zone had a marginal influence on overall SOC stocks of a given AFS where only coconut and mango AFSs showed a tendency towards higher SOC stocks in the respective wetter climate zone. In general for a given AFS, the SOC stock in reference to the forest plots increases with increasing rainfall. In natural forests, SOC stock was explained by tree basal area, clay fraction (%), pH, mean annual precipitation and mean annual temperature using a stepwise linear multivariate analysis (R^2 = 0.82, p ≤0.01).. Lastly, we found a strong correlation between tree species diversity in homegarden and coffee AFSs and SOC stocks, highlighting possibilities to increase carbon stocks by proper tree species assemblies. We conclude, soils under AFSs have a considerable potential for carbon storage, and it is more pronounced under high rainfall conditions.

P 3.1.93

Quality of water-extractable organic carbon in forest soil: impacts of clear-felling

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Introduction

Water-extractable organic carbon (WEOC) in soil is a complex mixture of organic compounds derived from plant litter, microbial biomass and root exudates. Despite the low absolute content of water-extractable compounds in soil organic matter (usually, about 1-5% of total organic carbon content), they are the most immediately available substrates and determine soil microbial activity and nutrient availability (Hamkalo, Bedernichek, 2014). The objective of this study was to evaluate the impacts of clear-felling of hornbeam in hornbeam-oak forest on soil WEOC content and quality.

Materials & methods

The experiments were carried out on ten 1 ha experimental plots: five in old-growth hornbeam-oak forest (control) and five in forest after clear-felling of hornbeam (49°32′ N, 23°20′ E). The soils in study area were *Gleyic Albeluvisols (ABg)*. For the last 30 years mean annual bulk precipitation was about 700 mm and the annual average temperature was 7.8 °C.

The soil was sampled on the third year after fellings down to 50-cm depth in 5-cm steps. The total organic C (TOC), was determined by wet combustion method (ISO 14235, 1998). Contents of cold (CWEOC) and hot (HWEOC) water extractable organic carbon were determined by two-step water extraction method (Ghani et al., 2003). CWEOC/HWEOC ration was used as indicator of WEOC quality.

Results

The highest TOC content was in soil under old-growth forest: 56 mg g^{-1} in the top 5-cm, 27 mg g^{-1} at 5 - 10 cm and decreased exponentially with depth. Clear-felling of hornbeam caused a significant ($p < 0.01$) decrease of TOC content in the whole soil profile. We assume that the reason of such decrease and TOC redistribution in soil profile may be the outflow of water-soluble organic matter from the soil because of the dramatic decrease of evapotranspiration after clear-felling. Another reason may be the input changes of microbial hotspots in soil: the role of rhizosphere decreased and detritusphere increased (Kuzyakov, Blagodatskaya, 2015).

The strongest changes of TOC, CWEOC and HWEOC were in Ah horizon (0 - 20 cm) and especially in top 5-cm layer. TOC content in the topsoil decreased after clear-felling of hornbeam by 54% in comparison to control, CWEOC - by 35% and HWEOC - by 66% respectively (Fig.1). Clear-felling led to rapid losses of TOC and increase of CWEOC/HWEOC ratio in soil profile.

Fig. 1. Content of cold (CWEOC) and hot water extractable organic carbon (HWEOC) along the soil profile of old-growth hornbeam-oak forest and after clear-felling of hornbeam (medians, maximums and minimums, n=5 for each layer)

In soil under old-growth forest the dependence of HWEOC from CWEOC content can be approximated with exponential function; after clear-felling of hornbeam - by linear function (Figure 2).

Fig. 2. Dependence of hot water extractable organic carbon (HWEOC) content from cold water extractable organic carbon content (CWEOC) in the top 0.5 m soil layer under old-growth hornbeam-oak forest and after clear-felling of hornbeam ($n=50$, $p < 0.05$)

In control, increase of CWEOC content in soil in wide range of values caused only slight changes of HWEOC content. By contrast, WEOC fraction in soil under clear-felling of hornbeam did not have any buffer properties: increase of CWEOC content led to directly proportional changes of HWEOC content.

Conclusion

In the large-scale study, the impact of clear-felling of hornbeam in a temperate hornbeam-oak forest was explored. We found that clear-felling of hornbeam is accompanied by a significant decrease of TOC and WEOC contents in soil. The most prominent changes occurred in the subsurface 5-cm soil layer. However, the redistribution of soil organic matter was observed in the whole studied 0.5-m soil profile. Clear-felling led to rapid losses of soil organic carbon and changed CWEOC/HWEOC ratio in soil. In addition, the dependence of HWEOC from CWEOC contents was linear in this section, while being exponential in the soil under old-growth forest. We explain this fact by severe losses of biodegradable dissolved organic matter after intensive felling and replacement of the old highly-condensed molecules by recent organic matter with low buffer properties.

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Figure 1

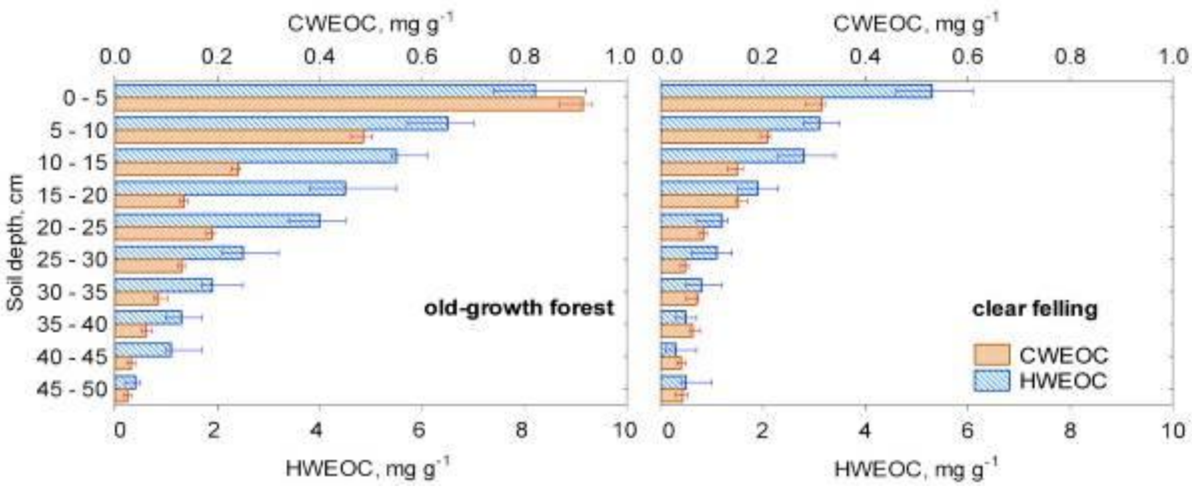
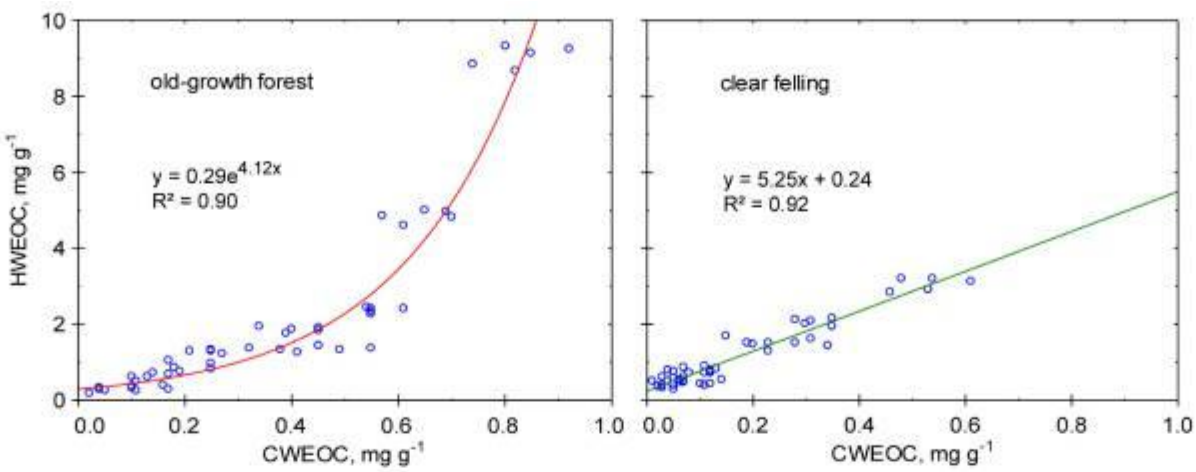


Figure 2



P 3.1.94

Using SOM modelling outcomes to support the carbon footprint analysis of industrial crops: a case-study of perennial vs. annual oleaginous crops in Sardinia Region

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Introduction

The use of industrial crops for bio-based products is increasing. Generally their sustainability is coped with their carbon (C) footprint, taking into account also the land use change in raw materials production, according to the Intergovernmental Panel on Climate Change (IPCC) methodology, as well as for biofuel sustainability criteria (i.e. in European directive 28/2009/CE or in US Renewable Fuel Standard). The calculation method proposed in the IPCC Guidelines for National Greenhouse Gas Inventories (Tier1 and Tier2) estimates the changes in soil C stock associated with management changes in croplands and grazing lands. The variations resulted from default C stock data, carried out with the same cultivation management for at least 20 years. However, this methodology is not suitable for estimating change in C stocks at farm or regional scale due to the high variability of parameters that could occur (e.g. existing C stock in soil). For these reasons a model to predict C stock changes in soil reflecting local or regional soil characteristics would result more accurate (according to IPCC Tier 3).

Objectives

Within the BIT^{3}G Italian project which deals with third generation bio-refineries, a C footprint assessment on a six-year crop *Cynara cardunculus* L. and an annual cultivation of *Carthamus tinctorius* L. (in wheat rotation) is being estimated, utilizing primary data. The research (still running) presented in this poster has two objectives: (1) to predict SOM dynamic in specific industrial agroecosystems, so as to avoid SOM depletion, (2) use the outcomes of SOM predictions as basis for assessing GHG emissions associated to the change of C-stocks in soil.

Materials & methods

Regarding objective 1, a simplified annual time step model (based on Henin-Depuis and Campbell models) was adopted using as input soil characteristics and data of the areas interested in crop cultivation. Study areas are located in Sassari Province (North-West of Sardinia Region), where, in 2015, 450 ha were cultivated with *C. cardunculus* and 4 ha with *C. tinctorius* , planning an increase in areas involved for the subsequent years. The climate region is Mediterranean subcontinental. The outcomes of the analysis (i.e. SOM variation in function of time and agricultural practices) were then used for quantifying potential GHG emissions coming from changes in C stock (objective 2). The proposed methodology can be summarized as follows: (a) collection of data from crop cultivation and soil characteristics (i.e. primary data), (b) SOM predictions based on data in input gathered in point a, (c) estimation of GHG emissions resulting from changes.

Results

The model has been preliminary tested with available data from agronomic scenario, climate and soil analyses, mainly regarding farm management and biomass production, annual temperature and rainfall, and main physico-chemical characteristics of topsoil, respectively. The soil-data, belonging the same soilscape (22,000 ha) and land use, originate from Italian Soil Information System. It was observed that the C stock in soil and agricultural practices applied (e.g. compost incorporation) heavily influences SOM dynamic predictions. In addition, applying the mentioned IPCC model to the research area, the increase in the use of rotations, manure and perennial grasses triggers an increase in C stock that corresponds to an emission saving higher than total C footprint published for oleaginous crops in Sardinia Region. This reinforce the importance of taking into account SOM change using specific data rather than default ones.

Conclusion

Taking into account SOM dynamics in agro-industrial C footprint assessment is fundamental to obtain substantive results, since the magnitude of GHG emissions associated to SOM variations (positive or negative) can be very relevant. The first results of this study show how the proposed model could be sufficient for preliminary approaches to predict C dynamic in soil as a subsystem in agro-industrial Life-Cycle Assessments. Representing a simple way, scientific sound, reproducible and transparent to take into account SOM variations with annual time step. Final results may be more accurate, testing the significance according to other, more complex, models.

P 3.1.95

Modeling land use impacts on soil organic carbon dynamics across France

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Introduction

Soils constitute the major reservoir of organic carbon storing around 2500 Pg C in the top two meters which correspond to approximately more than three times the amount of C stored in the atmosphere (Jobbágy and Jackson, 2000; Tarnocai et al., 2009) and six times the amount of C stored in terrestrial vegetation (Prentice et al., 2001). Consequently, small changes in soil organic carbon (SOC) stocks will greatly affect the global ecosystem carbon cycling and potentially the global climate (Davidson and Janssens, 2006; Heimann and Reichstein, 2008). Beside its importance in the global terrestrial C cycle, SOC is also a key component for sustainable productivity in agro-ecosystems. Improving agricultural practices represents a win-win strategy that has the potential to enhance soil fertility and sequester C (Lal, 2004). However, there still uncertainties about agricultural practices impacts on SOC stocks dynamics and controversial and contradictory results in the literature are common (Luo et al., 2010; Virto et al., 2011). These uncertainties are mainly attributed to the lack of continuous SOC monitoring in long-term experiments, the diversity of climatic conditions (Powlson et al., 2014), and the antagonistic effects of some practices such as fertilization or irrigation. Modeling represents a valuable tool to simulate the spatial and temporal SOC stocks dynamics in response to the fast changes in policies, agriculture practices and their complex interaction with current and projected future climatic conditions. The main objectives of this work were: to analyze the interaction between crop management and climatic conditions in the long-term on SOC dynamics using Century model (Parton et al., 1987) across France and to quantify GHG emissions and SOC stocks at different scales to apply the Tier 3 methodology for the GHG inventories.

Methods

We examined more than 20 sites with different Long-term experiments, ranging from 10 to 40 years, across the France. Different agricultural practices were studied such as tillage treatments, crop rotation, organic amendment, mineral fertilization, etc. We used the well-validated Century model which has been widely used all over the world to simulate SOC dynamics in agricultural systems. Model parameters calibration through inverse modeling using PEST (Doherty, 2010) was applied.

Results and Discussion

First results showed that the model gave satisfactory results for the simulation of SOC stocks dynamics over the layer 0-20 cm. Model parameters calibration improved the fit for to crop productivity and SOC dynamics. PEST proved to be a reliable on efficient tool to optimize model parameters. The important emerged results from this work emphasis that agricultural practices that maximize C input are more effective strategies for SOC sequestration than those that limit SOC mineralization. Further results will be given in the poster.

P 3.1.96

C-Status and -Dynamics after 20 years of Reduced/No Tillage First Results from two long term field trials in Saxony, Germany

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Question

This investigation is concerned with the scientifically controversial hypothesis of carbon sequestration through practices of Reduced Tillage (RT) or No Tillage (NT) under typical soil and climate conditions for central Europe. The focus of our research is on microbial turnover processes influencing SOM turnover / mineralization and on questions concerning the stability of (fresh) organic matter, which is of great importance for agricultural practices and policies.

Methods

For verification of the hypothesis, several sampling campaigns at two long term field trials in central Saxony (Eastern Germany) have been performed in the years 2012-2015. Both field trials include different tillage regimes (CT, RT, NT) and have existed since 1992. For both sites, several investigations by different institutions (LfULG, IfZ Göttingen, UFZ, etc.) related to the topic presented here precede ours.

Soil sampling was performed on an equivalent soil mass basis (Ellert & Bettany 1995). After the determination of soil bulk density for the different tillage regimes, the soil was sampled in five layers with fixed soil masses adding up to 9000 kg / ha for the entire profile sampled. Assuming an average bulk density of 1,5 g / cm^3, that would result in a sampling depth of 60 cm. Layer one and two comprise 750 kg / ha each, layer three and four 1500 kg / ha, layer five 4500 kg / ha.

So far, results for three sampling campaigns in spring 2012, fall 2012 and spring 2013 have been compiled.

Samples were taken at three sampling points per plot (RT and CT, three different crops) in Methau, as well as on a small strip of grassland (formerly also under cultivation) between the plots, adding up to a total of 21 sampling points. In Lüttewitz, samples were taken at nine representative sampling points on each of the four plots (CT, NT, RT shallow, RT deep).

The samples were analyzed for a variety of parameters with organic carbon being the most important one for this investigation. Furthermore, the main nutrients (N, P, K, Mg), pH and different carbon fractions (hot-water extractable carbon) as well as microbial indicators (Cmik CFE, dehydrogenase activity) have been determined.

Results

The first results show marked differences in amounts of organic carbon between tillage regimes for both sites. The arithmetic means of RT and NT plots for both sites are consistantly higher than for the CT plots at all three sampling dates. This is true for the entire soil profile (9000 t / ha) as well as for the topsoil (upper 4500 t / ha). The differences amount up to a maximum of 18 t C / ha for the shallow RT plot in comparison with CT (Lüttewitz), which is a difference of approximately 35 % (with CT = 100 %).

A general trend leading to a confirmation of the hypothesis is clearly visible, but the results still have to be subject to further statistical analysis.

The grassland strips in Methau contain markedly higher amounts of organic carbon than the plots under cultivation for both the entire profile as well as the topsoil. The differences in comparison with CT (=100 %) amount up to 40 t / ha (about 70 %) in October 2012.

Furthermore, we detected a general trend towards lower total amounts of organic carbon over the course of all three sampling dates for all tillage regimes.

If this trend is due to climatic factors (especially the long and cold winter 2012/2013 leading to a low turnover) or if it points towards a decrease caused by soil management has to be evaluated with the help of samples/results from our latest sampling campaigns.

Conclusions

In addition to the development of the amounts of organic carbon stored under different (continuous) tillage regimes, the stability of the newly formed organic matter is of great interest and importance. The question is, what consequences the common (German) practice of periodic plowing (every few years) has for the quantity and quality of organic matter in RT and NT plots.

In order to answer that question, three small strips in the formerly not tilled plot were plowed once in the fall of 2013 in Lüttewitz. Soil sampling was performed just before, right after as well as one month, six months and twelve months after plowing in order to understand the temporal dynamics of the assumed changes in C mineralization. This treatment and sampling procedure were repeated in the fall of 2014, when three new strips were plowed for the first time and the ones from 2013 were plowed for a second time. Through the analysis of parameters like microbial biomass (CFE), dehydrogenase activity, soil respiration and hot-water extractable carbon, we expect to gain more insight into the processes triggered by the described tillage events.

IT 3.2

Soil, climate extremes and the carbon cycle

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The soil is an important determinant of how ecosystems and their biogeochemical cycle respond to climate extremes, which have recently attracted attention for carbon cycle impact. In this presentation I will highlight the importance of the soil for global biogeochemical questions and pose the questions how it is affected by climate extremes and whether the complexity of the soil is adequately considered in global biogeochemical analysis and modeling. Vertical heterogeneity and vegetation-soil feedback, the role of soil (micro-)biota in the carbon cycle and bio-chemical and physico-chemical limitations of soil processes will be discussed as important topics in this context. Finally as synthesis I will present global residence times of ecosystem carbon, confront these with modeling results and discuss the difference in light of the above consideration.

O 3.2.01

Effects of drought stress on carbon allocation in different plant-soil systems

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Introduction

Global warming is one of the most persistent threats to nature and is expected to increase in future resulting in severe droughts in many places of the world. Droughts are supposed to effect individual plants and/or plant communities by bringing changes that affect their biotic/abiotic interactions. Although extreme climatic events such as drought have important consequences for belowground carbon (C) cycling, their impact on the plant-soil system of mixed plant communities is poorly understood.

Objectives

The objective of this study was to elucidate the impact of drought stress on C allocation and rhizosphere-mediated CO_2 fluxes of plant-soil system. It also included the combined effect of drought stress and plant types on C distribution in different soil aggregate fractions.

Materials and methods

The conceptual approach included repetitive $^{14}CO_2$ pulse labeling of plants grown under drought and optimum moisture levels in order to follow above and belowground C allocation. Impact of plant type was studied by growing maize (*Zea mays*) and sorghum (*Sorghum bicolor*) as monoculture and as mixture. After ^{14}C pulse labeling, ^{14}C allocation in different pools such as, shoots, roots, soil, soil respiration and microbial biomass and its DNA was traced. Incorporation of fresh assimilates in different soil aggregate fractions were also determined by tracing ^{14}C in different soil aggregates.

Results

Drought caused significant decrease in plant shoot biomass for maize and sorghum monocultures which resulted in increased root-shoot ratio of both plants due to drought stress. While, maize-sorghum intercropping (mixture) resisted against any change in plant biomass under drought stress. Drought conditions changed the source sink relationship of maize plants and as a result, relatively higher portion of assimilates were translocated towards roots compared to water sufficient plants. In continuation, drought increased the release of root exudates that enhanced the rhizomicrobial respiration ($^{14}CO_2$) in maize plants. In contrast, drought did not cause any significant change in ^{14}C incorporation in plant biomass as well as rhizomicrobial respiration for sorghum monoculture and mixture of both crops. Under drought stress, soil microbial biomass and well as its DNA was increased in unplanted control soil, while it decreased in planted soils. Increase in ^{14}C incorporation in microbial biomass and decrease in DNA showed active respiration under drought stress. Due to drought stress, there was increase in micro-aggregate formation in planted soils and higher fresh carbon assimilates (^{14}C) into the micro-aggregate fractions confirmed that higher root exudation due to drought stress helped in micro-aggregate formation under drought stress.

Conclusions

Thus maize plants performed quick adaptive response to drought stress by maintaining their biomass and translocating higher photosynthates towards roots for efficient water uptake. Plant type may modify the impact of climatic changes on carbon allocation and belowground carbon fluxes.

O 3.2.02

The effect of extreme weather events on the microbial utilization of litter carbon

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Climate change is expected to not only lead to an increase of average annual temperature but also to increase the frequency of extreme meteorological events. For example, extreme summer-droughts followed by heavy rainfall events are likely to increase within the next decades. This is hypothesized to change the biogeochemical cycles of terrestrial ecosystems, including SOM quality and quantity, nutrient stocks and availability and soil microbial community as well as their functions. In temperate ecosystems coniferous forest are one of the ecosystems, which are expected to show strongest effects by climate change. Therefore, we performed a tracer experiment in the “Fichtelgebirge” (Northern Bavaria) to verify the influence of strong drying followed by intensive rewetting on the microbial community structure and decomposition of litter-derived ^{13}C by individual microbial groups.

In 2010, sheltered plots with 1) artificially simulated drought, 2) with additional irrigation and 3) control sites under natural conditions were established at a Norway spruce forest. At each plot, we removed annual litterfall and added instead the average annual amount of ^{13}C- and ^{15}N-labelled spruce litter. Thereafter, we assessed the effect of extreme weather events on a) microbial community structure by phospholipid fatty acid (PLFA) analysis and b) we ^{13}C incorporation into bulk soil, microbial biomass and PLFA of the organic horizon and the mineral soil up to 10 cm. Additionally, respired CO_2 and its ^{13}C enrichment was quantified by closed chambers.

Drought reduced the microbial biomass only in the organic horizon, while in the mineral soil the microbial abundance did not decrease compared to the control and irrigated plots. The decrease in microbial biomass in the organic horizon of the drought plots resulted also in a strongly reduced incorporation of litter derived C: Incorporation of litter ^{13}C was a magnitude of three lower in the drought plots compared to the control and irrigation plots. Furthermore, after the drought period of 90 days the proportion of ^{13}C in CO_2 from soil respiration was reduced by about 95% on the drought plots compared to the control and irrigated plots. This is in agreement with the reduced degradation of litter derived C and thus a reduced C turnover under dry conditions.

PLFA analysis showed high amounts of gram positive and gram negative bacterial as well as fungal fatty acids, whereas actinomycets and protozoa represented minor groups. An increased ratio of the cyclo-PLFA to monounsaturated 16:1w7c+18:1w7c on the drought plots of the organic layer suggest that bacteria strongly suffered from water stress. In comparison to other microbial groups only the fungi were not depleted by drought showing the advantage of filamentous organisms in resisting unfavourable environmental conditions compared to the osmotrophic, single cells organisms. At both locations, in the organic horizon and the mineral soil, most ^{13}C was incorporated into the gram negative bacteria and into fungi, whereas actinomycetes and protozoa showed the lowest incorporation. This tendency is even enhanced for the drought plots. Gram positive bacteria showed a low incorporation of litter derived C despite their high abundance, which reflects their general preference for old SOM-derived C sources.

Combining ^{13}C-labeling and ^{13}C partitioning in microbial and SOM pools provides a powerful tool to assess alterations in biogeochemical cycles and to understand the mechanisms of SOM turnover. The combination with compound-specific isotope analysis of microbial biomarkers revealed group-specific effects of climate change and the consequences for the microbially controlled processes. This will fundamentally improve our understanding of C pool dynamics under changing environmental conditions like extreme whether events.

O 3.2.03

Microbial and water extractable P in soil as affected by extreme weather events

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1.Introduction

Climate change is one of the most dramatic challenges for nowadays civilization. Acceleration of greenhouse gases concentrations increases not only atmospheric temperature as such but results in frequent and intensive weather stress events as well. In turn, the latter dramatically activate available pools of nutrients, including phosphorus. Drying-rewetting and freeze-drying were shown to kill as much as up to 70% of microbial cells in soil (Blackwell et al., 2010) followed by solubilization of dead microbial biomass and drastic changes in partitioning phosphorus between sorbed and water extractable P pools. Therefore reasonable estimations of P transformations in soils caused by drying-rewetting are impossible without correct and reliable assays of microbial phosphorus in soil microbial biomass

2. Objectives

Our research was aimed to: I) determine conversion factors k_P by ^{33}P labeling and measuring ^{33}P recovery in microbial biomass in four soil types Podzol (Corg 3.3%, pH_{H2O} 3.5), Phaeozem (Corg 1.4%, pH_{H2O} 5.6), Chernozem (C_{org} 3.4%, pH_{H2O} 6.9), and Calcisol (Corg 1.9%, pH_{H2O} 8.3); II) estimate ^{33}P partitioning between pools of water extractable, microbial and soil solid phase phosphorus in the four soil types under i) optimal temperature and moisture (OPM treatment); ii) drying-rewetting (DRW treatment) and iii) freeze-thawing events (FTH treatment).

3. Materials and Methods

DRW treatment was provided by drying of wet soil at 60% water holding capacity (WHC) to air-dried state during 12 h at 22^oC followed by keeping them dry during 48 h and rewetting to 60% WHC and 12 h incubation. Soils in FTH treatment were frozen and stored at -10^oC during 60 h followed by 12 h thawing at 4^oC. Soils with optimal moisture and temperature were incubated during 72 h. At the start of the experiment soils in all three treatments were labelled with ^{33}P -orthophosphate spike (0.1 mg P as K_2HPO_4, 0.4 kBq g^{-1} soil). Microbial (P_{mic}) and water extractable P pools were analyzed in control soil in parallel with those in DRW and FTH. Microbial biomass P was determined by direct fumigation and anion exchange membrane (AEM) techniques. P concentration in extracts was determined by the malachite green (MG) colorimetric procedure, and ^{33}P enrichment by radioactivity. Total and ^{33}P labeled phosphorus in soil microbial biomass was calculated using conversion factors k_P. The latter was individually determined in a series of experiments with ^{33}P labeling and measuring ^{33}P recovery after ^{33}P sorption and ^{31}P - ^{33}P isotopic exchange.

4. Results

Conversion factors k_P were found to vary from 0.19 to 0.38. No detectable ^{33}P immobilization was detected in FTH treatment, irrespective of soil type. Maximal ^{33}P immobilization (58% of ^{33}P added) was found in Calcisol (OTM treatment). Total P_{mic} in four soils tested varied from 2.6 (Phaeozem, FTH) to 36.6 mg P g-1 (Mollisol, OPM). In general, total microbial biomass P and ^{33}P percentage in microbial biomass followed the pattern OPM > DRW > FTH. The considerable decrease of ^{33}Ppercentage in water-extractable P pool in DRW treatment as compared to OPM treatment was attributed mainly to enhanced ^{33}P sorption to solid phase after drying-rewetting event. ^{33}P recovery after i) sorption during AEM procedure and ii) ^{31}P - ^{33}P isotopic exchange was approximately 90%, practically irrespective of soil tested.

5. Conclusion

I. Correct measurements of phosphorus in soil microbial biomass are only possible when k_P values are determined individually for each soil type.

II. For determining k_P values, we would recommend to use the mean ^{33}P recovery of 90% both for ^{33}P sorption during AEM procedure and ^{31}P - ^{33}P isotopic exchange for any soil type.

III. Microbial communities restore total microbial biomass and re-immobilize available P much more intensively after rewetting than after thawing.

6. References

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O 3.2.04

CO_2 fluxes affected by soil water repellency in the long term drought and warming experiments

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Extreme weather events such as prolonged dry spells and heat waves can significantly affect soil ecosystem functions mainly due to decrease in soil moisture. Reduced soil water content causes changes in soil organic matter decomposition and alters carbon fluxes, which can be amplified when a soil becomes water repellent. Soil water repellency (SWR) is a common phenomenon worldwide, which develops when soil water content falls below a critical threshold. It reduces or inhibits water infiltration, which can increase overland and preferential flow. Where SWR is present, rain water infiltrates into soil very selectively, following more wettable zones usually adjacent to roots, cracks or stones via preferential flow paths, and leaving large volumes of soil dry. Given that soil microbial activity and carbon decomposition is highly dependent on soil moisture, this restricted rewetting of water repellent soil behaviour is also altering carbon fluxes.

The aim of the study is to find out whether repeated warming and drought lead to increased soil water repellency and consequently altered C fluxes in organic-rich soils. Two heathland study sites under long term (14 years) climatic simulations in NW Wales (UK) and The Netherlands (NL) have been investigated. At each site 6 plots were subjected either to rainfall exclusion or overnight warming, while the remaining 3 plots were kept as a control. In addition to continuous monitoring of the sites over the whole period of the experimental setup, measurements of CO_2 flux, soil moisture and SWR have been conducted during one whole season in the 14^{th} year of the experiment. Soil samples have also been collected from all plots to determine the changes in soil physical properties caused by the climatic simulation, which may alter soil carbon dynamics.

The results show that repeated drought and warming did not directly increase the severity of SWR, but reduced wettability occurred in all investigated plots over some period of time. The soil- atmosphere CO_2 efflux changed with moisture content; the lowest CO_2 flux rates occurred near saturation and at very dry conditions, while the highest CO_2 flux was at the intermediate moisture contents. The most pronounced effect of SWR on the CO_2 flux occurred during the rewetting of water repellent soil. The simulated rainfall did not rewet soil fully as most of water drained quickly through preferential flow paths, causing a very small and short lasting pulse of CO_2. The majority of soil stayed dry after the simulated rainfall and the CO_2 flux rates remained low.

The main conclusion of the study is that SWR, by strongly affecting soil rewetting patterns, plays an important role in controlling soil carbon fluxes. Given the predicted rise in frequency and severity of drought events in many regions, the influence of SWR on soil carbon fluxes is likely to increase in the future.

O 3.2.05

Response of soil structure and soil organic matter to recurrent severe drought events in a mountain meadow

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Introduction

Climate models associate the ongoing global warming with an increasing frequency and intensity of extreme events such as droughts and periods of heavy rain. Soil water storage capacities and soil carbon dynamics could be strongly affected by extreme droughts due to strengthened shrinking and swelling cycles of soil and inhibited primary production and microbial activities during droughts.While such effects are likely exacerbated by increased drought frequency, few studies have so far analysed the consequences of recurrent extreme drought in real-world ecosystems.

Objectives

In this study we examined changes in soil properties after experimentally simulating recurrent severe drought in a mountain grassland for three and seven consecutive years, respectively. To examine possible changes in the soil water holding capacity we analysed the soil porosity, the aggregate size distribution and stability as well as the amount and distribution of various soil organic carbon pools.

Materials & Methods

On a mountain grassland in the Austrian Alps (Stubai Valley, 1850 m a.s.l.) we experimentally simulated severe drought during seven consecutive years using rainout shelters for 8 weeks in the summer months of June and July. After three and after seven years we sampled undisturbed soil cores (8 cm diameter) in the toplayer (0-10 cm) of the Cambisol in both control and drought plots. Besides basic soil characteristics including pH, nutrient status, cation exchange capacity, (hydr)oxides, particle size distribution, we measured aggregate size distribution by dry and wet sieving, soil carbon contents of free organic matter (fPOM), aggregate-occluded organic matter (oPOM) and mineral-associated organic matter (MOM) by density fractionation in macro- and microaggregate size fractions.

Results

Data show that repeated drought events changed the distribution of dry-sieved aggregates showing an aggregate hierarchy in the control plots, whereas under the rain shelters an increase of medium sized macroaggregates (0.5 -2mm) was observed. After 3 years of consecutive drought events the stability of macroaggregates and macro-porosity decreased, and after 7 years the effect tended to be further enhanced. Interestingly, minor changes in the soil organic carbon contents in bulk soils as well as in relative amounts in the various aggregate size fractions were found, which points to a similar aggregate formation and life cycle in the soils.

Conclusions

We conclude that recurrent summer drought amplifies effects on soil structure, with potentially larger implications for water storage as compared to soil carbon storage.

O 3.2.06

10 years of irrigation in a drought prone pine forest speeds up carbon cycling but has negligible effects on total SOM stocks

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Introduction: Inneralpine valleys are experiencing repeated summer droughts, which have caused a die-back of pine forests since the 1990s. Drought limits the metabolic activity and hence C cycling in the plant and soil system. The net effects of drought on SOM storage is, however, ambiguous as drought affects both C inputs and outputs.

Objectives: Our aim was to examine to which extent soil C fluxes and SOM pools in the drought prone pine forests of inneralpine valleys are limited by water.

Materials and methods: In the driest part of the Rhone valley (Valais, Switzerland; 520 mm/year), we have been conducting a large-scale irrigation experiment in a mature pine forest on gravelly, shallow soils since 2003.

Results: The decadal long irrigation during summer time strongly increased ecosystem productivity with litter fall and fine root biomass being increased by +50 and +40%, respectively. At the same time, soil CO_2 efflux was stimulated by 60%, indicating that the removal of water limitation enhanced both the inputs and outputs of C into soils. The accelerated C cycling was mirrored by compositional shifts in the soil microbiome. 454-pyrosequencing of ribosomal marker genes indicated that irrigation promoted bacteria and fungi with more copiotrophic life style strategies, that are typical for nutrient-rich conditions. Determination of SOM pools revealed a C loss in the organic layer under irrigation (-900 gC m^{-2}) but a C gain in the mineral soil (+970 gC m^{-2}), resulting in a negligible net effect. The likely mechanisms for the altered vertical SOM distribution might be (1) an accelerated mineralization of litter combined with higher C inputs from the rhizosphere and/or (2) an increased incorporation of litter in the mineral soil as suggested by a litter bag experiment showing a stimulated activity of the macrofauna with a 5-fold increase of the earthworm density.

Conclusions: In summary, our long-term irrigation experiment revealed that the removal of water limitation during summer in a drought-prone pine forest strongly altered C fluxes and the belowground community composition. However, the net effect on SOM stocks was negligible due to a balancing out of C in- and outputs.

P 3.2.01

Climate Change Negative Impact on Soils Erosion in Georgia

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A lack of information about processes affecting soil erosion in Georgia by Climate Change impact is a Hugh problem and we should analyze how these are related to climate change or another problem. The transect approach aims to identify and understand relationships between climate and erosion at different scales. The methodological approach applied in the transect studies was developed to overcome scale problems are inherent to the methodologies of field experiments and modeling, traditionally used in geomorphological and soil erosion studies. It is a conceptual methodology that views the complex response of erosional systems, in terms of the hierarchy of processes that drive its dynamics, at different spatial and temporal scales. These processes can be affected by both socio-economic and biotic and abiotic factors. As soon as the temporal scale is considered, soil aggregation dynamics become important in explaining the longer term erosional impact of fire and grazing. This is because they are a key factor in explaining the resilience of the sites affected. This is why the areas of low biological activity are the most vulnerable to erosion under intensive disturbance regimes. The more resilient areas are subject to the most disturbances. The relationship of climate to erosion will therefore depend on the effect of climate at different scales.

Figure 2

P 3.2.02

The Effect of Drought on Forest Tree Species' Nourishment: The Chosen Path of Phosphorus Cycling

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Abstract

Future forests have to meet the ever increasing demand for high quality timber. However, reduction in water availability due to global climate change is expected to greatly reduce the stability and productivity of forests. Phosphorus is often lacking in tropical and subtropical forests. Global climate change has led to changes in precipitation patterns in the forests of temperate regions in the recent years, which inevitably affects phosphorus cycling and in effect tree nutrition. It is very important to keep the forest alive and well-nourished as it plays an irreplaceable role in mitigating global climate change through carbon capture but at the same time it must adapt to climate change. This research **"The effect of drought on forest tree species' nourishment: the chosen path of phosphorus cycling"** sought to evaluate the effect of drought on forest tree species with emphasis on bio-available phosphorus obtained via phosphorus cycling. Soil samples were collected at root zone depth from areas of varied altitudes and tree species thus H-horizon soils from the mountain Spruce forest at Bily Kriz, A-horizon soils from both the young Spruce monoculture at Rajec and Beech forest at Stitna. All of these areas are located in the Czech Republic. Acid phosphatase activity of the various soil samples was measured in optimal conditions of the enzyme in the laboratory using the already in use protocol developed by Tabatabai and Bremner (1969) and some modifications made by Rejsek (1991). Two other protocols were developed by this research by replacing the buffer component of the first with water to mimic the unstable pH situation which occurs in nature and simulating a drought situation in the laboratory by incubating the soil sample with powdered form of the substrate used in the original protocol and adding water after the hour-long incubation.

The results supported the earlier assumptions held before start of the research which were;

- Water stress or drought has negative effect on microbial activities and in effect enzymatic activities hence limits bioavailability of phosphorus.
- H-horizon soil has the highest soil enzymatic activities due to high microbe content as a result high organic matter content.
- Unstable soil pH negatively affects soil enzymatic activities.

Again soil sample from Stitna though had the same sampling depth as the Rajec soil sample, had higher acid phosphatase activity due to its clayey texture.

Key words: Drought, acid phosphatase, phosphorus cycle, climate change, forest tree species

P 3.2.03

Effect of fertilization and rainfall on soil organic matter (SOM) changes

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There is an concern for increased rainfall caused by climate change (CC) may reduce SOM in arable soils. As at the moment, little is known about interrelations of rainfall, and NPKCaMg fertilization on altering SOM. The present study aimed to investigate this problem in a long-term field experiment at Nyírlugos (Nyírség region, Hungary: N: 47º 41' 60'' and E: 22º 2' 80'' between 1962 to 2006) on a Haplic Luvisol. Over 44 yr NPKCaMg fertilization resulted in a significant ($P<0.001$) decline 15.5% in SOM for 1st 20-yr, while in 2nd 24-yr significant ($P<0.001$) increase 13.2% was detected. Seasonal correlations (R^2) among SOM, winter-half year (WHY: October-March), summer-half year (SHY: April-September) and year total (YT: October-September) rainfall ranged from 0.66 to 0.92 ($P<0.001$). Correlations (R^2) on influence of NPKCaMg fertilization on SOM and rainfall were significant ($P<0.001$): means for winter-half year (WHY: October-March), summer-half year (SHY: April-September) and over the 44 yr were 0.47, 0.62 and 0.66, respectively. Althought, our results indicate that in a long-term semi-arid farming can significantly increase SOM due to NPKCaMg fertilization and increasing rainfall can reduce SOM.

P 3.2.04

Study on mixed planting different ratios of vetch and triticale on the forage yield and soil physico-chemical properties of dry lands

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In order to study the effects of different ratios of vetch (Vicia villosa L.) and and triticale (Triticosecale) mixed cropping on forage yield and soil Fertility properties in rainfed conditions, this experiment carried out in Maragheh agricultural research station.The experiment was arranged with vetch and triticale levels (0,25,50,75 and 100%) as mixed planting as RCBD with threereplications. After sowing all plant protection affairs such as fighting with pests and weeds completed in all plots. At the proper time crop's grain and biomass yield harvested by Combine and the mean results statistically analyzed .The results showed that mixed cropping of of vetch and triticale in comparisom with their pure planting significantly increased forage and dry matter yields and soil fertility. It can be concluded that mix-planting of legume forage and cereal crops may increase forage and crop yield production and can reduce fertilizer use and lead to sustainable agriculture.

Key words: Mixed cropping, forage legume,triticale, soil fertility and dry lands.

P 3.2.05

High nutrient availability decreased temperature sensitivity of soil microbial activity in an alpine meadow soil

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Alpine meadow ecosystem on the Qinghai-Tibetan Plateau, as a huge soil carbon reservoir, is considered to be sensitive to global change. Any small changes in their SOM decomposition, which is mainly mediated by soil microbial activity, can in turn lead to large effects on global change. Given widespread nutrient limitation of alpine meadow, response of soil microbial activity to N and P addition will determine a major feedback to SOM decomposition. In this study, we tested the effects of N/P addition on soil microbial activity and its temperature sensitivity in a simulated addition experiment located at the Haibei Alpine Meadow Ecosystem Research Station. The experiment established four treatments, N addition (NA, 100 kg N ha^{-1} a^{-1}), P addition (PA, 50 kg P ha^{-1} a^{-1}), N plus P addition (NPA) and Control without nutrient addition. Soil microbial activity was determined with substrate induced heat production curve, and two microcarlorimetric parameters P_{max} (maximal substrate induced heat flow) and k (specific growth rate of soil microorganisms) were used to calculate Q_{10}. Compared with Control, there was a decreasing trend in temperature sensitivity via N/P enrichment. Q_{10} value of k was 1.66 in Control, and declined to 1.47, 1.57, 1.60 in the NPA treatment (p=0.110), NA treatement (p=0.414) and PA treatment (p=0.453), respectively. Q_{10} value of P_{max} was 2.61 in Control, and declined to 2.25 and 2.28 in the NPA treatment (p=0.105) and PA treatment (p=0.074). From the current short-term results, N/P enrichment affected soil microbial activity and a higher nutrient availability tended to decrease its temperature sensitivity in alpine meadow soil.

P 3.2.06

Variable effects of urea addition on mineralization of liable organic matter, SOM of microbial origin and humic-like substances in three typical Chinese cropland soils

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Soil organic matter (SOM) plays crucial role in relation to global carbon cycling and sustainable agricultural systems. Intensive use of nitrogen (N) fertilizers in agricultural soils can alter stability and turnover of SOM and hence carbon sequestration. Here, using ^{14}C-labeled catechol and glucose, ^{14}C-SOM of microbial origin and ^{14}C-specific labeled humic-like substances (either labeling in the aromatic or the proteinaceous component) as model SOM with different stability, effects of urea addition (0.1 and 0.2 mg N g^{-1} soil) on the mineralization of these substrates were investigated in three soils representing three soil types (i.e. Anthrosols, Fluvisols and Chernozems) over two months. Our results showed that urea addition significantly reduced the mineralization of ^{14}C-labeled catechol and glucose in the three tested soils, whereas it had no obvious effect on mineralization of ^{14}C-SOM of microbial origin. In addition, urea addition didn't affect the mineralization of the aromatic and the proteinaceous components in the Anthrosol, whereas it significantly reduced the mineralization of the two components (13.1-17.7 %) in the Fluvisol. Urea addition (0.2 mg urea-N g^{-1} soil) significantly increased the mineralization of the aromatic (8.1 %) and the proteinaceous (9.0 %) components in the Chernozem. Because humic substances are the most abundant components of SOM. The soil-specific mineralization response of humic-like substances to urea addition is in good agreement with the reported SOM change patterns of tested soils, suggesting that the variable effects of urea addition on certain components of SOM were partly responsible for the changes in SOM contents induced by inorganic N fertilizers addition.

P 3.2.07

Assessment of Climate Impacts on Soil Organic Matter Using GIS and Remote Sensing Techniques in Chamarajanagar District, Karnataka, India

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The immediate result of biological degradation is the loss of organic matter, the main consequences of which are physical degradation, loss of nutrients and increase of runoff and erosion. Loss of organic matter can also result from erosion, but in this section only the mineralization of organic matter without erosion is considered. A distinction is made between non-resistant organic matter (i.e. fresh organic residues) and resistant organic matter (humus). The biological degradation is understood in this text as mineralization of resistant organic matter or humus. A field study was conducted at Chamarajanagar district, Karnataka to understand the effect of climate on biological degradation of soil organic matter and intern its effect on other soil health parameter

Loss of organic matter can also result from erosion, but in this section only the loss of organic matter due to erosion is considered. Land degradation can be described as reduction in the present and prospective land quality and production, due to natural or anthropogenic dynamics. This phenomenon is one of the most important problems facing farmers and decision makers in several countries. This study aims to use GIS techniques to quantify land erosion in the Chamarajanagara district, Karnataka, India based on remotely sensed and field survey's data. A GIS spatial model has been developed based on the FAO methodology to apply a land erosion assessment in the study area. Final land erosion map has been produced by combining the outputs of different types of the factors affecting land erosion. The results show that the majority of the study area fall under the moderate land erosion classes. High land degradation class has been found in areas affected by high soil loss; this is major reason for Biological Degradation by removing plough layer of the top soil. GIS spatial modeling tools manifested great efficiency in land degradation assessment process, whose results hopefully may help decision makers to take the necessary actions to protect the most degraded spots.

P 3.2.08

Functional and structural responses of methanogenic microbial communities in Uruguayan soils to intermittent drainage

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Intermittent drainage is one of the most promising approaches to mitigate methane (CH_4) emission from paddy fields. Irrigated rice fields in Uruguay are temporarily established on soils used as cattle pastures. We studied soil from the pasture-rice rotation (UR) as well as soil from a permanent cattle pasture (UT) hypothesizing that activity and structure of the bacterial and archaeal communities involved in production of CH_4 change systematically with intermittent drainage and drying. Methane production started after 7 days and 16 days of anoxic incubation in UR and UT soil, respectively. Then, production rates of CH_4 were higher in UT than UR soil. Drying significantly decreased the rates of CH_4 production. Analysis of $\delta^{13}C$ indicated that CH_4 was mainly produced from acetate both in UR (73-86%) and UT (51-65%) soil. Drying did not change the pathway of CH_4 production. Quantitative PCR showed that methanogenic archaeal gene copy numbers (16S rRNA, *mcrA*) were much lower in UT than UR soil, but increased upon incubation under anoxic conditions. Terminal restriction fragment length polymorphism (T-RFLP) and pyrosequencing of bacterial and archaeal 16S rRNA genes showed that the communities were clearly different between UR and UT soil. The bacterial community consisted of 9 phyla with relative abundance of >1% in both soils. Whereas the archaeal community in UR soil was dominated by *Methanocellales* and *Methanosarcinaceae*, that in UT soil was dominated by *Crenarchaeota*. Anoxic incubation affected the composition of the bacterial and archaeal communities in UT soil, but not so much in UR soil. In UT soil, the relative abundance of *Clostridiales* increased to 19%, and the archaeal community changed to dominance by *Methanosarcinaceae* and *Methanobacteriales*. Subsequent drainage and re-flooding, however, had comparatively little effect on the composition, although it decreased the rates of CH_4 production in both soils. Difference in previous soil management and in the structures of the microbial communities apparently only affected their dynamics and functioning after the first flooding but not upon subsequent drainage and re-flooding.

P 3.2.09

Mechanisms of soil degradation and its consequences for soil organic carbon storage on alpine grasslands of the Tibetan Plateau

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Kobresia grasslands of the Tibetan Plateau cover an area of ca. 450,000 km². They are of high global and regional importance as they store large amounts of carbon (C) and nitrogen (N) and provide food for grazing animals. However, grassland degradation has occurred extensively in recent decades and has destroyed mainly the upper root-mat/soil horizon, with dramatic consequences for SOC storage in the background of climate change. Within this study we investigated the impact of soil degradation on SOC storage and hypothesized that SOC stocks strongly decreased due to soil erosion, SOM decomposition and an absence of C-input by roots as consequence of vegetation cover extinction. We selected six degradation stages (DS1-6), which were defined according to field observation by following the hypothetical idea of how degradation processes might be induced.

For triggering grassland degradation, we assume that the high grazing pressure reduce the ability of *Kobresia* pastures to recover from initial disturbances as maybe caused by freezing and drying events or/and disruption due to herbivore activities. Once the root mats are destroyed, we suggest that occurring cracks increase due to soil erosion, SOC decomposition and trampling activities of livestock.

The data show that SOC stocks and contents decreased along the degradation sequence from intact to highly disturbed stages. Carbon stocks declined from about 70% comparing intact *Kobresia* root mats (DS1) to bare soil patches (DS6). The thickness of the upper soil horizons strongly declined from DS1 to DS6. Considering the bare soil patches (DS6) on average 10 cm of topsoil was removed. This clearly suggests that soil erosion strongly contributed to SOC losses, especially from topsoil, where highest SOC contents occurred. A strong decrease of the vegetation cover (mainly *K. pygmaea*) demonstrated that soil degradation also resulted in dying of *K. pygmaea.* Consequently, root biomass decreased along the degradation sequence (DS1-2 > DS3-4 > DS5-6), indicating lower C input from roots into the soil. We also found decreasing $\delta^{13}C$ values with increasing degradation stages within the upper 20 cm of soil. Higher $\delta^{13}C$ values were found for intact root mats (DS1), whereas lowest $\delta^{13}C$ signatures occurred for the highly degraded stages (DS5-6). This agreed with relative lignin contents, which increased S3 to S5. Since lignin is ^{13}C depleted the $\delta^{13}C$ shift clearly indicates SOM decomposition. Using root biomass as indicator for C-input and $\delta^{13}C$ values for SOM decomposition, we could explain 70% of decreasing SOC contents. Our findings show that grassland/soil degradation led to large SOC loss due to soil erosion, SOM decomposition and absence of root C-input.

P 3.2.10

Influence of soil moisture on soil respiration

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Introduction

Soil respiration is under natural conditions influenced by many biotic and abiotic factors. Two dominant abiotic factors, which control soil respiration, are temperature and soil moisture. It has been documented in several studies that soil respiration increases with increasing soil moisture up to specific soil water content (which is different for different soils) and then mostly with increasing soil water content decreases. Another of important factor is the soil organic carbon content, which may considerably vary within the areas strongly influenced by water erosion.

Objectives

The aim of this study was to evaluate the effect of soil moisture on the soil respiration using a new laboratory wetting experiment and mathematical modeling with the HYDRUS-1D program. Another goal was to assess the impact of the organic carbon content on observed soil respiration.

Materials & methods

Study was performed on the soil samples from morphologically diverse study site in loess region of Southern Moravia, Czech Republic. The original soil type is Haplic Chernozem, which was due to erosion changed into Regosol (steep parts) and Colluvial soil (base slope and the tributary valley). The grab soil samples and undisturbed soil samples (using the 100 cm^3 columns and 713 cm^3 iron collars) were taken from the topsoil at 5 points of the selected elevation transect (to cover different degradation stages, i.e. variable soil organic carbon content, soil structure etc.) and also from the parent material (loess). The basic physical and chemical properties of the soil samples were determined using the standardized laboratory techniques (acidity, salinity, soil texture, particle size distribution, particle density, organic carbon content and carbonate content). The 100 cm^3 undisturbed soil samples were used to determine soil hydraulic properties using the multiple outflow tests. Finally, the soil samples in collars were used to measure soil respiration. Air dried soil samples were placed into kaolin tank. Soil samples were wetted by capillary rise up to their almost full saturation. Simultaneously net CO_2 exchange and net H_2O exchange rates were monitored using LCi-SD portable photosynthesis system with Soil Respiration Chamber. During the experiment the potential evaporation from water surface was also recorded. HYDRUS-1D and numerical inversion was applied to simulate water flow and vapor fluxes in the soil samples and to estimate the saturated hydraulic conductivity of each soil sample. Next CO_2 transport was also simulated.

Results

In all cases soil respiration rapidly increased with initial soil sample wetting. In the cases of the soil sample with the best developed soil structure (transect summit) and loess soil sample initially very fast increase of soil respirations turned into gradual decrease of observed soil respirations with increasing soil water contents. Respirations measured on soil samples from transect’s shoulder and the steepest part of the elevation transect showed considerably less gradual decreases. Finally, two soil samples with the worst soil structures (base slope) indicated relatively uniform trends of soil respiration with increasing soil water contents. Maximal values of soil respirations recorded for each soil sample during the entire experiments positively correlated with soil organic carbon contents. Simulation results using HYDRUS-1D well approximated water and vapor fluxes in all soil samples. The CO_2 transport was also relatively well estimated, when parameters describing CO_2 emission were manually adjusted.

Conclusion

Results showed that relationship between soil water saturation and CO_2 emission is considerable impacted by soil organic carbon content and soil structure. HYDRUS-1D program showed to be very efficient tool for simulating water and gas transport in soil porous media.

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P 3.2.11

How ecological restoration alters carbon sequestration in China's Loess Plateau

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Restoring disturbed and over-exploited ecosystems is important to mitigate human pressures on natural ecosystems. China has launched an ambitious national ecosystem restoration program called Grain to Green Program (GTGP) over the last decade. By using remote sensing techniques and ecosystem modelling, we quantitatively evaluated the changes in ecosystem carbon sequestration since China's GTGP program during period of 2000-2008. It was found the NPP and NEP in this region had steadily increased after the initiative of theGTGP program, and a total of 96.1 Tg of additional carbon had been sequestered during that period. Changes in soil carbon storage were lagged behind and thus insignificant over the period, but was expected to follow in the coming decades. As a result, the Loess Plateau ecosystem had shifted from a net carbon source in 2000 to a net carbon sink in 2008. The carbon sequestration efficiency was constrained by precipitation, and appropriate choices of restoration types (trees, shrubs, and grasses) in accordance to local climate are critical for achieving the best benefit/cost efficiency.

P 3.2.12

Effect of restoration on microbial activity and organic matter quality in long-term drained peatlands

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Introduction

In the mountainous region in Central Europe (Czech Republic), unique peatland ecosystems occur including ombrotrophic bogs and minerotrophic spruce swamp forests (SSF). However, most of these peatlands has been influenced by drainage for forestry during the 20th century. Restoration of peatlands is a relatively new practice and research was mainly focused on the regeneration of vegetation and C gas fluxes after rewetting. However, the recovery of the key soil processes and activity of soil microorganisms is crucial for restoration of whole peatland ecosystem functioning.

Questions

Therefore we proposed to study the microbial community activity in both long-term drained and restored bogs and SSF and find the links between the microbial community activity, organic matter quality and peat physico-chemical properties. The main aim is to determine how post-restoration development varies between bogs and SSF and how it is linked to different nutrient status of these peatland types. We hypothesize that lowered availability of organic matter and nutrients on long-term drained peatlands decreased the activity of microorganisms, which was more obvious in SSF than in bogs. On the contrary, restoration will increase nutrient availability, activity of the microbial community towards those of pristine peatlands, which will be faster in SSF than in bogs.

Methods

Our study sites comprised pristine, drained and restored ombrotrophic bogs (n=2+2+2) and SSF (n=2+2+2) in the Šumava Mountains, south-western Czech Republic. The surface layer of peat (0-10, and 10-30 cm) was sampled. Basis physicochemical analyses such as bulk density, soil pH, cation exchange capacity, total content of C, N and P, microbial biomass C and N, concentration of DOC and dissolved mineral and organic N and soluble reactive P. Quality and potential biodegradability of organic matter was quantified using chemical fractionation of soil organic matter. Near infrared spectroscopy was used for organic matter quality analyzes. Overall microbial activity reflecting mineralisation of organic matter was measured in laboratory condition using aerobic and anaerobic incubation, when production of CO_2 and CH_4 was measured. Microbial activity was also characterized by activities of several extracellular enzymes involved in mineralization of organic C, N and P.

Results

In pristine peatlands, organic matter quality and microbial activity varied according to nutrient status of a site and vegetation composition. Pristine SSF showed higher microbial activity and higher availability of organic matter (represented by higher content of C extractable by cold and hot water) compared to pristine bog. However, long-term drainage significantly reduced microbial activity and available fractions of C especially in SSF. Drained peat was enriched in recalcitrant compounds such as lignin-like structures and aliphatic compounds. Long-term drainage also led to higher bulk density, lower pH, decreased microbial C and N biomass, reduction of CO_2 and CH_4 production and DOC concentration. Drainage caused increase in potential enzyme activity, where betaglucosidase, cellobiosidase and leucinaminopeptidase showed higher potential activities compared to pristine SSF. Most of the changes were more dramatic in SSF, while bogs were only slightly affected by long term drainage.

On the other hand, hydrological restoration brings the first detectable result after 5-10 years. Bulk density slightly decreased, especially in the surface layer, where mosses were spreading. pH increased in restored SSF and reached the values characteristic for pristine sites. Microbial C and N biomass also showed an increasing trend in restored sites, which was reflected in increased CO_2 and CH_4 production. However, significant differences in organic matter quality have not been determined on restored sites compare to drained sites and this will require longer time period.

Conclusions

Overall, long-term drainage lead to C limitation of microorganisms, which was reflected in decreased microbial biomass and activity. Long-term drained peat showed low decomposability, which is related to poor substrate quality, enriched in recalcitrant compounds. This is reflected in low microbial biomass and activity. On the other hand, some of the measured parameters indicated that restored sites progress toward those of the pristine sites, which suggests successful restoration.

P 3.2.13

Sensitivity of Organic Matter Pools' Decomposition to Soil Temperature

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Introduction

Understanding the temperature sensitivity (Q_{10}) of soil organic matter (SOM) decomposition is important for predicting global carbon stock under warming scenarios.

Objective

This study aimed to prove the temperature response of SOM pools following ^{14}C glucose addition.

Materials & methods

Loamy Luvisol originated under C3 plants was incubated for six months at five temperatures (i.e. 0, 10, 20, 30 and 40 °C) with or without ^{14}C labelled glucose. The CO_2 flux dynamics was measured over short term (0-7 days) and long term (0-144 days) periods following ^{14}C glucose addition.

Results

The CO_2 efflux from SOM at 40 °C was six- (during first few days after ^{14}C input) to five times (toward the end of the experiment) higher than at 0 °C and followed single exponential kinetics. The glucose mineralization occurred in two phases in 10-40 °C (following a double exponential function), whereas at 0 °C a lag phase was typical. More than 50% of glucose was mineralized after one day (at 30- 40 °C), four days (at 10-20 °C) and 25 days (at 0 °C). Despite the differences in initial dynamics of $^{14}CO_2$ efflux at 30 and 40 °C, the total $^{14}CO_2$ evolved during 144 days was not significant. Maximum glucose mineralization rate at 0-10 °C was reached earlier (within 0-6 h) than at 20-40 °C (within 6-18 h). High temperatures increased the relative amount of ^{14}C incorporation into the labile pool relative to the recalcitrant pool. The turnover time for the labile pool at 40 °C was about three times greater than at 10 °C. The ^{14}C recovery in microbial biomass (MB) decreased with temperature and was about two times higher after 7 days than after 144 days, at all temperatures except 40 °C (no relevance for ^{14}C recovery in MB). Increasing temperature not only increased the priming effect (PE), but also had a stronger effect over longer incubation time. The amount of primed CO_2 showed a steeper linear increase with increasing temperature during the long term than short term. Labile C pool (glucose) was more sensitive to temperature (Q_{10} = 2.56) over the short term, whereas recalcitrant pools were more sensitive (Q_{10} = 1.72) over the long term. Short term incubations exhibited decreasing temperature sensitivity with decreasing lability of C pools, whereas for longer incubation periods the opposite trend was observed.

Conclusion

In conclusion, the temperature sensitivity of the soil C pools decreased in the order: glucose > SOM ≈ primed after 7 days and SOM > primed ≈ glucose after 144 days. The ^{14}C incorporation into MB decreased with temperature up to 35 °C. The amount of primed CO_2 increased with temperature.

P 3.2.14

Effect of soil parent material and forest vegetation on properties of soil humic acids

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The aim of the presented research was to examine differences in the chemical and structural characteristics of soil humic acids (HA) in mountainous forest soils in the Tatra Mountains, Poland. The goal was to answer the following research questions: 1) How do chemistry and structural composition of humic acids vary with soil depth? 2) What is the effect of soil parent material (shists and carcarous rocks) on HA properties 3) What is the effects of forest composition (beech ferest and spruce forest) on HA properties?

There were analyzed properties of HA extracted from organic and humus horizons of four following soils: Haplic Cambisol (Hyperdystric, Endoskeletic) developing under beech forest, Haplic Cambisol (Epidystric, Episkeletic) - under spruce forest, Rendzic Leptosol (Hypereutric, Episkeletic) - under beech forest and Rendzic Leptosol (Hypereutric, Episkeletic) - under spruce forest. The study plots were located in two adjacent valleys in lower montane belt in the Tatra mountains, in cool temperate climate.

The 13C NMR spectroscopy and dry combustion gas chromatography were employed to study isolated HA. HA were isolated with Shnitzer method with previous decalcitation.

The results of elemental composition and 13C NMR spectroscopy shows an increase in the HA alkyl component with soil depth because of selective preservation of highly recalcitrant compounds. In all examined profiles, ratio of aliphatic carbon (al-C) to aromatic carbon (ar-C) increases with depth. Similarly, the HA oxidation rate increases with depth. Mentioned changes suggest increasing decomposition degree of HA with soil depth.

Properties of HA strongly depend on soil parent material. In Rendzic Leptosols higher oxidation degree of HA than in Haplic Cambisols is observed, which suggest higher decomposition degree of HA. On the other hand, ratio of al-C to ar-C is lower in Rendzic Leptosols than in Haplic Cambisols suggests better protection of aromatic structures in these soils. This effect is most likely connected with presence of calcium cation which protects structures of HA from further decomposition. Differences between Rendzic Leptosols and Haplic Cambisols are well pronounced in both: organic and humus horizons.

In contrast to parent material, differences in HA properties between soils developing under beech and spruce forests are less pronounced and they are observable only in organic horizons. There is higher amount of C in lignin-derived groups in organic horizons in soils developing under beech forest than under spruce forest, which is most likely connected with chemical composition of plant material delivered to the soil. Higher oxidation degree in organic horizon of soils developing under spruce forest than under beech forest suggests higher decomposition rate of HA, which is in agreement with morphology of those horizons.

P 3.2.15

The Evaluation for Changes of Soil Carbon According to Morphological Characteristics with Several Kinds of Organic Material

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Organic matter is very important in soil ecosystem with several aspects such as carbon and nitrogen cycles. Recently, concerning about climate change, carbon sequestration in agricultural land has become one of the most interesting and debating issues. It should be necessary to understand carbon decomposition pattern about the kinds of organic matter sources to cope with well.

In order to evaluate decomposition of soil carbon according to organic material during cultivating rice in paddy field, we carried out to treat organic material such as hairy vetch, rice straw, oil cake fertilizer, and animal compost at 50 x 50 x 20 cm blocks made of wood board, and analyze contents of fulvic acid and humic acid form, and total carbon periodically. The experiment was conducted in 2013-2014, and sampled with interval in a month. The organic material was applied to treatment blocks in 2 weeks ago in rice transplanting of each year.

The treatment of animal compost the highest increased among the treatments about the changes of total carbon showed 9.3 g kg^{-1} July in 2013 to 11.1 g kg^{-1} August in 2014. The carbon as fulvic acid form which is considered to easily decompose has been showed fluctuation ranged from 1 to 2 g kg^{-1}. But after application of organic treatment, contents of fulvic acid form carbon increased in all treatments in 2014. As result as analyzing changes of carbon as humic acid phase, it was changed between about 3 to 4 g kg^{-1} in all treatments until organic treat had been applied at second in 2014. From May second year application to August, the contents of humic acid form carbon has increased to about 4 g kg^{-1}. Humic carbon at treatments of hairy vetch and no treat were recorded lower than other treatments, showed 3.6 and 3.63 g $kg^{-1,}$ respectively, at August in 2014. The treat of animal compost has showed the lowest ratio of fulvic acid, humic acid form among other treatments even though the amount of their ratio has been different according to time and treatments. The ratio of fulvic phase carbon was ranged about 13 to 23%, and humic phase carbon about 24 to 50%.

In conclusion, animal compost included wood as bulking agent is more superior to sequestrate carbon at agricultural land than raw plant materials.

Figure 1

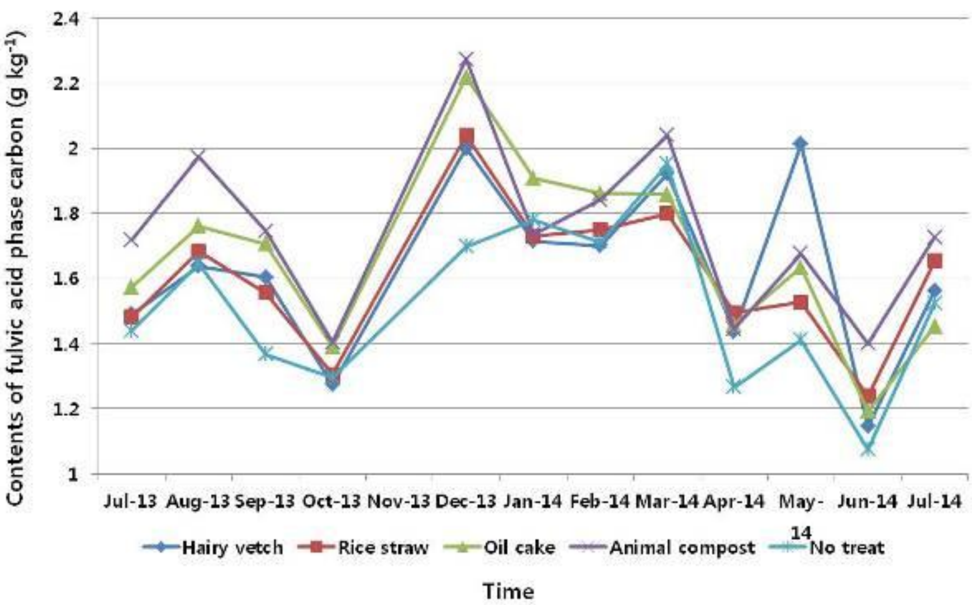
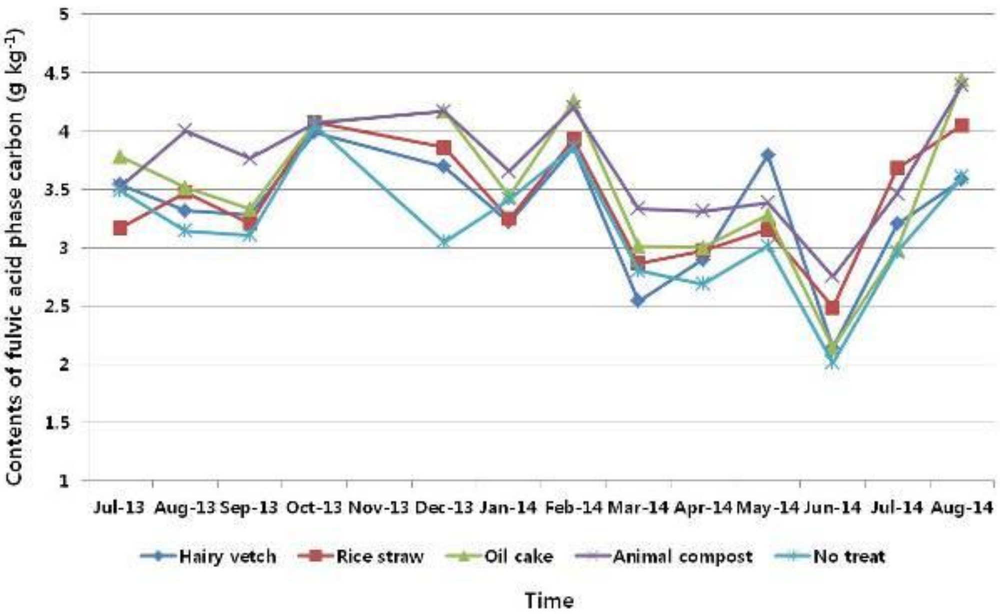


Figure 2


Contents of fulvic acid phase carbon (g kg-1)
5
4.5
4
3.5
3
2.5
2
1.5
1
Jul-13 Aug-13 Sep-13 Oct-13 Nov-13 Dec-13 Jan-14 Feb-14 Mar-14 Apr-14 May-14 Jun-14 Jul-14 Aug-14
Hairy vetch
Rice straw
Oil cake
Animal compost
No treat
Time

P 3.2.16

Drought stress and the stability of soil organic carbon in reduced till soils

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In the agricultural landscape, less intense soil management regimes, such as minimum tillage, are being promoted as sustainable options that can enhance soil ecosystem service delivery. Reduced tillage in particular has been linked to increased soil organic carbon and microbial biomass; but interactions between tillage systems and climate change scenarios are less well understood. In particular, the stability to stress of soil organic carbon in reduced tillage soils has rarely been investigated. Weather patterns in the south of England are predicted to become more variable, with an increase in the frequency and intensity of summer drought events. Here, we test the hypothesis that soil carbon accumulated in reduced and zero tillage soils is in a predominantly labile form that is susceptible to losses when experiencing drought related disturbance. A factorial experiment with three levels of tillage regime (plough: CT, min till: MT, zero till: ZT) and three watering regimes (Control, 15 day drought, and 3 month drought) was applied in a controlled environment room with four replicate 300g dry matter soil microcosms per treatment. Soils were collected from a field experiment where tillage regimes had been in place for six years prior to the laboratory incubation. Soil organic matter (SOM) was determined by loss on ignition (LOI), and dissolved organic carbon was measured by cold- and hot-water extraction and measured on a Shimadzu TOC analyser. In addition, a simulated leaching event was applied by flushing microcosms with deionised water and measuring organic carbon as described above. Total dissolved organic carbon (DOC) in ZT soils was greater than CT ($p<0.01$), but there was no effect of watering treatment ($p>0.1$), and no interaction between tillage and watering, indicating that DOC was greater in ZT under both control and drought conditions. Soil water leached from microcosms in the simulated leaching event revealed significantly greater organic carbon lost from soils that had previously experienced a drought event ($p <0.001$). There was also a significant interaction between tillage and rainfall treatment. Under ambient rainfall conditions there was no effect of tillage regime on TOC in leachate ($p>0.1$), but when soils had previously experienced a drought event, both MT and ZT soils leached more carbon than CT soils (TukeyHSD $p<0.05$, $p<0.001$, respectively). Although our data indicates greater carbon losses in MT and ZT soils after experiencing drought stress, the effects are potentially confounded with those of physical disturbance due to pre-experiment soil processing (sieving). This is particularly relevant in light of previous work showing that carbon in MT soils is susceptible to losses as a result of physical disturbances associated with occasional ploughing events. Further work is planned in order to disentangle these effects. As climate projections predict an increased frequency and intensity of extreme climatic events, we suggest more work is needed to evaluate the resilience to climatic stress of soil carbon under various land management scenarios before valid recommendations can be made to land users.

P 3.2.17

Soil phosphorus availability of plantation in degraded sub-tropical hilly red soil region

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Introduction

The long-term Forest Restoration Experimental Project (FREP) was established in 1991 on a sub tropical, barren, degraded, red soil with a rolling terrain located in Taihe County, Jianxi province, China. The objective of the FREP was to evaluate the effects of restoration, through afforestation by using various local climax species, on ecological functions to provide guidance for future restorations on severely deteriorated landscapes, which are very common in southern China. In this study, we selected three restoration forests: slash pine (*Pinus elliottii*), Chinese sweetgum (*Liquidamber formosana*) , slash pine x Chinese sweetgum mixtures, and one experimental control (natural recovery) to evaluate the differences in P and its' availability of soils under different vegetation types and different soil depths in hilly red soil of subtropical region; and to evaluate the advantages and disadvantages in artificial afforestation in hilly red soil of mid-subtropical region.

Methods

The FREP is located in Taihe County (26°44'N, 115°04'E), Jiangxi, China. Three 20m x 20m plots were located in each of the three forest stand types and in the control site for a total of 12 plots. In each vegetation plot, five sampling points was selected to sample soil at depths of 0-10 cm,10-20cm and 20-40 cm at each corner and the center of the plot. Soil samples combined per layer were obtained for chemical analysis for a total of 36 samples.

Soil samples were first dried at room temperatures with fine roots, gravels and debris removed, and then grinded and sifted. The soil samples were used for the test of available phosphorus, total phosphorus, organic phosphorus, water-soluble phosphorus, Al-P, Fe-P, O-P ,Ca-P and microbial biomass phosphorus.

A mixed model of two-way analysis of variance (ANOVA) was used to test differences of soil available phosphorus, total phosphorus, organic phosphorus, water-soluble phosphorus, Al-P, Fe-P, O-P ,Ca-P and microbial biomass phosphorus between treatments (control and restoration) and soil depths (0-10 cm, 10-20 cm and 20-40 cm). All analyses were conducted by using SPSS software (version 17.0), and an α value of 0.05 was used to determine statistical significance. Differences between treatment and soil depth's means were compared using a Tukey's test

Rusults:

Table1 Corrections between soil available phosphorus and phosphorus concentration

	Available Phosphorus	Total Phosphorus	Al-P	Fe-P	O-P	Ca-P	Organic Phosphorus	Microbial Biomass Phosphorus

Available Phosphorus	1	-0.398*	0.516**	0.650**	-0.617**	-0.631**	0.729**	0.411*
Total Phosphorus		1	-0.418*	-0.208	0.797**	0.814**	-0.382*	0.035
Al-P			1	0.548**	-0.666**	-0.783**	0.756**	0.133
Fe-P				1	-0.546**	-0.590**	0.693**	0.166
O-P					1	0.866**	-0.773**	-0.274
Ca-P						1	-0.728**	-0.057
Organic Phosphorus							1	0.549**
Microbial Biomass								1

Phosphorus								

Note: * *P*P

1. Vegetation restoration in degraded hilly red soil region has greatly changed soil P availability. In contrast to naturally restored grassland (control), the available P, microbial biomass P and organic P in 19-year-old forest soil were improved significantly, and surface gathering was found from each P. Soil available P and microbial biomass P in *Liquidambar formosana* forest and *P. elliotti-L. formosana* forest were significantly greater than those in *Pinus elleottii* forest; **2.** O-P, Ca-P and total P in planting sites were significantly lower than those in naturally restored grassland, but an opposite trend was noticed for Al-P and Fe-P;**3.** Soil available P was positively correlated with Al-P, Fe-P, organic P and microbial soil biomass P, suggesting that soil organic P, microbial biomass P, Al-P, Fe-P were potential resources of soil available P in forest soil of red soil region. Revegetation in degraded red soil would be helpful in improving accommodating soil activated P, especially in increasing the integration of Al-P and Fe-P. Better improvement effect was achieved in the broad-leaved forest and broad-leaved and conniferous mixed forest than in coniferous forest.

Acknowledgement

This study has received the support from Special funds for the development plan of Young and middle-aged visiting scholars in Jiangxi Universities(Jiangxi choi puts[2012]No.132), the State Scholarship Fund of China Scholarship Council（CSC[2014] No.3012）, National Science and Technology Support Project(2012BAC11B06), National Natural Science Foundation of China (30960312；32360177)， Science and technology project of Department of Education in Jiangxi Province (GJJ10107) and Science and technology project of the Environmental Protection Department in Jiangxi Province (JXHBKJ2012-7)

Figure 1

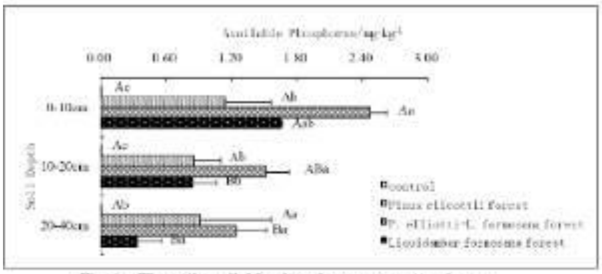

Fig. 1 The soil available phosphorus concentration at different soil depths among the reforestation types Note: The same upper case letter means statistically similar between soil depths, and the same lower case letter represents statistical similar between restoration types, α = 0.05. The same below.

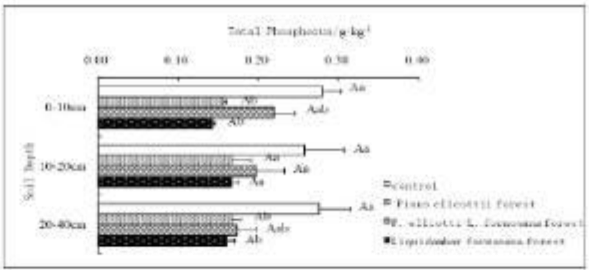

Fig. 2 The soil total phosphorus concentration at different soil depths among the reforestation types

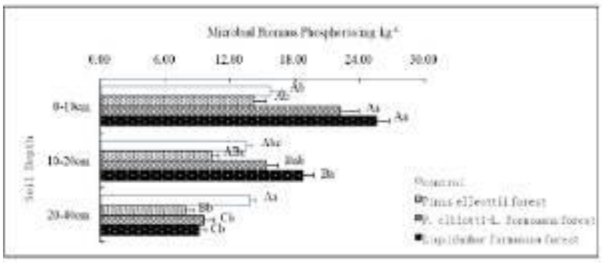

Fig. 3 The soil microbial biomass phosphorus at different soil depths among the reforestation types

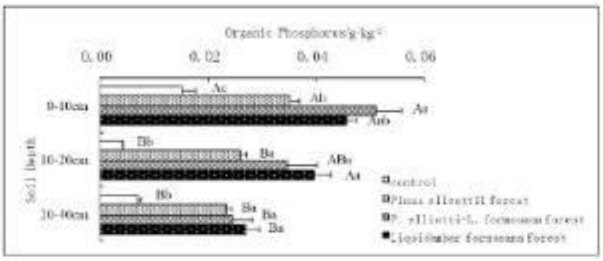

Fig. 4 The soil organic phosphorus concentration at different soil depths among the reforestation types

Figure 2

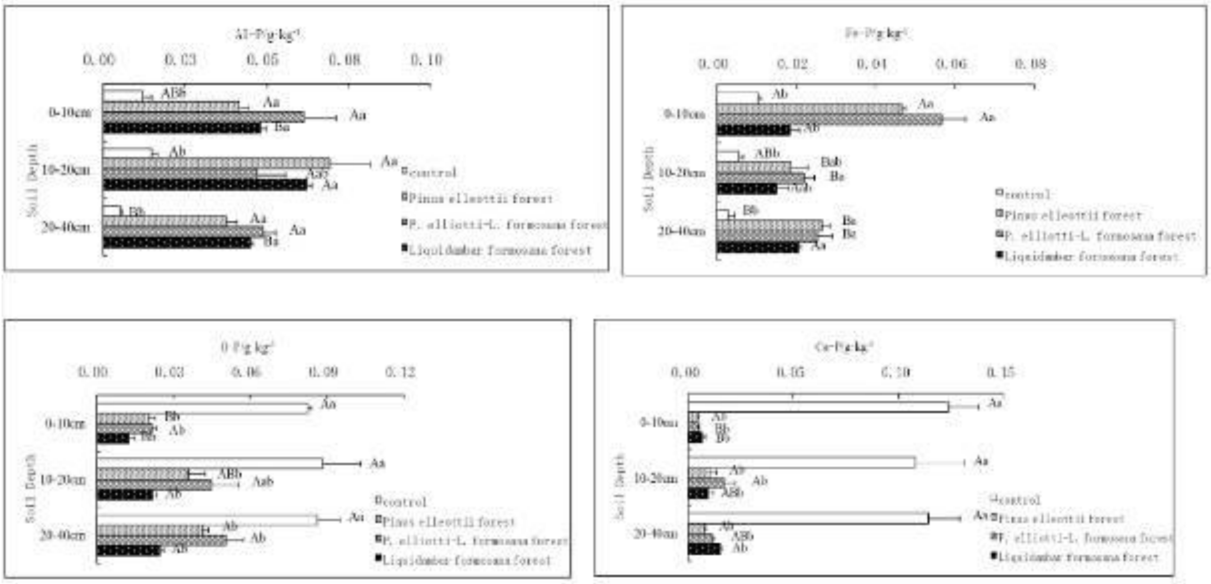

Fig. 5- The soil inorganic phosphorus fractions concentration at different soil depths among the reforestation types

P 3.2.18

Changes of humic acid properties during the humification processes in peat soils under raised bog of West Siberia

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Introduction

The peat soils from peatlands play a major role in the carbon biogeochemical cycling because the rate of biomass production is greater than the rate of decomposition in these environments (Clymo, 1983). The carbon biogeochemical cycling, the transformation of living organic matter into humic substances or humification is of key importance. To characterized the humification process which is a very complex processes and cannot be explained by using a single index, the main goal of this study is to characterize the humic acids in the peat soils during the changes of the humification degree along the profile using multidisciplinary approach.

Materials and Methods

A complete vertical profile of peat soil was collected from raised bog located in the boreal forest vegetation zone (in southern taiga zone) of West Siberia and belong to northeastern spurs of the Great Vasjugan Mire. The samples were collected using a Russian peat corer, underneath with 10 cm intervals. Humic acids (HAs) were extracted from each sample according to a procedure of the International Humic Society (Swift, 1996).

The elemental composition of the HAs was determined by a CHN analyzer (Vario El Cube). The FT-IR spectra were acquired in transmittance mode using a Thermo Nicolet FT-IR Spectrophotometer. The analysis of humification was carry out according Blackford and Chambers (1993) and expressed humification index (Ih).

Results

In the upper part of profile from 10 to 130 cm represented by Sphagnum dominated, the Ih was low (around 0.19 to 0.45) and C/N high and ranges between 65 to 94. Below 130 cm, a steep increase of Ih (from 0.45 to 1.1) and decrease in C/N ratio occurred suggesting increased decomposition and less peat accumulation. The most significant processes of humification occur in the layer of 180-210 cm presented by alternating layers of C*otton grass* and *Sphagnum papillosum* peats as evidenced by the high value of the Ih (0.86-1.30) then the Ih is slightly decrease to mineral layers presented by *Carex* dominated peats with constant values - 0.7.

The main atomic ratios in HAs isolated from peat samples is observed from elemental composition. The process of decomposition and humification of organic matter takes place against the reducing the N concentration in the HAs. The C/N ratio increased at depth (from 13.9 to 26.1) suggesting mobilization of N in the molecular of HAs during humification. The high atomic ratios of H/C (1.1-1.4) indicate a predominant aliphatic character in HAs whereas the O/C ratios change from 0.4 to 0.6 suggest the relatively large amount of O-containing groups.

According the FTIR spectra the maximum intensity of the absorption bands register for hydroxylic, carbonylic and carboxylic groups of aliphatic and aromatic fragments. Very interesting that the broad absorption occurring at 1640 cm^{-1}, ascribed to aromatic C=C vibrations, decreases in intensity relative the aliphatic group absorptions 2920 cm^{-1} especially in the central part (between 180-210 cm presented by alternating layers of *Cotton grass* and *Sphagnum papillosum* peats) of soil profile where the processes of humification are significantly intensive. At first sight this is contradict the generally accepted theories. However, the HAs of this layer characterized by highest 1040/1640 ratio indicating increase of alkoxides (- O-R). In our opinion, the aliphatic fragments in the molecular of HAs increase because of the alkoxide groups are more resistant to transformation processes in anaerobic conditions than alkyl ones. The upper layers are most undergo to oxidation for this reason the HAs characterized by contribution of carboxilyc group, as evidenced by increase of 3375/1610 ratios (-OH) and decrease of 1235/1640 ratio (-COOR).

The HAs isolated from a deeper mineratrophic layers have contrasting trends of changes of these ratios (3375/1610 ratios is decreased, 1235/1640 ratio is increased) at constant values of 1710/1640 ratio (C=O) along the profile as evidenced by enriched of ester.

Conclusions

In the investigated peat soils, the processes of humification (expressed as Ih) are increase at depth with maximal values in the middle part of profile. The changes in HAs compositions with depth were also different, and some cases contrasting trends in physical and chemical properties were observed. HAs composition appears to be determined not only by nature of the original organic material but also by other factors with higher depth-related variability i.e. water table position, redox potential and climatic changes during peat formation.

P 3.2.19

Soil organic carbon quality and quantity affects the sensitivity of microbial communities to temperature

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Introduction. Soil organic carbon (SOC) quantity, quality as well as environmental conditions such as temperature have a strong impact on the biodiversity and community structure of soil microorganisms and SOC was hypothesized to influence microorganisms sensitivity to environmental stresses. To our knowledge the sensitivity of microbial community structure to a perturbation (such as a temperature increase) when the organic carbon resource is scarce is poorly documented. Our aim was to investigate the soil microbial community structure in response to labile organic carbon depletion and a temperature increase.

***Materials and methods*.** To do so, we selected archived soil samples from four long-term bare fallow experiments located at Askov (Denmark), Grignon (France), Ultuna (Sweden) and Versailles (France). We used samples sampled at the start of each experiment and after 25, 48, 53 and 79 years of bare fallow respectively (which are depleted in labile organic carbon).

Soil samples were incubated at three different temperatures (4, 20, 35°C) and at a constant soil moisture (pF= 2.5) for 427 days. During the incubation, soil respiration was regularly monitored using a µGC technique. These measurements showed that the organic carbon contained in soils sampled after several decades of bare fallow was more resistant to microbial degradation. At the end of the incubation soil microbial DNA was extracted and amplified. We then studied the microbial community structures using pyrosequencing techniques.

Results. Both microbial community richness and equitability were impacted when the biodegradability of the organic carbon resource decreased. Overall richness and equitability were higher at reasonable temperatures (i.e. 4 and 20°C) when the organic resource was scarce but they dramatically decreased at 35°C. Moreover, several phyla were particularly impacted by the availability and/or the quality or the organic resource both among oligotrophic (such as Acidobacteria and Actinobacteria) and copiotrophic (Firmicutes) behaviour groups. The temperature had more impact on microorganisms in soils after decades of long term bare fallow, i.e. in soils poor in SOC and depleted in labile organic carbon, showing that (i) sensitivity of microorganisms to this stress increased when the trophic resource decreased and that (ii) a more diverse community does not necessarily exhibit a higher resistance to environmental stresses.

***Conclusion*.** Microbial community structure and sensitivity to stresses is strongly dependent upon their trophic resource, i.e. soil organic matter. The higher sensitivity of stable SOC mineralization to temperature, compared to labile SOC, is related to contrasting decomposers microbial communities.

P 3.2.20

Organic matter biodegradability in Siberian permafrost-affected soils: linking to microbial biomass and activity

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INTRODUCTION

Northern ecosystems are characterized by extreme climatic conditions and low productivity during the short growing seasons. Deep soil temperature regimes and partially water saturation of large areas give rise to low microbial activity and long turnover time for organic materials. As a result, accumulation of organic matter is favored in cold climate soils (Rodionow *et al.*, 2006). Knowledge of linking microbial community features and SOM quality as a substrate for decomposing organisms is necessary to predict the magnitude and the time-scale at which C will get mobilized in permafrost soils at climate change (Khvorostyanov *et al.*, 2008).

OBJECTIVES

The main goal was to identify links between the microbial biomass and activity and organic matter composition in soils underling by continuous permafrost.

SITE DESCRIPTON AND METHODS

The study site is located in the homogeneous larch forests of the Central Evenkia (N 64°, E 100°). The investigated area is situated in the continuous permafrost zone, with a permafrost thickness up to300 mand with the permafrost temperature of-3.5 °C. Soil cover is presented by Cryosols. Climate is highly continental with mean annual temperature of -8.9°C (mean temperature in January,-36 °C; mean temperature in July, +16 °C) and a mean annual precipitation of 370 mm.

Measurement of carbon and nitrogen contents in soil was done by an Elementar Vario EL III elemental analyzer, and stocks were calculated for different layers based on the bulk density and corrected for the rock content.

Labile organic matter was extracted using serial daily extractions of a soil sample by distilled water and 0.1N NaOH solution, without preliminary decalcifying. The content of stable soil organic matter was determined by a difference between the content of the total organic carbon and carbon of the labile organic matter.

Microbial biomass was assessed by rehydration method and using substrate-induced respiration (SIR). Basal (heterotrophic) soil respiration was estimated from CO_2 emission rate from soil samples incubated at 23ºC and 60% moisture content. Quantitative PCR was used for analysing abundance of the 16S rRNA genes of bacteria.

RESULTS

The total organic carbon stock in the active soil layer on the north-facing and south-facing slopes was 5.4 and 2.1 kg C m^{-2}, respectively, in spite of the thickness of the active layer on the south-facing slope, which was 1.3 times deeper thawed compared to the north-facing slope. The upper 0-20 cm soil layer of north-facing slope contained 2.3 times more carbon than soils on the south-facing slope. At both slopes, soil organic carbon concentrations decreased gradually with soil depth down to the permafrost table.

The main part of accumulation of soil organic matter stocks on both slopes was stable humus (C_{stab}). C_{stab} accumulation in the soil of the north-facing slope took place down to the permafrost table, while at the south-facing slope the accumulation occurred mostly within the top 0-30 cm of the mineral soil. Labile carbon (C_{lab}) had larger contents in soils of north-facing slope. We assume that higher moisture conditions of a north-facing slope favored the migration of dissolved organic matter to the lower part of the active layer, where it accumulated in both fractions, as labile and stable organic matter.

Basal respiration rate as well as heterotrophic microbial biomass within the active layer of soil profiles at both slopes decreased with depth and were strongly correlated with the organic carbon content. The number of bacterial 16S rRNA gene copies in the soil of the south-facing slope decreased down on a profile with sharp increase in close to the permafrost table, while the number of gene copies in the soil of the north-facing slope was rather evenly distributed within active layer profile, with a tendency to decrease close to the permafrost table. Possibly, such distinction is bound to various soil moisture and its flushing regime on slopes. Also the pattern of biomass of the heterotrophic microorganisms with soil depth was similar to that of the number of gene copies, indicating that the majority of the microorganisms in these soils were heterotrophs. However, the heterotrophic respiration in the deeper soil horizons was extremely low, thus showing that heterotrophic respiration is influenced by decreasing soil temperatures with depth.

Conclusion

The heterotrophic activity in the investigated permafrost soils is closely correlated to the labile fraction of soil organic matter while microbial biomass depends on total organic carbon content.

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P 3.2.21

Response of CO_2 fluxes from soils to weather extremes: the results of manipulation experiment in temperate region of Russia

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According to current prognosis (*Second Roshydromet assessment report..., 2014*), the climate change in Central Russia is likely to increase intensity and frequency of droughts during summer season and can also result in prolongation of period when soil remains unfrozen during winter time. Simultaneously, it is suggested that repeatability of soil freezing-thawing events during late autumn or early spring will increase. Being the leading biogeochemical cycle in the global scale, carbon cycle and its main components interact closely with climate changes via feedbacks. The aim of present study was to evaluate the effect of extreme weather events on summer and winter CO_2 fluxes from temperate soils.

To simulate mild, ambient and extreme climates, the manipulation precipitation experiment was established in grassland cenosis and bare soil (*Luvisols Haplic,* Moscow region, 54°50'N, 37°36'E; continental-temperate climate). During summer and early autumn seasons, the following precipitation patterns were foreseen: S1 -optimal moisture regime (98 mm per 3 months), S2 - repeating short droughts (30 and 48 days without rainfall), and S3 - severe drought (82 days without rainfall). The water losses were compensated at the end of each drought to simulate heavy rain events (15-55 mm).

To evaluate the effect of freezing events of different intensity on CO_2 fluxes from soils, the following winter scenarios were performed: W1- exclusion of freeze (simulation of deep snow cover by artificial heat insulation material); W2- natural depth of snow cover, and W3 - deep freezing (without snow cover). In the frame of whole experiment, variant S1 together with W1 simulated a mild climate (Mild) without droughts and freezing, while variants S2 and W2 corresponded to 'ambient' temperate climate (Ambient) with repeating droughts and natural depth of snow cover. Variants S3 and W3 together simulated the extreme climate conditions (Extreme) with severe summer drought and deep freezing during winter time.

CO_2 emission fluxes (total soil respiration, TSR) were measured by closed chamber method 2-3 times per week from early July, 2014 to late March, 2015 using Li-COR 6400 system during the summer period and by syringe technics during the winter time.

During summer-early autumn period, the TSR under optimal moisture level (variant S1) averaged at 169 and 128 g C/m^2 in grassland and bare plots, respectively. Severe drought stress reduced the TSR by 30% in grassland and by 10% in bare soil (Fig.). The impact of drought stress intensity on the TSR was insignificant both under grasses and in bare plots. Despite a significant increase of TSR after excessive wetting of soils at the completion of droughts, the CO_2 emission bursts had a small impact (2-10%) on the summer TSR from soils.

The winter cumulative TSR flux from grassland plots during 3.5 months of field observations varied between 34.7-44.0 g C/m^2 (under W2 and W3 scenarios) and 111.7 g C/m^2 in W1 variant (Fig). For the bare plots, TSR fluxes were 1.3-2.1 times less in comparison with grassland soil. The rate of CO_2 emission from frozen soils was very low and comprised 0.14-0.20 and 0.22-0.24 g C/m^2/day for bare and grassland plots, respectively. During the thawing periods, TSR rate has increased 1.6-2.9 times depending on treatment.

We conclude that under temperate climate, the summer TSR is regulated mainly by total duration of summer drought while the affect frequency of rainfall events was weaker. During cold season, the freezing events play an important role reducing significantly (more than 2-2.5 times) winter CO_2 emission fluxes from soils. In general, extreme events reduced TSR for 9 months of experiment by 38-40% compared to mild climate both in grassland and in bare plots.

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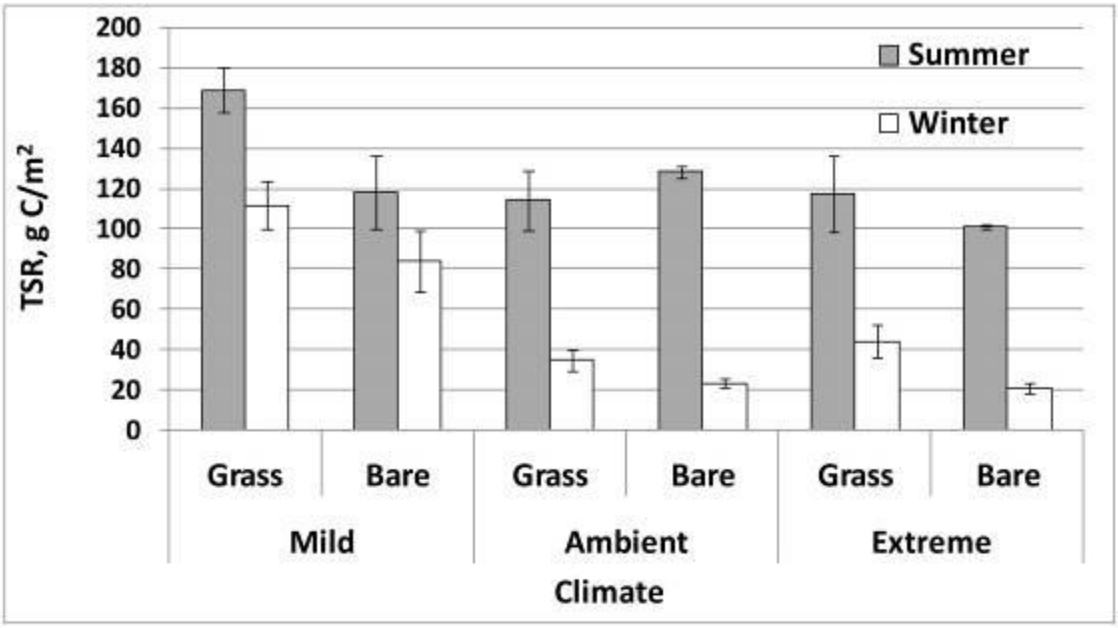
Reference

Second Roshydromet Assessment Report on Climate Change and its Consequences in the Russian Federation, General summary. 2014. 56 p.

Fig. Effect of weather extreme events on summer and winter TSR in grassland and bare soil.

Figure 1



P 3.2.22

Regional carbon losses due to deforestation in Russia in 2000-2013

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In Russia, the deforestation is associated with the transfer of forest land to non-forest for the expansion of settlements and construction of infrastructure. For our calculations we used available statistical data on the construction of trunk pipelines and oil product pipelines, rail lines and second tracks, roads, communication lines, oil and gas wells, transmission lines, etc., by regions of the Russian Federation.

To estimate carbon losses from deforestation we assumed complete oxidation of carbon pools in biomass, dead wood and litter in the year of deforestation. Considered 2 options of oxidation for soil organic matter: 1) with complete destruction of the soil carbon pool in the year of deforestation during construction of roads and railways, oil and gas wells; 2) partial oxidation of soil carbon happened within 20 years due to construction of pipelines, power lines and communication lines. To estimate carbon losses were used the average values of carbon stocks on forested lands calculated for each region of the Russian Federation. The method and a special program developed by the Center for ecological problems and productivity of forests RAS [http://www.cepl.rssi.ru/programms.htm] were used in calculations.

In 2000, the highest total carbon losses due to deforestation have been observed in the Northern regions, Siberia and the Republic of Bashkortostan. Thus in the Tyumen region the losses have reached 199.6 million tons/year, in the Khanty-Mansiysk Autonomous Okrug - 131.8, in Bashkortostan - 126.6, Irkutsk region - 175.4 and in the Komi Republic - 71.8 million tons C. The contribution of these regions to the national annual CO_2 emissions from deforestation amounted to 13, 9, 8, 5 and 5%, respectively. Total losses in 2000 are estimated about 1523.6 million tons of carbon.

By 2013 among the leading regions in deforestation area again were Khanty-Mansiysk Okrug, where the intensive development of oil-gas fields continues, Komi Republic and the Irkutsk region. Emissions from deforestation on the territory of the Moscow region increased by more than 3-folds for the period from 2000 to 2013 primarily due to the extensive construction of power lines and roads. The absolute magnitude of the carbon losses in the above regions in 2013 amounted to 162.9 million tons, 66.0, 53.4 and 101.8 million tons respectively. The total losses of carbon due to deforestation in Russia in 2013 is 1046,8 million tons. Reduction of the total emissions within the period from 2000 to 2013 by 31% explains by the decrease in the construction of infrastructure in the country from 34.2 to 23.2 th. hectares, and the termination of the residual emission from soils during partial oxidation of the soil organic matter in the ' 80s, (the period of stabilizing for which is assumed to be 20 years).

P 3.2.23

Carbon and nitrogen losses from soil depending on degradation of *Kobresia* pastures on Tibetan Plateau

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Question:

Kobresia pygmaea pastures on the Tibetan Plateau (TP) are one of the most important grassland ecosystems around the world due to its large grazing area and very high carbon (C) storage. However, degradation of *K.* pastures strongly increased on the TP in the last decades and contributed to a high loss of soil organic matter (SOM) and nutrients. *K.* pastures were classified into different degraded stages (Babel et al., 2014): (a) living root mat, (b) dying root mat and (c) dead root mat. Nevertheless, C and nitrogen (N) losses among different degraded root mats are still unclear.

Method:

This study investigated the C and N losses by carrying out two experiments. The first experiment was conducted to demonstrate the relationship between soil moisture content and nighttime CO_2 efflux. In the second experiment, daytime and nighttime CO_2 fluxes and concentrations of dissolved C and N in the leachate were measured weekly.

Results:

Dying root mat had the highest C loss as CO_2 efflux and also as dissolved organic matter (DOM) leaching compared to living and dead root mats. Consequently, SOM storage under dying root mat will rapidly decrease. Living root mat lost much less C and N compared to dying root mat. Nighttime CO_2 efflux was dependent on soil moisture and correlated well between living and dead root mats. This demonstrated that increased precipitation in the TP will increase soil moisture and accelerate C losses due to enhanced SOM decomposition. The highest NO_3^- amount was leached from dead root mat. We suggest that N was accumulated during longer mineralization and then was leached by water addition. Consequently, increasing precipitation also promotes NO_3^--N losses via leaching, especially from degraded sites. This additionally increases the negative effects of pasture degradation on N availability in these N limited ecosystems because of reduced recover potential of *Kobresia* pastures.

Conclusions:

These results demonstrate that saving and restoration of living *Kobresia pygmaea* pastures is the most urgent necessity to reduce C and N losses and protect *Kobresia* ecosystem against degradation.

P 3.2.24

Effects of rewetting and substrate addition on active microbial activity in soils under different tree species in semi-arid ecosystem, Delhi, India

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It is well known that the addition of certain substrates in soil may accelerate, decelerate or have no change in native soil organic matter (SOM) mineralization. This phenomenon is termed as priming effect (PE) which are short term changes in native SOM mineralization after addition of substrates in soil and it may be either positive (mineralization of native SOM) or negative (retardation of native SOM mineralization). We studied the effects of rewetting the soil and addition of glucose (easily available substrate) on active microbial activity (MA) at two different soil depths (0-10 cm and 10-20 cm) under different tree species (*Prosopis juliflora, Pongamia pinnata and Cassia fistula*) as compared to control soil (barren land) in a semi arid ecosystem,Delhi, India. We found clear effects of soil rewetting and also effects of different tree species on MA. These effects were stronger at upper soil layers (0-10cm) as compared to lower soil layers (10-20cm) at all the studied sites. MA was maximum in substrate (glucose) added soils as compared to fresh and only rewetted soil and it was maximum under *Prosopis juliflora*. This could be one reason why *Prosopis juliflora* is invading many parts of barren land in India because higher microbial activity may lead to stronger and faster mineralization of native SOM (PE) and subsequently release of nutrients which are further taken up by the tree. Addition of substrates in soil happens on regular intervals in terms of root exudates and litter inputs by plants and the overall priming and direction of priming (positive or negative) can regulate the nutrient balance in the soil. Furthermore, understanding the biological processes with higher resolution in soil may help us in soil conservation and soil reclamation strategies.

Key words: priming effect, substrate, rewetting, active microbial activity

P 3.2.25

Fungal decomposition of dissolved organic matter from forest soils

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Introduction

Boreal forest soils serve as an important terrestrial C sink, containing ca. 16% of global soil C stock in total [1, 2]. Soil C cycling and stabilization are governed by soil microbial activities. A major source of SOM in boreal forests is plant litter which has high concentrations of lignin and other phenolic compounds [3]. Filamentous saprotrophic fungi are thought to have a unique ability to degrade such compounds and are considered to be the main decomposers of forest SOM [4]. Recently ectomycorrhizal fungi (ECM) was found to show capacity to degrade and transform humus-rich SOM [5, 6]. However, the mechanisms involved in fungal decomposition of SOM are still poorly investigated, which hinder the prediction of response of soil C dynamics to environmental change [7].

Dissolved organic matter (DOM) represents one of the most actively cycling organic matter pools in soils [8, 9], which has been used as an index of soil microbial activities [10] and litter decomposition [11]. It is formed by the decomposing activities of microorganisms. In these processes, hydrolytic depolymerizations and oxidative modifications of biomolecules like lignocellulose, lipids, polyphenols play a key role because they could decrease the size and increase the polarity/ionization states of the litter derived molecules, which in turn enhance their water solubility and reactivity toward mineral surfaces [12]. DOM is essential in the transportation of C and N from forest floor to mineral soils, where DOM can be further decomposed by soil microorganisms and/or stabilized via interactions with soil minerals [13].

In this study, we have compared the capacity and mechanisms by which a saprotrophic fungus (*Hydnomerulius pinastri*) and an ECM fungus (*Paxillus involutus*) decompose DOM extracted from forest soils. The fungi are closely related species within the Boletales clade. Recent genome sequencing have shown that the two species have distinctive differences in the content of genes predicted to encode hydrolytic and oxidative enzymes predicted to act on plant cell wall material [14]. When compared to *H. pinastri*, *P. involutus* lack many genes encoding glycoside hydrolases and carbohydrate esterases that are likely involved in the hydrolysis of cellulose and hemicellulose, while both species have a large, but distinct array of genes encoding oxidative enzymes.

Objectives

The objective of this research is to answer the following research question:

- Do saprotrophic and ectomycorrhizal fungi modify DOM present in forest soils to products of different sizes and functional group chemistry?

Materials & methods

A soil sample was collected from an *Oa* layer of a forest soil profile in south Sweden. Dissolved organic matter was extracted by boiling the soil with a solid to Milli-Q water ratio of 1:5 for one hour and filtrated through a 0.22 um PES Membrane (Millipore Inc.). Glucose was added into the DOM samples (2.5 g L^{-1}) and they were sterilized by another filtration (0.22 um). The fungi *P. involutus* and *H. pinastri* were grown axenically in Petri dishes on a layer of glass beeds [5]. The cultures were incubated for 5 days (DOM5) and 10 days (DOM10). The initial DOM sample was designated DOM0.

Samples of DOM0, DOM5 and DOM10 were fractionated according to a modified Leenheer procedure [15] into two major fractions, a hydrophobic and a hydrophilic fraction, respectively. Molecular sizes of the DOM and its fractions were determined using size exclusion chromatography (SEC). Alterations of functional groups were examined by FTIR and Raman techniques. The contents of proteins, sugars, lipids and phenolic compounds were assayed using colorimetric methods.

Results

This is an ongoing study, and data will be collected shortly. The results will be analyzed in terms of changes, as a result of fungal decomposition, in: i) changes in the proportions of hydrophilic and hydrophobic compounds; ii) chemical composition of DOM; iii) molecular sizes of DOM and its fractions; and iv) functional groups of DOM and its fractions. Changes will be compared for the two fungi with an emphasis on their capacity to depolymerize and oxidize the DOM.

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P 3.2.26

Soil organic matter chemical composition of freshwater peatlands from contrasting climate zones

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^{13}C Solid State Nuclear Magnetic Resonance (ssNMR) has become an essential tool for discerning the bulk chemical composition of soil organic matter (SOM). Over 25 years, ^{13}C ssNMR analysis has been used to analyze peatland carbon from across the globe and a range of peatland communities. However, critical geological regions and peatland types are missing from the database. Furthermore, there has been no synthesis of global peatland SOM chemical composition as determined by ^{13}C ssNMR. We resolved to complete the first meta-analysis of ^{13}C ssNMR data on peatland soils to understand differences in chemical composition across climate zones, vegetation types, land uses, and nutrient status. Soil samples from the upper 20 cm were collected by the University of Florida Wetland Biogeochemistry Laboratory and global collaborators (numerous samples from the Global Peatland Microbiome Project) and analyzed with ^{13}C ssNMR. Additional ^{13}C ssNMR data of peatland SOM was mined from the literature provided that the study documented peatland type and soil chemical parameters. Canonical correspondence analysis (CCA) revealed patterns in ^{13}C ssNMR functional groups concentrations: carboxyl, aromatic, O-alkyl, methoxyl, and alkyl. The CCA model ($p<0.001$) showed statistical significance between climate zone (0.001), drainage status (0.001), and carbon to nitrogen ratio (0.002) but not pH ($p>0.05$). O-alkyl composition was dominant in the tundra climate, but decreased in abundance for warmer climate zones. Subtropical and tropical samples had higher alkyl, methoxyl, aromatic, and carboxyl functional group concentrations. Forested systems were composed of more alkyl and methoxyl carbon, and extensively drained and farmed sites had the highest aromatic concentrations. O-alkyl contribution decreased as carbon to nitrogen ratio decreased. The meta-analysis highlights important trends and drivers of SOM chemical composition in peatland soils. Contrasting peatland SOM composition should be considered when considering peatland soil responses to external drivers.

P 3.2.28

The possibility of *Anabaena flos-aquae* spontaneously form humus

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In the study of humus formation, scientists found that some autotrophic organisms could use inorganic carbon source to synthesize humus or humic-like substances. There was record showed that peat had originated from algae in geological literature. It was also found that microbes could synthesize humus by algae residue. Before the original soil formed on earth, photoautotrophic cyanobacteria, as a class of ancient prokaryotic microbes, had been common present in the original water environment, so whether the formation of initial humus had relationship with cyanobacteria or not was an interesting question. It was important but seldom investigated. The paper explored whether the cyanobacteria could spontaneously form humus or the precursors or not in its growth cycle with the absence of organic matter, then speculated the source of humus components in the earth's original soil. The *Anabaena flos-aquae* (from the Freshwater Algae Culture Collection at the Institute of Hydrobiology, FACHB-collection) was inoculated into the sterilized BG-11 medium, and cultivated in large capacity light shaker with temperature of 25~30 °C, light of 1000~1500 lx and rotate speed of 120~150 rpm. Samples were respectively collected from phases of lag, logarithmic, stable and decline in its growth cycle. The clear liquid (extracellular metabolites) and precipitation (*Anabaena flos-aquae* thallus) were obtained after high speed centrifugation. Methods such as TOC, differential thermal and infrared spectrum analysis were used to analyze total organic carbon, thermal properties and functional groups structure of extracellular metabolic liquid and cyanobacteria residue.

Results showed that: (1) with the growth of *Anabaena flos-aquae*, organic carbon in the system reached maximum value in stable phase, then began to decline in its death phase. The change was caused by the increase and decrease of organic matters through photosynthesis and decomposing metabolism. The carbon content of extracellular metabolic matters was ever-increasing, which suggested that some organic materials were released into the medium with the metabolism of cyanobacteria. (2) The exothermic peak temperature was between 260~330 °C and high exothermic peak temperature was about 500 °C, which respectively represented the aliphatic and aromatic compounds decomposition of samples in different phases in the *Anabaena flos-aquae* growth cycle. The calorie and weightlessness high/medium ratios of metabolic liquid increased with the growth time, but they were still lower than that of the cyanobacteria thallus. It showed that with the growth of *Anabaena flos-aquae*, the aromatic/aliphatic ratio of extracellular metabolites gradually increased, and the aromatic degree was elevated soon afterwards, but they could not catch up with the bacteria thallus. Even if these extracellular metabolites could eventually form complex organic substances, they were just humus precursors with low molecular weight. (3) The infrared spectrograms displayed that the *Anabaena flos-aquae* thallus had consistent and stable functional groups structure. Compared with FT-IR spectrograms of humic acid and fuvic acid derived from dark brown soil, the spectral features of cyanobacteria samples were much closer to the latter, which was relatively simple in structure. But the absent 1720 cm^{-1} characteristic peak, strengthened 1650 cm^{-1} and 1530 cm^{-1} characteristic peaks of cyanobacteria samples proved that algae organic matter had rich organic nitrogen and less organic carbon than natural organic matter. With the growth of *Anabaena flos-aquae*, the (2926+2860)/1650 and (2926+2860)/1530 ratios of metabolic liquid decreased, which means that the extracellular metabolites of decline phase had higher aromatic degree than that of other phases. The conclusion was agreed with the differential thermal analysis. In a word, compared with natural humus, the aromatic degree of *Anabaena flos-aquae* samples was lower in its normal growth cycle under the moderate cultivated condition, regardless of the extracellular metabolites or thallus itself. The growth and decay of cyanobacteria may be only as an original organic carbon accumulation. But the increased amide materials in metabolites may synthesize humus as precursor substances under certain conditions. There was another probability that thallus could form humus in chemical polymerization or under the action of microorganisms after their decline. They will be investigated in further research.

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Key words：**possibility**，***Anabaena flos-aquae***，**humification**，**humic-like substances**

IT 3.3 1

Holding it all together: the role of organic carbon in soil self-organisation

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1. Introduction

Managing agricultural soils to maintain soil organic carbon (SOC), suited to a particular soil type and environmental conditions, promotes a wide range of soil physical, chemical and biological benefits (Dungait et al., 2012). Most of the properties of soil that are important for supporting primary productivity change with time. Soils are continuously subject to changing environmental conditions, and many agricultural practices result in specific changes in key soil parameters including SOC that have a negative impact on beneficial functions. Soil is often managed with a view to attaining a target state characterised by a set of static metrics. However, it is the capacity of soil to adapt and recover from shocks that is one of its most important qualities for sustaining natural fertility, and we are far from having the necessary understanding to manage soil as a dynamical state.

In this paper, we review the evidence for feedbacks between the abiotic and biotic components of soil and for the emergence of a self-organising state. We will discuss the regulation of these feedbacks and how management may impact to change the dynamical state of soil. Finally, we will outline some priorities for future research and potential new approaches that would allow us to arrive at a more definitive understanding of the dynamical state of soil and how to manage it.

2. Objectives

To determine how, when and where SOC drives the creation of physical soil structure, and how this knowledge can be used to manage soils for optimal function.

3. Materials & methods

Mixtures of ryegrasses and clovers were sown on poorly-draining clay soil on the North Wyke Farm Platform and the development of roots (mass and depth), change in SOC and N content and effects on losses of water from hydrologically isolate fields were compared with permanent pasture after one year.

The relative influence of soil texture (clay content), management practice (N fertilisation) and soil organic carbon (SOC) on soil strength and the energy required for mouldboard ploughing (specific draught *S*) were investigated on the Broadbalk experiment.

Bulk density, pore size distribution, aggregate strength and friability, wettability, water content and water retention were measured and related to SOC content in long term fallow, arable and grassland soils from the Highfield experiment. The location of SOC from each treatment was explored in 'peeled' aggregates.

The effect of microbial activity were explored by extracting and characterising extracellular polymeric substances (EPS) from fallow and grassland soils from the long term Woburn experiment. The effect of addition of different N substrates was explored using ^{15}N-labelling.

4. Results

Deeper and more prolific roots and increased SOC were measured under newly sown swards on the North Wyke Farm Platform but water losses were least from permanent pasture suggesting the physical effects of cultivation were dominant in the short term.

At Broadbalk, specific draught (*S*) increased with clay content but decreased with additions of organic fertiliser. Increasing applications of mineral N resulted in relatively small increases in SOC but a large reduction in *S*. Minimum SOC values increased with increasing clay, suggesting that clay stabilises SOC (Watts et al., 2006).

Soil management had a major effect on SOC and TN and the development of macro structure (greatest to smallest amount of macro pores) decreased significantly in the order grass > arable > fallow at Highfield. The exterior and transition regions of aggregates from grass had a cumulative strength 2.5 and 8 x greater than arable or fallow, respectively. There was more SOC and TN interior region of grass aggregates than the exterior, with the opposite observed in aggregates from the arable treatment, with no significant differences in fallow aggregates.

At Woburn, 2 to 3 x more EPS was measured in grassland than fallow soil (Redmile-Gordon et al., 2014). EPS production in soil can vary independently of the total SOM content and is highly responsive to C/N ratio of available substrate (Redmile-Gordon et al., *in press*).

5. Conclusion

The feedbacks between the living and dead components of the soil complex has the potential to give rise to self-organisation as biotic and abiotic processes at the microscopic scale lead to spontaneous organisation of components that might otherwise be randomly arranged, at scales that matter for determining the ratio of air to water in the soil matrix, and therefore with potentially profound consequences for biotic processes manifest at the macroscale.

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IT 3.3.2

Coupling physical-chemical fractionations with advanced solid-state NMR to investigate the structures of soil organic matter

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To study soil organic matter (SOM) within the context of a specific research issue, it is useful to isolate and characterize pools whose turnover rates are relevant to that issue. The objective of this presentation is to demonstrate how advanced solid-state NMR techniques may be coupled with physical and chemical fractionations to obtain detailed SOM chemical structures that are potentially related to agricultural practices. We hypothesize that the chemical structures of SOM fractions are distinct and change with land use. The physical and chemical fractionation methods to be discussed include (1) physical separations into eleven soil aggregate fractions using wet sieving, (2) physical fractionation into clay and silt fractions based on gravity sedimentation, (3) physical fractionation into light and particulate organic matter (POM) fractions, and (4) chemical fractionation into humic acid fractions. The ^{13}C solid-state NMR techniques used included quantitative DP/MAS; semi-quantitative CP/TOSS; spectral-editing techniques such as dipolar dephasing, ^{13}C CSA-filter, CH selection, CH_2 selection, and protonated-only-carbon; as well as two-dimensional ^{1}H-^{13}C heteronuclear correlation NMR. The results of such fractionation studies indicated that different methods isolated fractions with reproducible variations in chemical structure. In general, large soil aggregates contained more O-alkyls than small ones, and the extent changed with agricultural management. The NMR spectra of the light and POM fractions were comparable and dominated by O-alkyl signals, whereas humic acid fractions primarily contained aromatic C and COO/N-C=O groups. The spectra of whole soil organic matter contained all the signals attributed to either physical or chemical fractions. Our results suggest that either chemical or physical fractions alone can only partially represent whole SOM. Integrated interpretations will provide greater insight into SOM structures and possibly functions, depending on the research issues.

O 3.3.01

Physical Functionality of Soil Organic Matter Fractions

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Soil contains different fractions of soil organic matter, which may play different role in formation of soil structure and functioning. A series of incubation experiments were performed to determine the role of particulate, dissolved, microbial derived organic matter in stabilization of soil structure by using restored degraded soils (parent materials) under different vegetations or agricultural practices. In addition, the roles of soil structure on separation of soil microbial community and microbial functional stability to perturbations were also examined. Despite of the increase in soil porosity, the tensile strength and aggregate stability increased with increasing total soil organic matter. Dissolved organic matter was enriched on the aggregate surface with increasing number of wetting and drying cycles, resulting in an increase in soil aggregate stability, but the magnitude of the increases varied with vegetation type due to the variation in soil water repellency. Particulate organic matter addition increased soil friction and cohesion, but decreased the compressibility with increased wetting and drying cycles. Chemical structure of soil organic matter largely varied among agricultural practices at the first year of recovery, but the variations became smaller among the soils, but became larger among different physical fractions. Soil microbial community structure was significantly separated by aggregate size irrespective of differences in tillage and land use. Destruction of soil aggregates per se did not change soil microbial community structure, but caused a shift of soil microbial community structure due to different perturbations (copper and heating). Presence of organic C also affected the leaching of cation and then transformation of clay minerals. In conclusion, heterogeneity of soil organic matter may enhance the multiple biophysical functions through different mechanisms.

O 3.3.02

The heterogeneous evolution of the chemical structure of organic carbon and soil aggregation under different soil agricultural practices during early pedogenesis of a Mollisol

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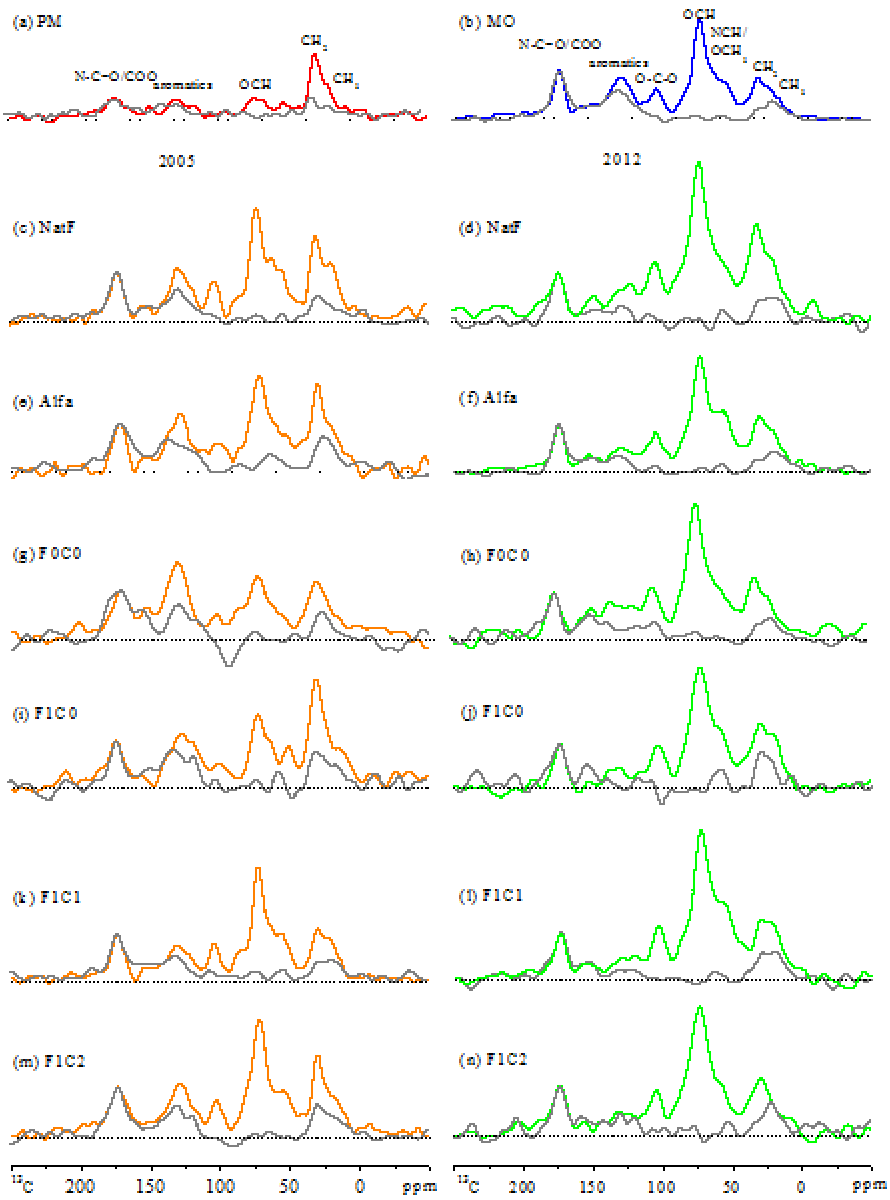
Soil organic matter improves soil aggregation, which is influenced by agricultural management. The coupling processes, however, are largely unknown at the initial stage of soil formation. Using a field experiment established in 2004 to study soil development from parent materials under different agricultural practices, the objectives of this study were: 1) to characterize changes in chemical structure of soil organic carbon (SOC) with time and aggregate sizes in comparison with the initial parent material and a mature Molliso, and 2) to model the dynamics of physical fractions of SOC with consideration of soil aggregation. The field treatments included two no-tilled soils supporting perennial crops, and four tilled soils under the same cropping system, with or without chemical fertilization and organic C amendments. The content of SOC increased with time and the amount of organic inputs, being about 40 % that of arable Mollisol. The spectra of ^{13}C CP/TOSS NMR and its combination with dipolar dephasing demonstrated that the chemical structure of SOC largely varied among agricultural practices at the second year of recovery, but the variations became smaller among the field SOC and that in SOC of Mollisol, but became larger among different aggregate fractions, with increases of O-alkyl and alkyl C groups in SOC, but decreases in nonpolar alkyl C, aromatic C and COO/N-C=O groups. These results suggested that newly-plant derived C entered into soil SOC and caused a decomposition of native C in parent material. The processes of soil aggregation experienced a dramatic formation of macro-aggregation/porosity and decreased micro aggregation/soil bulk density during the early forming stage by calibrating the CAST model. While in arable soil without any OC input, the macro-aggregate presented a disruption in the sixth year restoration and any further SOC increase was due to micro-aggregation resulting in the increase of bulk density and decrease of porosity. Moreover, the contents of SOC of POM in macro-aggregate increased with restoration years, with SOC in other aggregate fractions slightly changed. These results demonstrated that the processes of mineralization and organic C decomposition play significant role during soil forming stage. The chemical structures of SOC become homogeneous among field treatments, while more heterogeneous in aggregate fractions, which indicated that the concurrent evolution of SOC and aggregate forming during the initial stage of soil formation.

Figure 1


(a) PM
N-C-O/COO
aromatics
OCH
CH2
CH3
(b) MO
N-C-O/COO
aromatics
O-C-O
OCH
NCH/
OCH2
CH2
CH3
2005
2012
(c) NatF
(d) NatF
(e) Alfa
(f) Alfa
(g) F0C0
(h) F0C0
(i) F1C0
(j) F1C0
(k) F1C1
(l) F1C1
(m) F1C2
(n) F1C2
13C 200 150 100 50 0 ppm
13C 200 150 100 50 0 ppm

O 3.3.03

Contribution of microbial biomass to soil organic matter formation and its consequences for physical properties

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Introduction

Recent research has shown that microbial biomass residues contribute significantly to soil organic matter (SOM) formation, with cell envelope fragments playing an important role. Both bacterial and fungal biomass residues are involved in this process. This means that, although the primary input comes from plant biomass residues, microbial biomass residues may have an important influence on the chemical and physical properties of SOM. As the wettability of microbial cell surfaces varies over a wide range, the effect on soil particle wettability may be particularly strong. Surface wettability of bacterial cells differs between taxa, but also depends on environmental conditions. Bacteria tend to adapt to environmental stress, e.g. drought, by decreasing the wettability of their surfaces.

Objectives

The aim of our study therefore was to test whether the wettability of bacterial cells and its changes due to reduced water availability is reflected in the surface properties of associations between cells or cell envelope fragments and minerals.

Materials and methods

We tested how reduced water availability (osmotic stress) affected cell surface wettability, measured by the water contact angle, of a number of typical soil bacteria grown either in solution or on an agar surface, and how the bacterial cell surface contact angles were reflected in cell-mineral associations.

Results

All investigated bacteria responded to osmotic stress by changing their surface contact angle. In particular for Gram-negative bacteria showed an increase of the contact angle if osmotically stressed. Various amounts of unstressed (contact angle ≈ 40°) and stressed (contact angle ≈ 70°) *Pseudomonas putida* cells were then mixed with quartz sand (contact angle 0°), quartz silt (contact angle ≈ 15°) or kaolinite (contact angle ≈ 45°), and the contact angles were determined after 2 h of adaptation. Depending on the cell number, the contact angle of the quartz sand increased to values > 90°. A rather low surface coverage (< 10% of the surface area) was sufficient to significantly decrease the wettability of the quartz sand. Stressed cells consistently resulted in higher contact angles of the associations. Similar results were obtained for cell fragments and for associations with quartz silt and kaolinite.

Conclusions

The data demonstrate that the surface properties of bacterial cells, in particular the wettability, are reflected in their associations with minerals and thus also in SOM. The effect is stronger for stressed cells with a higher contact angle. This can result in a positive feedback: Non-wettable domains in soil are relatively dry because water is not retained at these sites. This causes drought stress for the microorganisms inhabiting these domains, resulting in relatively low wettability of the cell surfaces. After cell death and stabilization of the microbial biomass residues, this property will be reflected in the surface wettability of soil particles, resulting in even less wettability and thus higher drought stress and lower wettability for the microorganisms. This mechanism may explain the origin and persistence of water repellency in soils.

O 3.3.04

ON SOIL ORGANIC MATTER DENSITY AND VAN BEMMELLEN FACTOR

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INTRODUCTION

Soil organic matter (SOM) is a mixture of various organic compounds. It is often difficult to extract and analyse directrly. Simple conversion factors from easily-determined soil organic carbon to SOM(SOM/SOC) are often used. Most commonly the van Bemmellen factor (1.724) based on 60% carbon content in SOM, or suggested by Weil and Brady the less accurate value of 2 are used. Assuming that SOM would affect the soil particle density we have attempted to estimate the SOM/SOC ratio from density measurements. Furthermore, the reported values for OM density range from 0.25 to 1.35 Mg/m^3. Here we tried to introduce sone clarity into the matter by analysing the effect of SOC content on soil particle density.

MATERIALS AND METHODS

The study was conducted in the Mvoti river catchment measuring some $300km^2$ located in the Midlands area of KwaZulu-Natal, South Africa. A combination of forestry/grassland and cultivated areas were selected for soil carbon inventory.

A range of soil samples from 48 profiles selected throughout the catchment, sampled at depths of 2.5, 7.5, 12.5, 17.5, 30, 40, 50, 75 and 100cm for particle density, LOI and SOC ("Walkley and Black) determination.

RESULTS AND DISCUSSION

Assuming a simple mixture,

$$\rho_s = \rho_m \cdot (1-C_{om}) + \rho_h \cdot C_{om}$$

Where ρ_s is soil particle density (Mg/m^3), ρ_m - average density of mineral fraction, ρ_h - average density of SOM and is the organic matter content, as weight fraction.

Expecting a constant average SOM/SOC ratio, the effect of the OM density may be estimate as a slope coeffecient for ρ_s decline vs. SOC, $\%_{wt}$ with increase in C_{om}:

$$k = (\rho_h-\rho_m)/100 \cdot SOM/SOC$$

Assuming ρ_h = 0.25 Mg/m^3, the SOM/SOC ratio was calculated as 2.25 implying that SOM in the studied soils is not likely to contain more that 44.5$\%_{wt}$ carbon. The correction of k value may be significant for understanding the soil organic matter composition.

The regression of LOI vs SOC has shown that for the range of samples excluding plinthic horizons, the value of SOM/SOC factor was estimated as 2.107. This value was used to calculate the densities of organic matter.

Further separating the sampled soils into three groups by land use type, we have estimated the OM density as 0.25, 0.43 and 0.58 Mg/m^3 for pine plantations, native grasslands and maize fields respectively.

CONCLUSIONS

It is concluded that the density of organic matter may be estimated from SOM/SOC ratio and ρ_s determinations in soils with varying SOM content.

ACKNOWLEDGEMENTS

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P 3.3.01

Modeling unsaturated hydraulic conductivity and diffusivity in relation to water filled pores in cultivated clay soils

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New equations to estimate unsaturated hydraulic conductivity *K(ϑ)*[LT^{-1}], water diffusivity *D(ϑ)* [L^2T^{-1}] and intrinsic permeability, *k* [L^2] in plant-root zone were assumed. Three alluvial clay soils located at middle and northern Nile Delta were used to apply the assumed equations. Two soils were planted with cotton yield during 2009 season and the third was uncultivated. The soil profiles were different in their salinity, clay % and source of irrigation water. The equations which assumed to predict soil water movement parameters considered only the matric potential as a driving force in capillary pores, and gravitational potential that is critical for the large, non-capillary pores. An equation for predicting so called potential hydraulic conductivity *Kp(ϑ)* [$M\ L^{-1}T^{-3}$] (erg $cm^{-3}.sec^{-1}$ or joule m^{-3} sec^{-1}) was derived in vadose zone. Pore size distribution for the investigated soil profiles was obtained using water retention data. The calculated *K(ϑ), D(ϑ)* and *k*values for soil pore classes were conformable to the common measured ranges, indicating the applicability of the proposed equations for predicting water movement parameters in clay soils. The values of the new suggested parameter *Kp(ϑ)* were also calculated for soil water filled pores and obtained for each pore size class.For all sites, disturbed samples were air-dried, gently crushed, sieved through a 2 mm sieve, and were used to determine the *h*(θ) at higher pressure heads (Klute,1972),water adsorption capacity (*Wa*), OM%, $CaCO_3$, salinity (EC), and sodium adsorption ratio (*SAR*).Amer, (2009) used vapour adsorption isotherm method with applying BET equation to estimate moisture adsorption capacity (*Wa*), where *Wa* is equal to three layers of adsorbed water (films)on soil particles.Soil samples of II and III profiles were taken at plantation (P) and at harvest (H) of cotton crop. Physical and chemical analyses of the soil samples of the three soil profiles were done (Sparks et al., 1996; Dane and Topp, 2002). The values of water diffusivity *D*(θ) were higher than those of *K*(θ) for all pore size classes. D(θ) values decrease much less rapidly than the hydraulic conductivity as soil dries.It is evident that the unsaturated hydraulic conductivity equations can be applied for fine-textured soil and incorporated flow reduction inorganic,and dry soil due to sorbed water, as well as enhanced flow through large pores in the wet soil.

P 3.3.02

High rate of residue addition decreases stabilization efficiency due to priming and low physical protection

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1. Introduction

Increasing crop residue input was suggested as an effective way to increase soil organic carbon (SOC) levels in cropland soils. Recent work, however, has shown the assumption of SOC models that C-input and SOC-stock are linearly related is not always met. Consequently, adding higher amounts of residue may be an ineffective way to increase SOC and an alternative use of residues may be justified.

2. Objectives

The objective was to test under controlled conditions, if the rate and plant part (above- or belowground) affects mineralization of residues or SOC by interaction with aggregate formation.

3. Materials & methods

Labeled wheat plant residues (leaves, stalks, roots) were added to samples of a loess soil at rates of 140 mg 100 g^{-1} and 504 mg 100 g^{-1}. Water content was adjusted to 70% of water holding capacity and CO_2-evolution was monitored by means of NaOH traps. Residue- and soil-derived CO_2 was determined with an isotopic mixing model using the ^{13}C signature of residues and CO_2 of the unamended control. Water-stable aggregates were determined by wet sieving and macro (> 250 µm) - and microaggregates (53-250 µm) were quantified.

4. Results

Soil-derived CO_2 almost doubled in treatments receiving high rates of residues, thus priming on SOC mineralization was lower at low rates. Although macro-aggregate formation was higher at high rate (leaves > stalks > roots), a higher proportion of initial residues C was retained within macro-aggregates at low rate. Microaggregates even retained twice as much residue C at low rate than at high rate. At low rate, amendment with roots increased residue-C in microaggregates as compared to leave and stalk amendments.

5. Conclusion

Adding residues at high inputs level reduced the efficiency of different aggregate fractions to retain residue-C and thereby increased CO_2-C production by enhancing the mineralization of SOC. At low rate, roots were preferentially retained in stable micro-aggregates. Therefore, there might be an optimal residue-rate at field level above which SOC storage becomes ineffective and alternative use (e.g. bioenergy) is not on cost of decreasing SOC stocks. However, physical soil fertility should not be disregarded in this respect.

P 3.3.03

Biochar and wood ash effect on soil physical functions: a field experiment

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Increasing use of forest fuels for energy production might be accompanied by forest management intensification that could drive to nutrient and soil organic matter (SOM) depletion, and derive into soil degradation, mainly due to biomass extraction. In Europe, Atlantic forest plantations are the hot-spot of these energy production strategies.

SOM however, plays a key role in soil structure that regulates several critical soil functions such as water holding capacity (WHC) and nutrient provision. Functions that are considered crucial to buffer, resist and adapt to abiotic and biotic impacts derived from Climate Change (CC), that in the Atlantic area summers likely to be drier and hotter.

Therefore, energy production via pyrolysis or combustion and subsequent application of biochar or wood ash to forest soils might be considered a strategy to mitigate and adapt to CC while fulfilling the demands of the EU's growth strategy Europe 2020.The higher surface area and a greater porosity of the biochar, relative to other types of SOM, are supposed to improve soil quality, by enhancing WHC and reducing bulk density (BD), among other soil physical properties. Positive tree growth responses are also expected. This fertilization and liming effect might also contribute to a better habitat for microorganisms and, therefore, it will induce better soil structure.

The main objective was to study the soil responses to the addition of biochar and wood ash in WHC and BD, in two contrasted forest soils of the Atlantic area.

Two forest plantations from the Atlantic side of the Iberian peninsula that differ on soil type, altitude, annual mean temperature, and vegetation, were selected (Table 1). Both sites were second growth forests established on previous *Pinus radiata* D.don stands.

The Biochar (BC) applied, was produced by the pyrolysis of *Myscanthus* sp. at 450ºC. The pH (1:5 H_2O) was 9.8 and contained a 87% of C. Wood ash (WA) was produced by the combustion of *Pinus radiata* in a commercial boiler. The pH (1:5 H_2O) was 10.6 and contained a 30% of C. The amounts of WA applied to the soil were equivalent to the Ca content in BC taking into account that the ratio of WA Ca: BC Ca was 2.5. Both subproducts were enriched with 0.8% of N in form of ammonium nitrate.

Fifty-six undisturbed sample cores (D=53mm, h=50mm) were taken from the first 5cm of soil profile. The sampling was performed two years after the application of the treatments in Karrantza and one year after in Oiz. The field moist samples were first saturated. BD of the samples was measured based on the Archimedes method.The available water content (AWC) for plants was defined as the water held between field capacity (FC) and the permanent wilting point (PWP) The FC was measured by desorption using a sand-kaolin box at a -100hPa matric potential, and the PWP by pressure plates at -15000hPa.

The soil organic carbon (SOC) of each sample was estimated by a CHN-S elemental analyser. Due to the absence of inorganic C in any of the soils, total C was considered as SOC.

Both soils were characterized by similar acidic pH (Table 1) but natural SOC content was significantly different (2.96%±1.03 inKarrantza and 11.92%±6.07inOiz).

The addition of charred C by the application of BC or WA did not result in significantly higher SOC in any treatment. This could be explained because field trials show high natural SOC variation.

The AWC content was significantly higher in Oiz due to the higher amount of SOM, but no effect of BC and WA addition was observed in any of the sites (Figure 1).

The BD in Karrantza was higher than in Oiz (Figure 1), despite the clayey texture in the former because of high SOC in Oiz. The addition on BC and WA did not result in any statistically significant change in BD.

The application of biochar or wood ash to temperate forest soils did not result in any improvement in soil physical functions. No evidences were seen in the sandy loam soil after one year of application, neither in the clayey loam soil after two years of the application.

The evaluation of longer term effects should be carried out, when actual incorporation of both products to the soil will happen.

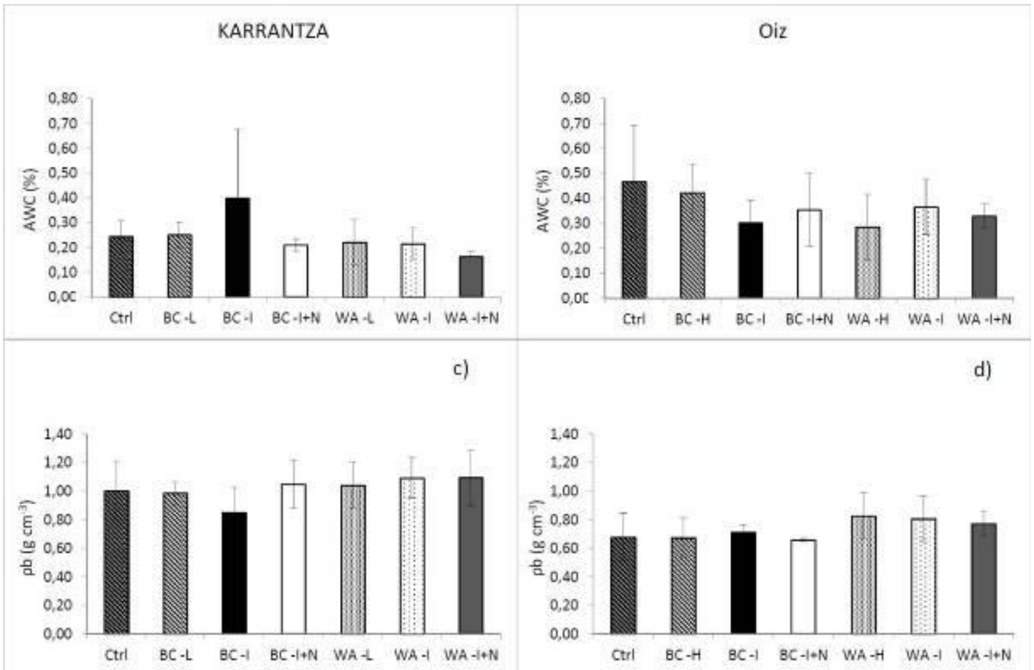
Figure 1 Available water content (AWC) (a and b), and bulk density (ρb) (c and d), for each treatment at each experimetal site: karrantza (a and c), and Oiz (b and d). Columns show mean values and error bars show standard deviations. Ctrl= Control, BC= Biochar, WA= Wood ash; L= Low dose, I= intermediate dose and H= high dose; +N= 0.8% N.

Table 1 Schematic description of the experimental design. Characteristics of each experimental site, type of amendment, treatment details, code and number of replicates (n).

Figure 1

Localization	Amendment	Treatment	Code	n
Karrantza	No adition	Control	Ctrl	4
	Biochar	9 Mg C-biochar ha^{-1} + 0.8% of N	BC -I+N	4
P.radiata D.don (20yr)		9 Mg C-biochar ha^{-1}	BC -I	4
Clayey loam soil		3 Mg C-biochar ha^{-1}	BC -L	4
2% SOC	Wood Ash	1.2 Mg C in wood ash ha^{-1} + 0.8% of N	WA -I+N	4
pH 4.7		1.2 Mg C in wood ash ha^{-1}	WA -I	4
		0.4 Mg C in wood ash ha^{-1}	WA -L	4
Oiz	No adition	Control	Ctrl	4
	Biochar	9 Mg C-biochar ha^{-1} with 0.8% of N	BC -I+N	4
*Q. pyrenaic*a Willd.(2yr)		18 Mg C-biochar ha^{-1}	BC -H	4
Sandy loam soil		9 Mg C-biochar ha^{-1}	BC -I	4
12.5% SOC	Wood Ash	1.2 Mg C in wood ash ha^{-1} + 0.8% of N	WA -I+N	4
pH 3.91		2.4 Mg C in wood ash ha^{-1}	WA -H	4
		1.2 Mg C in wood ash ha^{-1}	WA -I	4

Figure 2



P 3.3.04

Assessing the relationship between soil organic matter and bulk density for Irish forest Podzol soils - preliminary results

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1. Introduction

Soil organic matter (SOM) is known to have a strong effect on soil bulk density (BD) [1]. Direct BD measurements require the samples to be taken from a soil pit, which is especially challenging for forest soils due to potentially remote, rocky, steep and difficult terrain, and roots. Therefore, SOM data are often used for predicting soil BD [2]. Here we asses the relationship between the SOM and BD using preliminary data from Irish forest Podzol soils on afforested sites aged ≥ 20 years. The potential effect of soil horizon depth and slope is also investigated.

2. Objectives

This study forms a part of the CForRep project, which aims to improve the estimates of carbon (C) stocks, stock changes and emissions for Irish forests [3]. BD is one of the key parameters required in measurement and modelling of soil C stocks. The work presented here aims to assist the development of forest Podzol soil BD pedotransfer functions (PTFs), with an intention to contribute to the study on refinements of soil organic C stock and stock change estimations for Irish forested mineral soils.

3. Materials & methods

Samples were collected from six forest sites located on Podzol soils (Fig. 1). Sampling strategy was by soil horizon from a 3 x 3 grid (Fig. 1) for composite soil samples (used for SOM) and soil horizon depth measurements [4]. BD sampling was done from a soil pit in the centre of the grid (further details are given in Fig. 1) [4]. Slope was measured at the site using a clinometer. SOM was measured in duplicates by loss on ignition at 550°C for 6 hours. The relationships between the measured variables were analysed using Pearson's correlation and stepwise multiple linear regression (SMLR) in R 3.1.1 [5].

4. Results

BD and horizon depth values were normally distributed, whereas SOM and slope values showed normal distribution after the natural-logarithm (ln) transformation. The strongest significant negative correlation was observed between BD and SOM ($r = -0.78$; $p<0.001$); a significant positive correlation was found between BD and horizon depth ($r = 0.67$; $p<0.01$); whereas no significant correlation was found between BD and slope (Fig. 2a). The scatterplot matrix indicated that ln transformation of SOM and slope may provide a better fit. The ln transformed SOM and slope variables were used in the SMLR analysis. SMLR analysis showed the best BD PTF to be based on SOM alone (PTF_3, Fig. 2c), as follows:

$BD = 0.01430 - 0.37642 \cdot \ln SOM$; [RMSE 0.17 Mg/m^3, adjusted R^2 0.81].

The inclusion of horizon depth and slope appeared not to improve the model performance (see PTF_1 and PTF_2, Fig. 2b).

5. Conclusion

Preliminary results showed soil organic matter (SOM) alone to be the best predictor for soil bulk density (BD) for the Irish forest Podzol soils. In this study the BD pedotransfer function (PTF) based on the SOM natural-logarithm explained 81 % of the variation in observed BD, whereas the inclusion of soil horizon depth or slope appeared not to improve the model performance. Additional data are required to confirm this. Future work will include data from more sites sampled within the CForRep project in order to develop new BD PTFs with an intention to use SOM as a simple predictor for BD of different Irish forested mineral soils.

Fig. 1 Soil sampling strategy

Fig. 2 Relationship between soil organic matter (SOM), bulk density (BD) and other measured variables from six sampled Irish forest sites located on Podzol soils: correlation coefficient matrix (a); plotted values of measured variables with accompanying PTFs (b) & (c)

Acknowledgements

The CForRep project is funded by the Irish Department of Agriculture, Food and the Marine under the CoFoRD programme. Thanks go to Gero Jahns and Martijn Leenheer for their support during the parts of field sampling.

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Figure 1

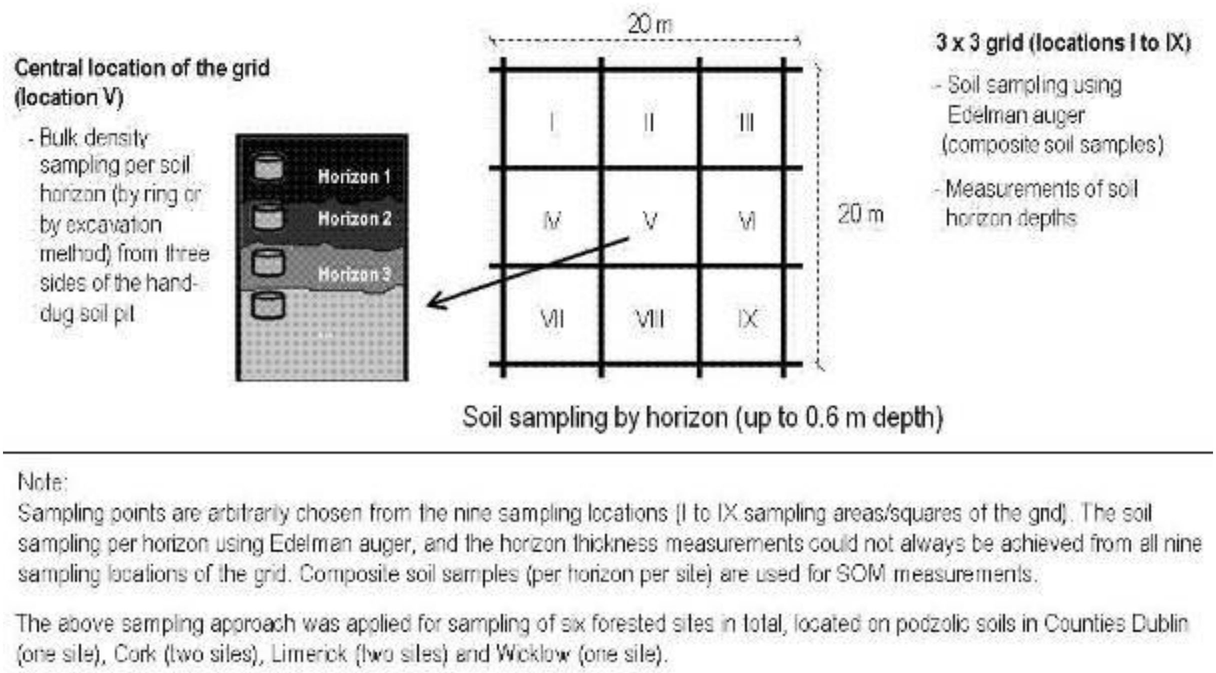


Figure 2

a

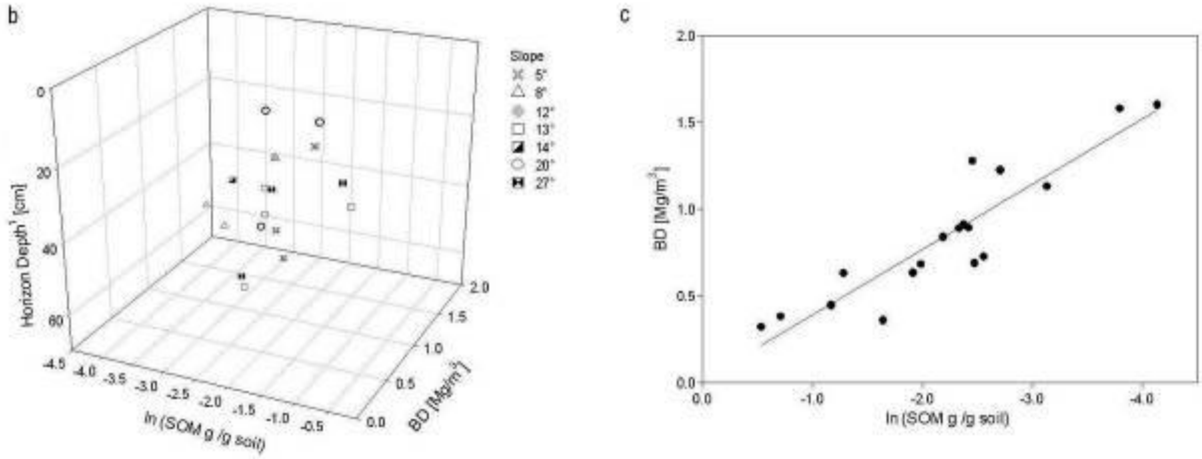
Pearson's product moment correlation coefficient matrix

	SOM [g OM/g soil]	BD [Mg/m³]	Horizon Depth[1] [cm]	Slope [degrees]
SOM [g OM/g soil]		-0.73***	-0.59*	0.16
BD [Mg/m³]			0.67**	-0.25
Horizon Depth [cm]				-0.18

Significance (p-value): <0.001 '***'; <0.01 '**'; <0.05 '*'.

[1] ...corresponds to the average of maximum horizon depth measured at each site

b c



PTF₁: $BD = 0.13870 - 0.35753 \cdot \ln SOM + 0.00108 \cdot \text{Horizon Depth} - 0.04723 \cdot \ln \text{Slope}$
RMSE = 0.180 Mg/m^3
adjusted $R^2 = 0.78$

PTF₂: $BD = 0.00951 - 0.35854 \cdot \ln SOM + 0.00132 \cdot \text{Horizon Depth}$
RMSE = 0.176 Mg/m^3
adjusted $R^2 = 0.79$

PTF₃: $BD = 0.01430 - 0.37642 \cdot \ln SOM$
RMSE = 0.172 Mg/m^3
adjusted $R^2 = 0.81$

Note:
n =18 measured soil horizons. The performance of regression models (PTFs) were compared using root mean squared error (RMSE) and adjusted R-squared (adjusted R^2).

P 3.3.05

Enhanced positive priming effect due to increases in manipulated macropores rather than change in microbial communities

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Addition of fresh organic matter causes priming of decomposition of native organic matters. Physical structure may control the process through the influence of availability of organic matters to microbial uses, but there is no experimental evidence yet. A surface soil of a Mollisol under continuous cropping of soybean was mixed with its parent materials to manipulate soil porosity without changing minerals. The parent materials were heated at 500℃to remove organic matter and microbes. Through a 56-d incubated experiment with addition of ^{13}C-labeled maize straw under constant soil moisture, the objectives of this study to determine the effects of mixed soil (ApC) on the decomposition of added and native organic matter and functional soil microbial communities compared with the no mixing soil (Ap) and to disentangle physical and biological controlling factors. Functional microbial communities were measured using stable isotopic probing of phospholipid fatty acid (PLFA). Computer scanning demonstrated that the 40-60 and >300 µm macroporosity in the straw added soil was higher over the period of incubation in ApC than in Ap and the difference increased with time. Positive priming effect was observed for both soils, with the magnitude larger by 27-201% in ApC than in Ap during the whole incubation period. The decomposition rate of added straw was also larger in ApC than in Ap. Straw addition caused a shift of microbial community compared with the soils without straw addition. The effects of soil mixing on the microbial structure based on gross communities and functional communities were not significant. Soil microbes tended to preferentially use the organic C in soil than the straw derived-C when the SCC increased, due to the role in modulating soil porosity and fixation of the by-products of soil microbes. Therefore, only the increase in macroporosity can explain the enhanced priming effect. The results also suggest that anthropogenic or natural mixture of soil (e.g. through dust deposition) may also influence organic C cycling the surface soil.

P 3.3.06

Effect of long-term straw incorporation and different tillage on the composition of physical aggregations and nutrient content and quality in arid and semi-arid area in China

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Soil organic C (SOC) is one of the key index of soil quality. We examined the effects of straw incorporation and different tillage practices on the proportion of different aggregations and SOC quality in terms of different chemical composition in a fifteen years long-term field of monoculture of winter wheat (Triticum aestivum L.) in arid and semi-arid area in China. The nutrient content of SOC, total nitrogen (TN) and total phosphorus (TP) were also compared under different practices. Three different tillage treatments investigated were conventional tillage with residue removal (CT), rotary tillage with residue cover (RT) and no-tillage with residue cover (NT). Physical proportion and Carbon and TN in different aggregations -size classes and composition of C species of bulk soil in the 0-10 and 10-20 cm soil layers were evaluated. Following results were found:

i） SOC of RT and NT treatments showed higher by 530% and 13.9% than that in CT treatment in upper 10 cm soil layer.

ii） The proportion of >1 mm aggregates from RT and NT treatments were higher than that of CT treatment at both 0-10 and 10-20 cm soil depth.

iii） The NT treatments had significantly higher SOC, but lower N content in the >1 mm fraction at both depths.

iv） O-alkyl-C, aromatic-C and alkyl-C dominated in the all treatments at both soil layers.

v） The proportion of O-alkyl-C (0-10 cm soil layer) and aromatic-C (10-20 cm soil layer) from NT treatment were higher than that from CT treatment.

It was indicated that straw incorporation/mulch and no-tillage can increase the content of macro-aggregates and then improve the physical stability of soil. . On the other hand, we also conclude that conservation tillage can enhance SOC in arid and semi-arid area . Our conclusion suggested that straw incorporation and conservative tillage can significantly enhance the soil carbon sequestration in arid and semi-arid area.

P 3.3.07

Lignin in soil aggregation and physical functions

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Introduction: Lignocellulose - cellulose, hemicellulose, and lignin - constitutes the largest organic component in soils. There, lignocellulose along with other organic macromolecules becomes incorporated into soil organic matter (SOM). Through binding of particles, SOM facilitates the formation of aggregates and structure, and thus modifies soil water and gas dynamics. However, SOM can differ in terms of lignin content and composition. The role of lignin in controlling SOM properties and soil aggregation is unknown.

Objectives: In this project, the importance of lignin and its transformation products for aggregation and, consequently, soil physical properties and functions is investigated. We hypothesize that high lignin input enhances soil aggregation, thereby increasing the occlusion of particulate organic matter within aggregates and improving water availability.

Materials & Methods: Relations between cupric oxide (CuO) oxidation lignin markers and both aggregate and soil physical qualities will be checked for at eight *Fagus sylvatica* forests in southwestern Germany. Test points under decomposing trunks were compared against reference points 2-5 m away. Lignin content, SOM occlusion in aggregates, aggregate stability, porosity, and water holding capacity are the response variables to be analyzed.

Results: Preliminary tests have indicated significant differences in lignin content (taking $SUVA_{280}$ absorption as a lignin proxy), total C, and dissolved organic carbon between test and reference points. Results for CuO-oxidized lignin, aggregation, and soil physical properties of interest will be presented.

Conclusions: We expect to obtain important information on the relevance of woody litter input for ecological properties of forest soils.

O 3.4.01

Charcoal-enriched soils increase sequestration of maize-derived carbon: a carbon isotopic approach

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Introduction

Black carbon (BC), including charcoal, is a very resistant form of organic matter with estimated residence time in soil of hundred or even thousand years. Therefore, applying BC to soil is considered as a promising strategy to offset our current carbon emissions. However, the effects of BC amendment on sequestration of non-BC in soil (i.e. priming effects) are still uncertain, especially on the long-term.

Objectives

Historical charcoal production sites in the south of Belgium were used to evaluate the long-term effect of BC amendment on sequestration of crop-derived organic carbon (OC) in a field-scenario.

Materials and methods

These charcoal production sites, identified as black spots, are currently located on arable fields on which silage maize (C4 vegetation) is cultivated for at least 17 years. This situation allows to accurately quantify the build-up of crop-derived OC in charcoal-enriched soils, by a combination of different BC quantification methods (dichromate oxidation (Cr_2O_7), chemo-thermal oxidation (CTO-285, differential scanning calorimetry (DSC)) and carbon isotopic signature ($\delta^{13}C$) analysis. To explore the effect of charcoal on the distribution of non-charcoal C over C fractions with different turnover rates, a physico-chemical fractionation protocol was performed. To quantify degradation of maize residue, ^{13}C-labeled maize straw was added to topsoils of black spots and adjacent soils and carbon mineralization (CO_2) was monitored.

Results

Black spots had higher %OC than adjacent soils (3.5 vs. 2.0, $p<0.05$) and OC concentrations derived from BC varied among techniques and ranked CTO-285>DSC>Cr_2O_7. Irrespective of the BC quantification method, $\delta^{13}C$ revealed that black spots contained 1.6-1.8 fold more ($p<0.05$) maize-derived OC compared to adjacent soils. The concentration of non-charcoal-C (i.e. sum of maize and older OC) was 1.0-1.6-fold higher in black spots than in adjacent soils, but differences were only significant ($p<0.05$) when based on the Cr_2O_7 method.

More maize-derived C was recovered in a physically protected soil OC fraction in charcoal-enriched soils compared to adjacent soils. After 77 days of incubation, total soil respiration (mg C/g soil) and specific maize respiration (% of initially added maize-OC) were slightly lower inside black spots than in adjacent soils (1.00 vs. 1.04 ($p=0.11$) and 32.8 vs. 34.0 ($p=0.11$) respectively) with p-values decreasing with time.

Conclusion

These results show that high charcoal concentrations in soil can enhance the long-term storage of maize-derived C, possibly due to a reduced mineralization. Despite large differences in the charcoal content between different BC quantification techniques, general conclusions about sequestration of crop-derived C remain the same.

O 3.4.02

Effect of pyrochar and hydrochar amendments on sorption and mineralization of the herbicide isoproturon in an agricultural soil

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Amendment of carbon (C)-rich, solid products from pyrolysis (pyrochars) and hydrothermal carbonization (hydrochars) to soil are thought to improve soil fertility and allow C sequestration. Due to a high surface area and a considerable amount of functional groups, we hypothesize that application of pyrochar or hydrochar to an agricultural soil will lead to a reduction in bioavailability of pesticides, thereby reducing the risk of groundwater contamination. To compare effects of feedstock and production conditions, chars from different feedstock materials (digestate, *Miscanthus*, woodchips) and production processes (pyrolysis at 750°C, hydrothermal carbonization at 200°C and 250°C) were applied to a loamy sand at two different amounts (0.5% and 5% dry weight) and sorption and incubation experiments with ^{14}C-labeled isoproturon (IPU, 0.75 kg ha^{-1}) were carried out. The capacity of agricultural soils to adsorb IPU could be enhanced by amendment of both, pyrochars and hydrochars. Amendment with pyrochar reduced the amount of *in situ* available IPU in the soil by a factor of 10-2283 while hydrochar application led to a reduction by a factor of 3-13. Sorption of IPU could be best predicted by the surface area of the charred material. Due to the great importance of surface area as a driving factor for the sorption capacity, the influence of feedstock material was of less importance compared to the production conditions. The bioavailability of IPU was related to the degradability of the added chars. Mineralization of IPU after 50 days of incubation in pure soil amounted 8.1% of the applied IPU. In pyrochar-treated soil, IPU mineralization was reduced by 81% (±6%) and in hydrochar-treated soil, the reduction amounted 56% (±25%). Compared to pyrochars, hydrochars contain higher amounts of water extractable C and oxygen containing functional groups, to which the pesticide may bind reversibly. This allows for controlled pesticide mineralization while reducing the risk of leaching and pesticide accumulation in hydrochar amended soil.

O 3.4.03

Potential use of biochar as amendment in plant growing media

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Municipal waste management is an ever-increasing problem for many cities. Biochar produced from urban biosolid and green-waste (urban biochar) and used as a soil conditioner can be a sustainable way of managing these waste streams although production and transport costs are currently prohibitive for broad scale agriculture. A more likely market for urban biochar is the horticultural industry where biochar may also have the potential to replace environmentally unfriendly substrates such as peat in growing media while simultaneously sequestering carbon. On the other hand, loss of nutrient from growing media systems is a huge problem. In soil systems, biochar has shown to reduce loss of nutrients from coarse textured under leaching conditions. Whilst similar results would be expected in growing media there are a lack of studies on extent of nutrient loss from biochar amended growing media.

We studied the effect of urban biochar on nutrient retention and plant growth in a controlled environment pot experiment over a period of 14 weeks. Nitrogen loss pathways evaluated were: loss in leachate, nitrous oxide emission along with plant uptake and nutrient retained by media. The treatments used were: a mixture of 20% (B20), 60% (B60) biochar and composted pine bark. The reference treatment was a mixture of sphagnum peat (20%) and composted pine bark (B0) - which is industry standard. Four replicates of each treatment were used in a completely randomized block design. The experiment was conducted using custom-made plant growth chambers capable of leachate collection and gas flux measurement. Each pot was maintained at 85% water filled pore space every day and basal micronutrients were added at the start of the experiment. Silverbeet plant was grown in the chambers. Weekly doses of nitrogen, phosphorus and potassium were added at the equivalent rate of 55 kg/ha, 42kg/ha and 25 kg/ha respectively. Emission of nitrous oxide was measured once a week using a chamber method. Leachate was collected once a week and measured for ammonium, nitrate and phosphate. Chemical and physical stability of biochar in media was measured using Mid-Infrared Spectroscopy and particle size analysis. Nutrient taken up by plants and retained by media was also measured.

Urban biochar treatments were able to retain more nutrient which led to a relatively smaller loss of nutrient in the leachate of B60 when compared with B0. Nitrous oxide loss was also significantly smaller in B60 than in B20 and B0. Plant growth in biochar amended media was similar to B0. The media amended with biochar was physically more stable in terms of particle size breakdown and shrinkage of media volume. Nutrient uptake by plants on biochar amended treatments was higher due to more developed root systems aided by the porosity from biochar. Hence, we came to conclusion that adding urban biochar to plant growing media can improve plant growth and save cost of fertilizer addition in nurseries by minimizing the loss of phosphorus and nitrogen in leachate and also reducing nitrogen loss in the form of nitrous oxide.

O 3.4.04

Biochar Degradation in Soils: The Overlooked Processes

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Recent data collected from both artificially and naturally weathered biochars suggest that a potential significant pathway of biochar disappearance is through physical breakdown of the biochar structure. Through scanning electron microscopy (SEM) we characterized this physical weathering which increased the spacing between the graphitic sheets due to the expansion accompanying water sorption, freeze-thaw, as well as desiccation and rewetting. As these sheets expand (exfoliate) this further accelerates physical break-down of the biochar. Soil texture plays an important role in this process, since clay particles were observed to seal pores and the spaces between the graphic sheets limiting the physical disintegration processes. In addition, these soil particles are virtually impossible to remove quantitatively, thereby skewing the resulting chemical analyses of the weathered biochar making it appear like chemical alteration rather than physical alteration was occurring. Lastly, the micro and nano-scale biochar particles resulting from this physical disintegration are still carbon-rich particles with no detectable alteration in the O:C ratio of the carbon structure, but are now easily suspended and moved by infiltration. There is a need to understand how to produce a biochar that is resistant to physical degradation in order to maximize the long-term C-sequestration potential of biochar in the soil system.

O 3.4.06

Effects of pyrochar and hydrochar on greenhouse gas emissions and microbial abundances in an arable soil

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Introduction

Since a few years biochar is discussed as a usable means to increase soil fertility, crop yield and for carbon sequestration in soils. Two main production processes are actually favored for biochar production from plant residue feedstock: pyrolysis (pyrochar - produced at 550°C for 30 min) and hydrothermal carbonization (hydrochar - produced at 200°C for 2 h). Chemical and physical characteristics strongly differ between pyrochar and hydrochar potentially showing different effects on soil biota.

Objectives

The objectives of the present study were: a) to investigate the decomposition of the different amendments and that of the native soil organic matter to get information about possible C sequestrations, b) to follow potential changes of the soil microbial community over time and whether changes of abundances of different members of the microbial community are related to observed decomposition patterns.

Material and methods

We added pyrochar, hydrochar (unwashed and washed) and un-carbonized feedstock material (*Miscanthus*) (2 % w/w) to a sandy arable soil and adjusted a similar water tension (pF 1.8). Soils were incubated in microcosms at 20°C for 240 days. Fluxes of greenhouse gases (GHG: CO_2, N_2O and CH_4) were measured and soil samples were analyzed for physicochemical (pH, N_{min}, $^{13}C_{org}$, extractable organic C and N) and biological (microbial biomass, $^{13}C_{mic}$, abundances of archaea, bacteria and fungi by qPCR) properties after 15, 30, 60, 120 and 240 days of incubation.

Results

Both hydrochar and the feedstock material increased CO_2 emissions, while showed no effect on N_2O and CH_4 emissions. Lowest CO_2 emissions and mineralization of the material itself were found in the pyrochar treatment, but N_2O emissions were highest in this treatment. Microbial biomass was strongly increased by hydrochar and feedstock material leading to N-immobilization. Fungal abundance (gene copy numbers of the fungal ITS region) increased during the incubation in both hydrochar treatments. Abundances of bacteria and archaea (gene copy numbers of specific 16S rRNA) were reduced during the early phase of incubation in the hydrochar treatments, indicating the presence of inhibitory substances. In comparison to the untreated soil pyrochar addition showed only weak effects on microbial abundances.

Conclusion

We conclude that especially the incorporation of unwashed hydrochar influenced microbial abundances, without showing a strong reduction of GHG emissions in comparison to the feedstock material, pointing out the risk of hydrochar incorporation into soils. In contrast, reduced GHG emissions, lowest mineralization in combination with only minor effects on microbial abundances and community structure suggest that pyrochar could be a usable addition to increase C-sequestration in arable soils.

O 3.4.07

IN VITRO A*erobic* and Anaerobic Degratation of Biochar

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INTRODUCTION

The inherent stability of biochar against oxidation led to the assumption that biochar is chemically and biologically inert to such an extent, that its mineralization rate was thought to be negligible. The main focus in such studies has been on CO2 evolution. Here we include the analysis of liquid products resultin from char solubilization. The ability of some microorganisms to metabolize coal is well known since the studies conducted by Potter (1908).The inoculation of coalbeds with methanogens to enhance methane production is a commonly used process referred to as Microbially Enhanced Coalbed Methane production. Here we study the rate of biochar degradation in anaerobic conditions, assuming that in such conditions it should be highly-degradable. This assumption is based on the lack of report on any significant accumulations of char in sedimentary basins.

MATERIALS AND METHODS

Different concentrations of H_2O_2 (0.333, 0.166, 0.083 and 0.042 M) were used. The H_2O_2 can be catalysed to various free radicals by transition metals such as Fe^{3+}/Fe^{2+}, Mn^{2+} and Cu^{2+} present in the matrix of the biochar. The biochar was assumed to be exposed to a OH•-producing system due to the pH range used and the metal catalysts present in the biochar. The biochar's elemental composition (% C, H, O, and N), surface chemistry (FT-IR spectrums, surface acidity/basicity and pH) and intermediates released upon degradation were determined

The incubation study was conducted in closed columns installed in a laboratory at room temperature and filled with silica sand amended by addition of 10%wt biochar. The biochar used was produced from pine wood pyrolized at 450ºC. Microbial inoculation was done with a filtered suspension produced from rotting pine wood.

The anaerobic degradation trial was conducted in 500 ml Erlenmeyer flasks containing 50 grams of granulated methanogenic consortium to investigate the effect of pH and increasing biochar loads (expressed as chemical oxygen demand -COD), on the biodegradation of biochar. The trial consisted of three main treatments assessed over three periods each with increasing biochar loads. The trials were conducted at pH 5.5, 7 and 8. The COD input were increased every 28 days from ±900 to ±1850 to ±2250 $mg \cdot L^{-1}$. N and P were added to all treatments based on carbon loads at the rate of 1000:10:1 (C:N:P). Sampling was done four times within each incubation period. The substrate feed and the effluent parameters monitored with every feed included the following: COD reduction (APHA, 1998), pH, alkalinity (as $CaCO_3$), total biogas produced and its composition.

RESULTS AND CONCLUSIONS

Biochar is H_2O_2 degradable via hydroxylation and carboxylation reactions resulting in aromatic ring cleavage and the release of carboxylic acids. Basidiomycetes should therefore be able to degrade the highly aromatic structure of biochar.

This study has clearly shown that biodegradation of biochar in aerobic conditions produces not only gaseous, but also liquid products, which were previously disregarded in biochar degradation studies. The rate and volumes of biodegradation are largely controlled by nutrient availability, particularly N and P.

The greatest COD removal efficiencies were attained from digesters with starting pHs of 7 and 8. The increase in COD input had no significant effect on COD removal efficiencies in any treatment. The methanogenic consortium produced CO_2 throughout the trial, whilst methane production was was very erratic at starting pH=7, but occurred more often compared to the other treatments. When methane production did occur the biogas composition consisted of ±70% methane and ±26% CO_2. Anaerobic degradation rates of up to 33% of initial char (as COD) input per week were observed.

O 3.4.08

Tracing the fate of biochar in the field: quantification, distribution, and changes in properties

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Tracing the fate of biochar in the field in the years following application is important both in terms of verification of C storage and fertility effects. If biochar becomes an accepted technology for C sequestration there will be a need for field-based verifications. However, under field conditions and conventional soil ploughing practices, the heterogeneity of biochar distribution in the field can be large, and present an obstacle to properly evaluating quantities and distribution. We conducted a field experiment on a clay loam at the Norwegian University of Life Sciences field station in Norway. The biochar was made by Pyreg Gmbh from chaffed miscanthus biomass. This feedstock was chosen for its ^{13}C isotopic signature, which is different from that of Norwegian agricultural soils, thereby allowing us to estimate the mineralization rate of the biochar in the field through $^{13}CO_2$ measurements. Biochar was applied to replicated plots in 2010 at rate of 8 and 25 t C ha^{-1} and in additional plots in 2012.

Here we explore a series of methods for quantifying the biochar distribution, both at the profile scale and among plots. Hyperspectral imaging of an undisturbed soil monolith of the Ap horizon was conducted with the aim of mapping the biochar distribution in the soil profile and assessing the amount of biochar amendment. The hyperspectral method proved promising but further progress is needed to make this method operational. At a larger scale and among plots, we compared mapping of biochar with ^{13}C isotopic measurements to that obtained with other methods applicable on larger samples such as soil fractionation before simple C analyses and loss of ignition. In addition, biochar particles extracted through fractionation were compared to the initial material, notably through composition mapping with SEM-EDX. Assessment of methods for quantification and distribution as well as changes in properties will be presented.

O 3.4.09

Effect of pyrolysis temperature on the microbial decomposition of corncob and miscanthus biochars in soil

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Biochar, a collection of materials produced through the charring of biomass, serves as a promising management tool for sequestering C in soil and reducing our carbon footprint. Because charring can be performed at different intensities, biochars have varying properties including their residence time in soil. This study was designed to investigate the effect of the highest treatment temperature (HTT) on biochar properties during slow pyrolysis and compare them to properties of biochars obtained through other charring methods. Feedstock (non-pyrolyzed biomass), slow pyrolysis biochars, hydrochars, and flash carbonization biochars from corncob and miscanthus were incubated in a sandy loam soil and their mineralization monitored over one year. Soil C mineralized at rates that were closest to that of the stabilized C fractions from hydrochars. Compared to feedstocks, these hydrochars had half-lives that were 4.5 times longer while slow pyrolysis biochar half-lives were found to increase by 60 times at charring temperatures of 370 ˚C with no further increases in soil residence time when higher HTT was utilized. Such a threshold related to charring temperature was not observed when mapping microbial community structures of bacteria and fungi. These changed significantly with increasing HTT and charring intensity of biochars, indicating a clear effect of high-temperature biochars on soil microbes. The observed transient positive priming of SOC from biochars used in this study indicated that the change in microbial community structure was not due to toxic effects but to adaptation to decomposing a new substrate. These results suggest that stable biochars having minimum effects on microbial community composition can be produced at charring temperatures of 370 ˚C.

O 3.4.10

Co-composting of biochar and farm manure; influence on plant growth and carbon mineralization in an alkaline soil

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Introduction

Unlike compost, biochar is a predominantly stable, recalcitrant organic carbon (C) compound, prepared through pyrolysis of biomass at 300 and 1000 °C, under low oxygen. It is proposed that the application of BC into a composting system increases the carbon sequestration potential of compost as well as nutrients retention in the compost (Hua et al. 2009). The objectives of present studies were to investigate the potential effects of co composted biochar on wheat growth and carbon mineralization in an alkaline soil.

Materials and methods

The soil was an Aridisol with high pH, calcareousness and low organic matter. The biochar (derived using lawn grass and litter) was mixed with farm manure at various proportions (100:0, 75:25, 50:50, 25:75 and 0:100 on V/V basis). In the plant growth experiment, wheat crop were grown in pots using treatments comprised of T_1 = Control, T_2 = $FM_{100}BC_0$, T_3 = $FM_{75}BC_{25}$ T_4 = $FM_{50}BC_{50}$, T_5 = $FM_{25}BC_{75}$, and T_6 = FM_0BC_{100} at two fertilizer levels (half and full). For carbon mineralization study, an incubation experiment was conducted using the same treatments but without fertilizer limitations. The CO_2 released during incubation was captured using alkali absorption method.

Results

The results show significant effect of treatments at half fertilizer level, in terms of number of spikes, grain yield per pot, and concentrations of nutrients in soil and plants. At full fertilizer level, the grain yield per pot was not significantly affected (Table 1). At half fertilizer, maximum number of grains per spike were observed at T_6(FM_0BC_{100}) while at full fertilizer level the same effect was recorded at T_1. In the incubation experiment the co-composted biochars were mixed with soil and incubated over a period of about 80 days. The results show highest mineralization from T_2 where compost of $FM_{100\ \%}$ was applied. The lowest mineralization was found in T_1 (control) followed by T_6 ($BC_{100\ \%}$). The overall trend of carbon mineralization was as $T_2>T_3>T_4>T_5>T_6>T_1$ (Figure 1). Our results clearly demonstrate that compost derived from higher amounts of farm manure has lowest stability in soils under our local climatic conditions. However when we increased the amount of BC in the composts the stability of carbon increased and reached maximum where only BC compost was applied. There was no effect of treatments on soil pH and EC but on soil organic matter (SOM) (Table 2). The highest SOM was found in treatment where equivalent volumes of farmyard and biochar were composted and applied in soil (T_4, $FM_{50}BC_{50}$). Reasons behind higher mineralization at start of incubation are higher amounts of degradable organic compounds in the composts and soils which were depleted with passage of time. The CO_2 release rates from 100% BC treatment are even lower than control which means stabilization of native carbon in soil.

Conclusions

This finding clearly depicts higher carbon sequestration potential of composted biochar in alkaline soils. From the results of present study it is concluded that the co composts of biochar and farm manure have the potential to increase the crop yields even at lower fertilizer applications.

Figure legend:

Figure 1. Cumulative release of CO_2 from soil amended with co composted biochar.

Figure 1

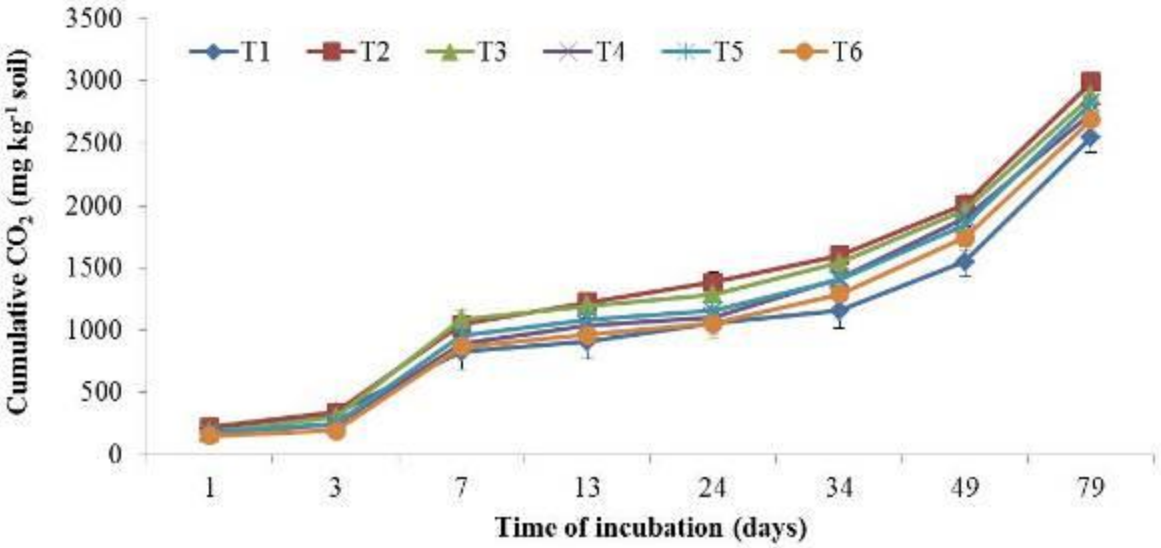

Figure 2

Table 1. Effect of compost and composted biochars on growth parameters of wheat crop.

Treatments	Fertilizer level	No. of tillers	No. of spikes	Grain Yield per pot (g)	shoot length (cm)	1000 grain weight (g)	spike length (cm)
T_1 (control)	F_1	5.28 ± 0.59 ***	5.06 ± 0.63 **	25.95 ± 2.00 *	19.94 ± 0.27 n.s.	200.00 ± 5.07 n.s.	5.00 ± 0.14 n.s.
	F_2	6.35 ± 0.06	5.64 ± 0.21	31.83 ± 1.67	18.98 ± 1.46	196.25 ± 11.88	5.17 ± 0.37
T_2 ($FM_{100}BC_0$)	F_1	5.41 ± 0.17 *	4.51 ± 0.17 *	23.40 ± 1.02 **	21.17 ± 0.80 n.s.	214.50 ± 8.37 n.s.	4.65 ± 0.17 n.s.
	F_2	5.99 ± 0.14	5.81 ± 0.13	30.63 ± 1.44	21.50 ± 1.01	217.25 ± 8.61	4.27 ± 0.29
T_3 ($FM_{75}BC_{25}$)	F_1	5.81 ± 0.24 n.s.	4.78 ± 0.53 n.s.	22.05 ± 3.84 n.s.	18.49 ± 1.06 *	214.25 ± 5.69 n.s.	4.05 ± 0.32 n.s.
	F_2	6.41 ± 0.21	5.44 ± 0.33	26.36 ± 3.55	21.50 ± 0.98	218.50 ± 6.59	3.92 ± 0.17
T_4 ($FM_{50}BC_{50}$)	F_1	5.78 ± 0.87 n.s.	6.25 ± 0.69 n.s.	32.59 ± 4.22 n.s.	17.05 ± 1.47 n.s.	201.50 ± 8.11 n.s.	3.70 ± 0.54 n.s.
	F_2	5.53 ± 0.29	5.72 ± 0.36	27.83 ± 3.37	19.37 ± 1.31	210.25 ± 3.57	4.21 ± 0.30
T_5 ($FM_{25}BC_{75}$)	F_1	6.25 ± 0.39 n.s.	6.09 ± 0.33 n.s.	31.95 ± 1.88 *	20.11 ± 0.48 *	222.00 ± 3.12 n.s.	4.67 ± 0.17 n.s.
	F_2	6.00 ± 0.34	5.28 ± 0.11	25.05 ± 0.83	18.07 ± 0.59	218.00 ± 5.96	4.58 ± 0.03
T_6 (FM_0BC_{100})	F_1	6.91 ± 0.42 n.s.	6.73 ± 0.39 n.s.	33.30 ± 1.68 n.s.	19.23 ± 0.31 n.s.	222.00 ± 1.58 n.s.	4.51 ± 0.12 n.s.
	F_2	6.16 ± 0.22	6.04 ± 0.11	30.19 ± 1.35	19.50 ± 1.24	231.50 ± 5.17	4.23 ± 0.17

Table 2. Effect of compost and composted biochars on soil pH, EC, and organic matter.

Treatments	pH	EC	OM
T_1 (control)	8.97 n.s.	345.50 n.s.	0.73 (a)
T_2 ($FM_{100}BC_0$)	8.89	199.50	0.70 (a)
T_3 ($FM_{75}BC_{25}$)	9.04	146.75	1.44 (ab)
T_4 ($FM_{50}BC_{50}$)	9.00	196.50	1.57 (b)
T_5 ($FM_{25}BC_{75}$)	8.84	225.00	1.34 (ab)
T_6 (FM_0BC_{100})	8.80	201.50	1.37 (ab)

n.s. not significant

O 3.4.11

Processes affecting biochar removal from the site of its deposition

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Biochar to soil has been postulated to be useful to increase soil C sequestration potential as well as the soils fertility. Due to its high persistence, biochar mineralization rates in soil most probably approach several centuries. Physical processes, which may determine biochar loss at much shorter timescales, are those leading to its physical disintegration and transport off site. Fresh biochar even when incorporated into the mineral soil is characterised by absence of mineral interactions at the time of application, which makes it prone to export by leaching or erosion processes, similar to those affecting free particulate organic matter derived from plant material. In the first years after disposal these processes may be much more important in terms of quantitative biochar fluxes than microbial degradation (Major et al, 2010; Foereid, et al, 2011).

In the present study, we assessed the effect of biochar on soil C storage in the first years after its addition to soil under temperate and tropical climate conditions. The objectives of our study were to (1) quantify its effect on soil C storage; and (2) to assess its fate in soil in terms of mineralisation and removal through transport. Our conceptual approach included a combination of laboratory investigations of biochar mineralisation after artificial weathering and field investigation on C storage and biochar loss under natural rainfall conditions.

Our results indicated that biochar is susceptible to physical weathering, which may lead to production of colloidal material, susceptible to be lost from soil, while losses following mineralization may be minimal. Addition of 30t ha-1 of biochar to temperate soils led to C increase in the first 15 cm of soil in the first year after deposition. However, in the following three years 38% of biochar was lost from the uppermost soil layers. As the site was under permanent grassland and erosion thus neglectible, we assume that these losses were due to leaching, i.e. vertical transport. This was also evident in a tropical environment, where more than 50% of biochar exposed on soil in litterbags were lost after one year of exposure on flat soil. Biochar losses were found to be reduced, when mixed with compost or vermicompost.

We conclude that physical disintegration and subsequent loss of biochar as colloidal material are important mechanisms controlling the fate of biochar in the first years after disposal. While erosion may be an important factor in sloping terrain, vertical transport seems to be equally important. Biochar losses may be attenuated by its mixture with other organic materials.

Reference

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Major, J., Lehmann, J., Rondon, M. and Goodale, C. (2010), ‘Fate of soil-applied black carbon: downward migration, leaching and soil respiration’, Global Change Biology, vol 16, 1366-1379.

Acknowledgments

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P 3.4.01

Is biochar worth its salt as an amendment? - A comparative evaluation

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Biochar is considered more effective at sequestering carbon and improving soil fertility than traditional amendments but few direct comparisons have been conducted. Thus, we examined the carbon sequestration potential and ability of biochar, spent mushroom compost (SMS) compost and corn stalks to improve selected soil fertility indicators. Biochar had the highest soil mean residence time among amendments when extrapolated from a 80-day incubation, followed by SMS compost and plant residues the least. This confirms that biochar is more effective at sequestering carbon for extended periods. However, biochar application had no influence on soil fertility apart from increasing the pH of acidic soils whereas corn stalks increased soil microbial biomass carbon content and had similar impacts on the pH of acidic soils. SMS compost increased soil pH, available nitrogen and soil microbial biomass carbon content but increased soil salinity to levels potentially harmful to plant growth. This result challenges the position that biochar is superior to traditonal amendments for the dual-roles of carbon sequestration and improving soil fertility, and suggests that certain composts may be superior alternatives.

P 3.4.02

Biochar contains abundant extractable phosphorous and effectively improves the availability of phosphorous in an alluvial soil

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With the depletion of global P reserves, promoting sustainable P management by utilizing alternative P fertilizers has received more and more attentions. Biochar, co-product from pyrolyzing biomass, has been reported to have benefits increasing soil C sequestration, water retention, soil microbial activity and soil nutrients, when being applied to soil. In this study, we aimed to identify whether biochar could be used to alternate P fertilizer in a P-deficient alluvial soil. Olsen-P method with 0.5M $NaHCO_3$ was used to extract and analyze the content of available P from biochar and the tested alkaline soils. The biochar exhibited 5 times higher extractable P than the corresponding rice straw. Extractable P content of biochar was significantly increased with grinding, being 80% higher at particle size 0.149 mm than at 4 mm. Even un-grinded biochar reached a high level of 680 mg/kg extractable P, which was 70 times higher than the soil. When biochar was applied to the soil, a strong positive correlation was shown between the soil available P and biochar addition levels (with the fitted curve y=624.4x+4.4， R^2=0.99). The slope was 624.4 mg/kg, slightly smaller than the extractable P content of biochar, indicating that biochar did not increase the sorption of P in the alluvial soil and available P contained by the biochar can be available for plants after being applied to the soil. Moreover, results from the pot experiment showed that soil available P was significantly increased at a biochar application rate of 1% (w/w). At harvest, the above ground dry weight and P uptake was 24% and 31% greater than control, respectively. Our results suggest that biochar itself contained abundant extractable P and effectively improved the availability of phosphorous and crop growth in the alluvial soil. Biochar thus can go partly or even fully on alternative mineral P fertilizers and be beneficial for reducing fertilizer utilization in agriculture.

P 3.4.03

Prospect of Soil Improving Improvement through Modern Agricultural Waste Management in Africa

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Traditionally, the way agricultural wastes are being discarded creates more problems in terms of contamination and other environmental challenges. Utilising these wastes in line with the modern practice, would avail the farmers value adding products like biofterlizer and green energy among others. This helps farmers to improve soil quality, have increased yield and play part in climate change mitigation. The paper will therefore review how capacity of African farmers could be developed so as to promote good soil and environment practice. It would also highligh the socio-economic benefits derivable as well as review the experiences of other places.

P 3.4.05

Basal respiration on soil amended with poplar biochar: Effects of slow and fast pyrolysis

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Today biochar is considered as stable-carbon source that is able to improve soil quality. However, although biochar effects on some soil properties are already well known, its decomposability or ability to reduce CO_2 emissions in absence of plants (e.g. simulating land reclamation or fallow scenarios) has yet to be better assessed. A sandy-loam, low-organic-matter, calcareous soil was mixed with biochars obtained from slow and fast pyrolysis of poplar biomass (mean rate: 13 g/kg) and incubated in a greenhouse without seeding. Two sampling campaigns, one month and one year after biochar amendments, were performed. ANOVA and Kruskal-Wallis tests were used to determinate differences between treatments and sampling times. Soil respiration on bare soil was decreased by slow and fast pyrolysis poplar, one month after biochar application, while it was increased by fast pyrolysis poplar one year after biochar application (Fig. 1a). Soil pH was modified only one year after biochar application, where fast pyrolysis poplar decreased soil pH (Fig. 1b). Soil organic carbon was increased by both biochars at both sampling times (Fig. 1c). Effects of biochar on soil electrical conductivity were not observed (Fig. 1d), while the quantity and velocity of water absorbed by capillarity (Figs. 1e and 1f) were reduced by fast pyrolysis poplar at both sampling times. No changes in soil-water contact angle between treatments were observed (Fig. 1g), while saturated bulk density was increased by both biochars at both sampling times (Fig. 1h). As a result, it was observed that soil respiration and the soil-water properties related with soil organic matter decomposition, were mainly modified by the biochar obtained from fast pyrolysis.

In order to explain the biochar influence on microbial activity, several interactions between soil respiration and soil properties were analysed. It was observed that: (i) Increases in soil pH decreased soil respiration at both samplings (Fig. 2a), (ii) In contrast, increases in soil electrical conductivity promoted soil respiration (Fig. 2c), (iii) During the first sampling, increases in soil organic carbon and saturated bulk density (Figs. 2b and 2f) tended to decrease soil respiration, while during the second sampling increases in soil organic carbon and saturated bulk density tended to increase soil respiration, (iv) During the first sampling, increases in the quantity and velocity of water absorbed by capillarity (Figs. 2d and 2e) tended to increase soil respiration, while during the second sampling increases in the quantity and velocity of water absorbed during capillarity tended to decrease soil respiration. Linear regressions between soil respiration and soil-water retention, aggregate stability or soil-water contact angle were not significant. Thus, it was clear that several physic-chemical properties are able to stimulate or inhibit CO_2 emissions from soil, which could change drastically in time. We conclude that the specific impact of biochar components depends on the pyrolysis technique used during its production.

Figure 1

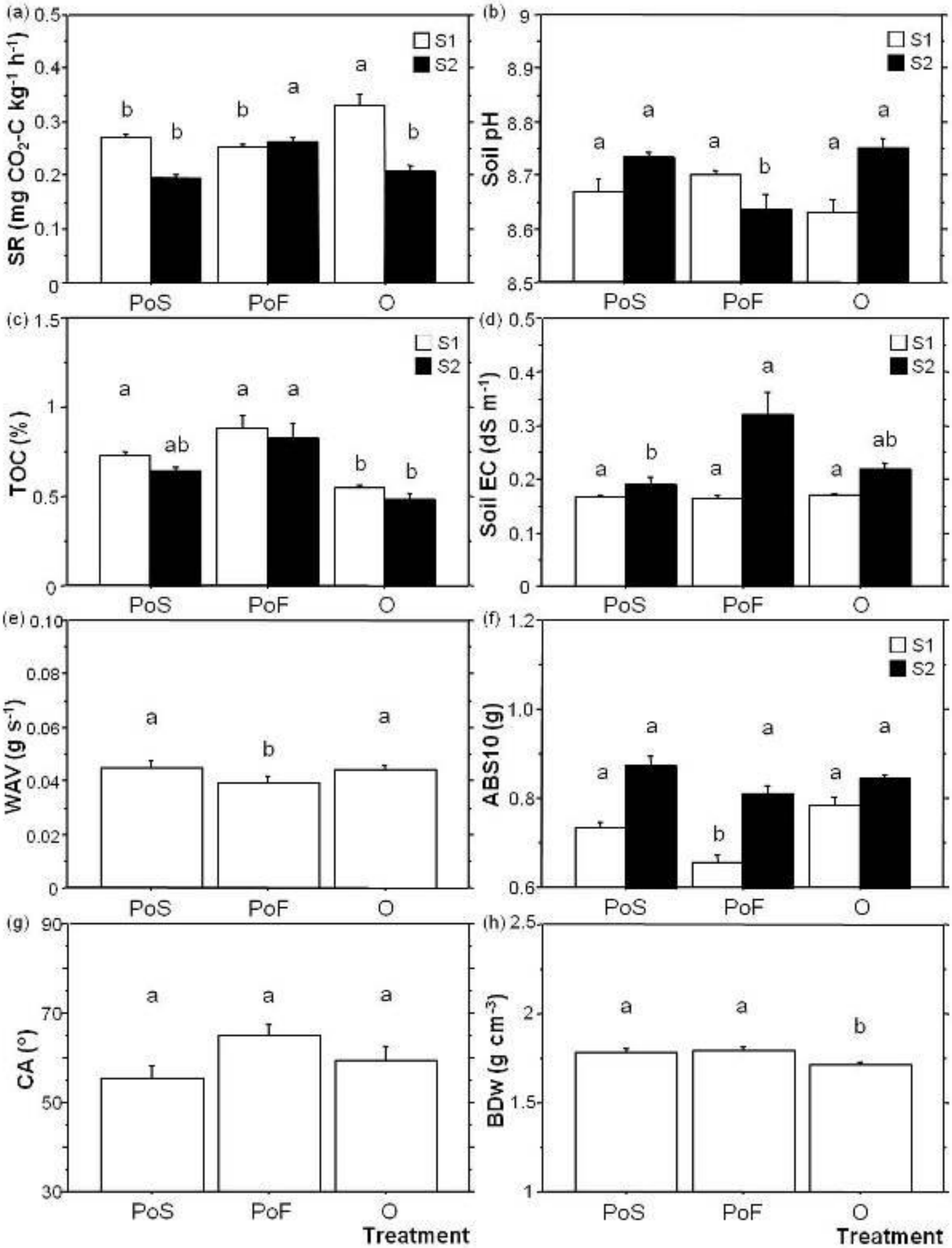
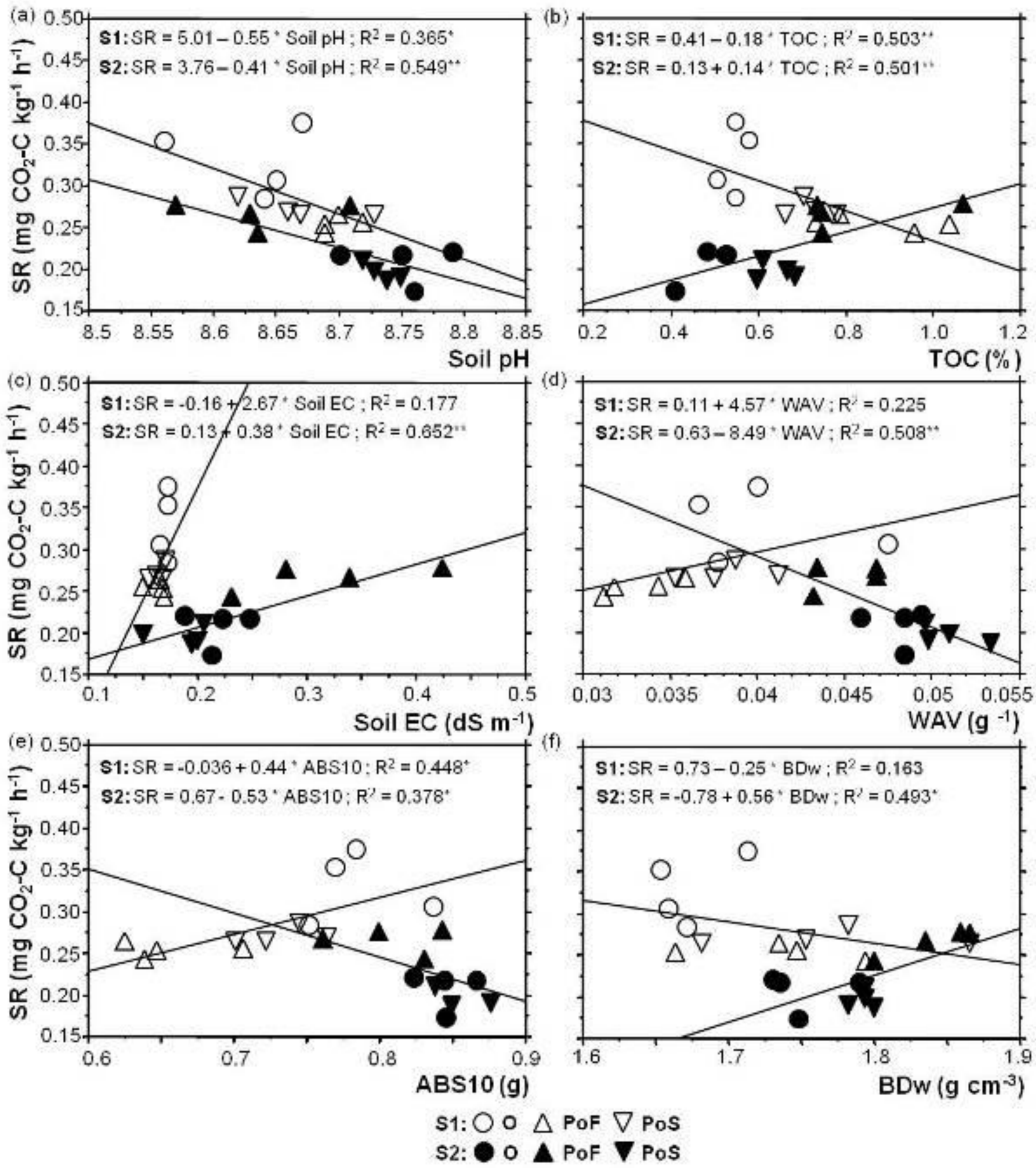

(a)
SR (mg CO_2-C kg^{-1} h^{-1})
S1
S2
PoS
PoF
O
(b)
Soil pH
(c)
TOC (%)
(d)
Soil EC (dS m^{-1})
(e)
WAV (g s^{-1})
(f)
ABS10 (g)
(g)
CA (°)
(h)
BDw (g cm^{-3})
Treatment

Figure 2



S1: SR = 5.01 – 0.55 * Soil pH ; R² = 0.365*
S2: SR = 3.76 – 0.41 * Soil pH ; R² = 0.549**
S1: SR = 0.41 – 0.18 * TOC ; R² = 0.503**
S2: SR = 0.13 + 0.14 * TOC ; R² = 0.501**
S1: SR = -0.16 + 2.67 * Soil EC ; R² = 0.177
S2: SR = 0.13 + 0.38 * Soil EC ; R² = 0.652**
S1: SR = 0.11 + 4.57 * WAV ; R² = 0.225
S2: SR = 0.63 – 8.49 * WAV ; R² = 0.508**
S1: SR = -0.036 + 0.44 * ABS10 ; R² = 0.448*
S2: SR = 0.67 - 0.53 * ABS10 ; R² = 0.378*
S1: SR = 0.73 – 0.25 * BDw ; R² = 0.163
S2: SR = -0.78 + 0.56 * BDw ; R² = 0.493*
SR (mg CO2-C kg-1 h-1)
Soil pH
TOC (%)
Soil EC (dS m-1)
WAV (g -1)
ABS10 (g)
BDw (g cm-3)
S1: O PoF PoS
S2: O PoF PoS

P 3.4.06

Mineralization, mobilization and stabilization of biochar carbon in contrasting soils under planted field conditions in Australia

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Introduction

Biochar carbon (C) can be lost from soil via mineralization (albeit at a much slower rate than C in parent biomass), dissolution and leaching, and wind/water erosion. Besides being a relatively persistent C pool, biochar can influence the cycling of native soil organic C (SOC). However, the persistence, mobility and interaction of biochar with plant-soil C and soil minerals, as well as the underlying mechanisms are poorly understood.

Objectives

The aims of this study were to (i) monitor the fate of biochar C in respired CO_2 and quantify biochar stability under field conditions in the presence of plants, (ii) determine the influence of biochar on native soil C emission, (iii) track downward migration of the surface (0−10 cm) applied biochar over a 1-year period, and (iv) investigate stabilization of biochar by determining the partitioning of biochar C in mineral-free and mineral-associated fractions.

Materials & Methods

An *Eucalyptus saligna* green-waste biochar ($\delta^{13}C$ -36.6‰; total C 66.8%) produced by slow pyrolysis at 450° C was applied at 29.2 t ha^{-1} (equates to 19.5 t C ha^{-1}) to 10-cm depth in circular (0.66-m diameter) micro-plots, encompassing three soils [Tenosol, Dermosol and Ferrosol (Australian Soil Classification); Arenosol, Planosol, Ferralsol (WRB Classification)] under C_3 temperate pasture systems across New South Wales and Tasmania, Australia. A static-chamber alkali trap method was used to monitor soil C emission. Biochar C mineralization was estimated by applying a two-pool C isotope model. Biochar persistence (mean residence time; MRT) in soils was calculated by one-pool, two-pool and infinite-pool models to evaluate whether including additional pools would vary and improve MRT estimates. The C recovery of applied biochar C was monitored in the soil profile to 30- or 50-cm for up to 12 months. The soils at 0−8 cm depth were separated into light and heavy C by density fractionation and then the total C and ^{13}C in fractions were measured. The two-pool C isotope model was used to calculate the proportion of biochar C associated with minerals.

Results

The results showed a lower proportion of biochar C mineralised over 12 months in a relatively clay- and C- poor Tenosol (2.0%), followed by a clay- and C- rich Dermosol (4.6%) and Ferrosol (7.0%). The biochar C mean residence time (MRT), estimated by different models, varied between 44−1079 (Tenosol), 18−172 (Dermosol), and 11−29 (Ferrosol) years, with the shortest MRT estimated by a one-pool exponential and the longest MRT by an infinite-pool power or a two-pool exponential model. The two-pool model was best fitted to the sequence of cumulative biochar C mineralized over 12 months. The vertical migration of biochar C was the greatest in the Tenosol (*vs.* Dermosol and Ferrosol). The biochar C recovery to 12−30 cm depth varied as 1.2% (Tenosol), 2.5−2.7% (Dermosol) and 13.8−15.7% (Ferrosol) after 8−12 months. There was a further migration of biochar C below the 50-cm depth in the Tenosol, as the biochar C recovery across the mineralised pool and in the soil profile was 82.2%, in contrast to the Dermosol (100.7%) or Ferrosol (104.4%) after 12 months. Cumulative CO_2-C emission from native soil-plant C sources was lower (*p*vs. non-amended Ferrosol.

Biochar C recovery in the heavy fraction increased with time (from day zero to 12 months) i.e. from 0.30 to 11.0% in the Tenosol, from 4.3 to 21.3% in the Dermosol and from 4.7 to 33.3% in the Ferrosol. On the other hand, biochar C recovery in the light fraction ranged from 93.7 to 97.3% across all soils at day zero, which decreased to 72.4-85.9% after 12 months.

These results clearly indicated the association of biochar with the relatively slow cycling, heavy (organo-mineral) fraction, which could contribute to its stability in soil.

Conclusions

This field study shows that the persistence and downward migration of biochar vary with site-specific characteristics and particularly, biochar C mineralization increased with increasing soil C content. The downward migration of biochar C was high in a relatively sandy soil (Tenosol) or in an earthworm abundant soil system (Ferrosol). The physical fractionation analysis showed association of biochar with a slow cycling, organo-mineral fraction over time, possibly facilitated by development of functional groups on biochar surfaces and their interactions with plant C input and clay minerals over time. Our findings on the mineralization, mobilization and stabilization of biochar in contrasting soils and pasture systems possess implications for C models to assess the C storage potential of biochar in planted field conditions.

P 3.4.07

Biochars exert different effects on soil organic carbon stability in tropical soils with contrasting properties

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1. Introduction

Research results on biochar effects on soil organic carbon (SOC) stability showed inconsistency due mainly to different soil types, notably texture and mineralogy, and climatic conditions. Additionally, most studies were conducted in the temperate, while those in the tropics remain less assessed.

2. Objective

To investigate effects of two biochars possessing different major properties, i.e., fixed C, volatile matter (VM), and ash contents, arisen from different pyrolysis temperatures, on SOC stability in tropical soils contrasting in texture and mineralogy.

3. Materials & methods

A pot experiment in which three consecutive planting cycles of corn in two biochar-treated soil types was conducted. Total experimental duration was 144 days after biochar incorporation. Two tropical soils of different textural and mineralogical types, i.e., a coarse-textured, Al-rich Ultisol from Thailand, and a fine-textured, Mn-rich Oxisol from Hawaii, were treated with two types of eucalyptus wood derived biochars, i.e., low (~350^{o}C) and high (800^{o}C) temperatures, at four rates (0, 1, 2, and 4% w/w). Soils were sampled after the harvest of the third crop of corn.

4. Results

SOC stability, indicated by relative soil C remaining (% initial native soil C + biochar C), in the Ultisol were significantly higher than the control at the low and medium rates of both biochars. However, that of the highest rate of the low temperature biochar was significantly lower than its medium rate. In the Oxisol, high temperature biochar at all rates had significantly lower SOC stability than the control, while similar results in the low temperature counterpart were only found under the medium and high rates. Additionally, under the high rate in this soil, high temperature biochar showed significantly higher SOC stability than its low temperature counterpart.

5. Conclusions

Both biochars produced contrasting effects on SOC stability in the two different tropical soils. While the Ultisol showed increases in SOC stability with increasing rates of biochars up to the medium rate (2%), the Oxisol showed the opposite effect. Soil texture and mineralogy and biochar properties played key roles in altering SOC stability. Possible mechanisms were proposed as to biochar effects on increasing SOC stability in the Ultisol to include interaction of biochars with Al and SOC; and toxicity of VM constituent of biochar to decomposer microorganisms. Despite the SOC stability increase, priming effect at the highest rate of low temperature biochar caused a decrease in SOC due to biochar-derived VM fuelling microbial degradation of native SOC. Meanwhile, possible mechanisms underlying decreases in SOC stability under the Oxisol was related to soil aggregate destruction via dissolution of Mn oxides by VM constituents of biochars. At the highest rate of biochar application (4%), the high temperature biochar increase SOC stability over its low temperature counterpart regardless of the soil types. It was proposed that higher fixed C of the former added higher amount of stable C pool to the SOC than the latter biochar.

P 3.4.08

Carbon sequestration and maize biomass as affected by different biochars and application rates in a Brazilian Arenosol

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Introduction

Arenosols account for 13% of the state of Mato Grosso, Brazil, equivalent to an area of 11.7 Mha (SEPLAN, 2008). Much of this area is used to grow maize during the dry season. However, Arenosols are very sandy soils with low organic matter content that drain easily and are thus heavily leached. The potential of biochar (charcoal derived from waste biomass by pyrolysis) to improve soil water retention and carbon (C) sequestration has been observed under some conditions (Lehmann, 2007), and so its amendment to sandy soils could potentially be beneficial in this system.

Objectives

The objectives of this study were to assess how much C could build up in a sandy soil with different types of biochars, and which application rates allowed maximum C sequestration while increasing plant growth.

Materials & Methods

In this study, four biochars were used derived from four different feedstocks: cotton husks, eucalyptus sawmill residue, filtercake resulting from sugarcane distillation, and swine manure, pyrolysed at 400°C. Biochar was mixed into pots at 4 application rates: 1, 2, 3, and 4% dry weight to 8 kg of an Arenosol for a total of 17 treatments (including the control with no biochar) replicated 4 times. Maize seeds were planted in all pots. Pots were arranged randomly across 4 benches in a greenhouse at 30°C for 6 weeks. After this period, soil samples and plant biomass were collected and dried at 60°C for analyses.

Results

Results showed that there was a significant ($P < 0.005$) treatment effect on % soil C, which increased as the dose increased. However, not all biochar treatments significantly increased % C in soils more than in control soils without biochar (Figure 1). Soils with cotton biochar at 4% application rate had the highest mean % C (1.81 ± 0.20 % C) while soils with filtercake biochar at 1% application rate had the lowest mean (0.98 ± 0.05% C). The control soil with no biochar contained 0.83 ± 0.07 % C.

There was also a significant ($P < 0.005$) treatment effect on maize dry biomass. Maize from soils with filtercake biochar applied at 1% application rates had significantly ($P < 0.05$) greater mean dry biomass than maize from soils with cotton biochar at all rates. However, no biochars led to significantly greater maize biomass compared to the control. Overall, maize biomass from soils with cotton and swine manure biochar tended to decrease as application rate increased (although this effect was not statistically significant at $P < 0.05$) while for filtercake and eucalyptus biochar there was less of a pattern.

Conclusions

Biochars at high application rates (e.g. 4%) can increase C content in the soil. However, higher application rates of certain biochars may lead to lower maize biomass, as was the case for soils with cotton and swine manure biochars. Maize biomass from soils with biochars did not significantly increase more than biomass from soils with no biochar, but there were significant differences between the feedstocks (i.e. filtercake and eucalyptus biochar additions produced greater maize dry biomass compared to cotton and swine manure biochar additions). This study reflects the importance of determining appropriate biochar feedstocks and application rates when attempting to increase C sequestration in agricultural soils while still ensuring crop yield.

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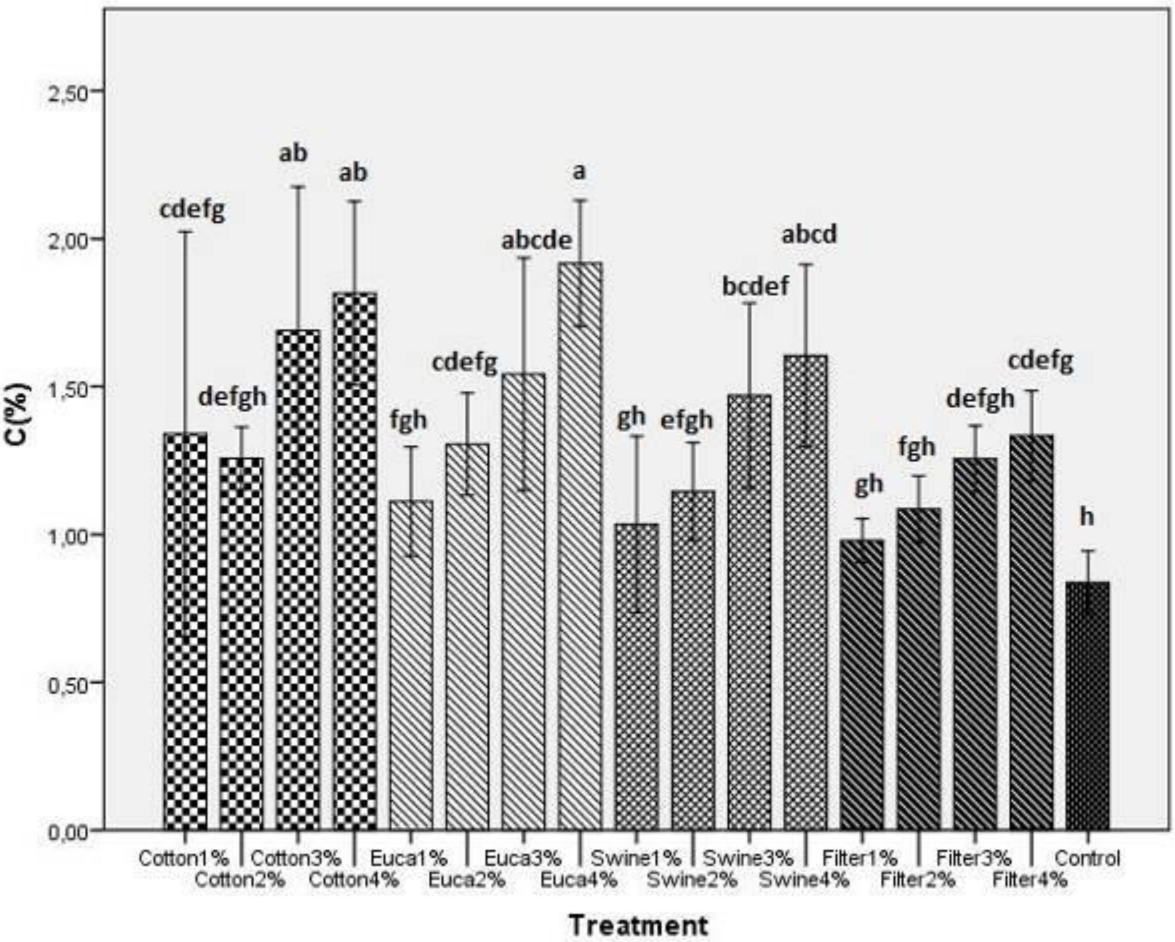
Figure 1: Percent soil carbon (C) in soils with different biochar treatments. Letters above bars represent significant differences between treatments (*P* < 0.05, Tukey-HSD test). Columns are the mean values with standard error bars (n=4); column labels indicate the feedstock material and percentage applied to soil on a dry-weight basis. All biochars were produced at 400°C. Treatment designations: Cotton=cotton biochar, Euca=eucalyptus biochar, Swine=swine manure biochar, Filter=filtercake biochar, Control=no biochar

Figure 1



P 3.4.09

Biochar decomposition and priming effects in soils under long-term conventional and organic farming management

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Introduction Biochar has a great potential to ameliorate agricultural soils, especially those that are low in organic matter. Photosynthetically fixed atmospheric CO_2 stabilized in biochar may thus act as a direct carbon sink and help to mitigate climate change, as it is supposed to remain for hundreds of years in soil. But biochar turnover times seem to depend not only on biochar itself, but also on climatic conditions and on soil. Thus predictions of biochar decomposition and effects on soil organic carbon (C_{org}) and microbial biomass carbon (C_{mic}) need to consider biochar and soil properties case by case. ***Methods*** In this study, biochar-derived carbon fluxes to the atmosphere, the soil organic carbon pool and the active microbial biomass carbon pool were investigated in the course of an aerobic incubation experiment at room temperature in the dark. The investigation was performed using two loess soils from the DOK long-term system comparison experiment located in Therwil, Switzerland. The two soils were managed organically (Soil D) or conventionally (Soil M) in the past 28 years and were fertilized only with composted manure or mineral fertilizers , respectively. The two soils show a distinct difference in microbial community, abundance and activity. Both soils were amended with two biochars and their feedstock material as a control. The biochars were produced by pyrolysis (pyrochar) and hydrothermal carbonization (HTC; hydrochar). The maize straw (*Zea mays, L.)* used to produce biochar was artificially enriched in ^{13}C. Soil respiration was monitored continuously as CO_2 emitted from soil; C_{mic} and C_{org} were measured at two distinct time points, after the initial peak in mineralization (12 days) and after return to a constant CO_2 evolution rate in all treatments (205 days). Biochar mineralization rates and priming effects on soil organic carbon were assessed by stable isotope techniques, measuring $^{13}CO_2$, $^{13}C_{mic}$ and $^{13}C_{org}$ in bulk soil.

Results In both soils the trend of soil respiration measured, as C flux from soil into air, was similar in respect to the treatment. In the maize straw treatment soil respiration was slightly higher in Soil M. Whereas the soil respiration in the hydrochar treatment was higher in soil D during the first fifty days and in the pyrochar treatment of both soils lower soil respirations were measured than in the respective control treatment. The mineralization rates of maize straw and hydrochar amendments were higher in soil M, the decomposition of pyrochar was hardly to access in both soils and showed no difference between the soils. A distinct priming pattern for soil carbon mineralization by each amendment over time was found. Maize straw induced soil carbon mineralization the same way and amount in both soils, Hydrochar showed a higher initial priming in soil D and Pyrochar induced a negative priming in both soils. The microbial biomass at day 12 followed the mineralization rate of the amendments and was highest increased in the Maize straw treatment followed by the Hydrochar and Pyrochar treatments, in comparison to the control. Hydrochar derived carbon was readily incorporated in the microbial biomass of both soils, pyrochar resisted nearly completely. At the end of the experiment, microbial carbon of both biochar treatments was again at the level of the control with the difference that one fifth was hydrochar originated, in the respective treatments of both soils, whereas in the pyrochar treatments the microbial biomass carbon remained from soil origin. The comparison of the soil carbon pools at day 12 and day 205 shows that a stabilization of maize feedstock of more than a double could be achieved by hydrothermal carbonization and far beyond that scale by pyrolysis.

Conclusions This study shows that the mineralization pattern of biochar and a resulting priming effect on soil organic carbon induced by biochar is dependent on the degradability of the biochar itself but also on the soils autochthonous microbial community. In regard of carbon sequestration the HTC technique, which is promising for wet biological wastes, never matches the sequestration potential of pyrolysis.

P 3.4.10

Effect of Biochar Application on Tobacco-planted Soil Biological Characteristic of Flue-cured Tobacco

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Objective

To study the effect of peanut-shell-biochar and tobacco-stalk-biochar application on biological characteristics of tobacco-planted soil.

Methods

The variety tested was Zhongyan 100. The field experiment was carried out in jiaxian of Henan. The experiment has four treatments: CK for no fertilizer, T1 for conventional fertilizer, T2 for peanut-shell-biochar + T1, T3 for tobacco-stalk-biochar + T1. The quantity of biochar is 6000 kg/hm^2.

Results

Biochar application can increase the quantity of soil bacteria and bacteria quantity show a big increase after transplanting 45 d - 75 d. Biochar application can increase the quantity of soil fungi. Tobacco-stalk-biochar application has an obvious effect in former growth stage of tobacco and peanut-shell-biochar application has an obvious effect in later growth stage of tobacco. Tobacco-stalk-biochar application has a tendency to increase the quantity of actinomycetes, but peanut-shell-biochar application has little influence on actinomycetes quantity. Application of peanut-shell-biochar can increase the content of soil microbial biomass carbon (MBC) and tobacco-stalk-biochar application can decrease the content of MBC in later growth stage of tobacco. Tobacco-stalk-biochar application can increase the content of microbial biomass nitrogen (MBN) in soil. Application of biochar can increase the ratio of MBC/MBN in former growth stage of tobacco and decrease the ratio of MBC/MBN in later growth stage of tobacco. Application of biochar can increase soil total carbon and total nitrogen content and peanut-shell-biochar application has a better effect.

Conclusion

Peanut-shell-biochar and tobacco-stalk-biochar application have a better effect on soil improvement in biological characteristics of tobacco-planter soil.

P 3.4.11

Effect of Biochar Types on Tobacco-planted Soil Carbon Pool and Quality of Flue-cured Tobacco Leaves

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Question

Field experiment was carried out to study the effect of biochar types on tobacco-planted soil carbon pool and flue-cured tobacco leaves quality in 2013 at Hanzhong of Shanxi. The variety tested was Yunyan97.

Methods

The experiment had five treatments: CK (no fertilization), T1 (conventional fertilizer), T2 (T1+ wheat-straw-biochar 600 kg/hm^2), T3 (T1 + peanut-shell-biochar 600 kg/hm^2), T4 (T1 + rice-husk-biochar 600 kg/hm^2).

Results and Conclusions

Results showed that: (1) Adding biochar can increase organic carbon mineralization rate, dissolved organic carbon content, easy oxidation active organic carbon content, soil total carbon content and improve soil carbon management index. (2) Adding biochar can decrease total sugar, reducing sugar, K/Cl and reducing sugar to nicotine ratio, but it can increase Nic content, RS/TS. (3) Adding wheat-straw-biochar can improve the sensory evaluation quality of cured-leaves. (4) Adding peanut-shell-biochar can increase easy oxidation active organic carbon and improve soil carbon management index better. Adding peanut-shell-biochar can also increase K^+ content. (5) Adding rice-husk-biochar can significantly increase soil total carbon content and Nic content of cured-leaves, but high-nicotine content decrease the quality of cured-leaves.

P 3.4.12

Limited utilization of pyrogenic organic matter by soil microbes and nematodes reduced soil C and N cycling in tallgrass prairie soils with different fire history

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Litter decomposition is the main process that returns C and nutrients fixed by plants during net primary productivity back to the atmosphere and soil from where they came. Grasslands store an estimated 30% of the total world's soil C, and are often managed by frequent burning. In frequently burned grasslands fire stimulates grass productivity but also removes the aboveground litter layer that would otherwise decompose and contribute to soil organic matter (SOM) formation, while returning more chemically recalcitrant pyrogenic organic matter (Py-OM) to the soil. Soil organisms are responsible for the transformation of plant material into SOM, but may be unable to utilize Py-OM, thus altering the belowground soil food web energy transformations in frequently burned ecosystems. Here we present the results of a one-year 13C and 15N labeled litter and Py-OM decomposition field study at both an annually burned and an infrequently burned tallgrass prairie site. We traced litter and Py-OM into CO_2 fluxes, the soil down to 20 cm, SOM fractions, microbial phospholipid fatty acids (PLFAs) and soil nematodes separated by functional group. We found that litter was decomposed by both microbes and transferred through the soil food web to herbivore, bacterivore, fungivore, omnivore and predator nematodes and respired as CO_2. In contrast, Py-OM was slightly used by microbes and contributed a small amount to CO_2 fluxes, but was too small of a source of C to support higher trophic levels. Fire history also affected the decomposition of litter, with more C measurable in mineral associated SOM fractions, microbial PLFAs and contributing to CO_2 fluxes at the annually burned site compared the infrequently burned site. The effect of fire on removing bio-available litter from the soil formation process causes a limitation in N availability, which would typically be released during decomposition. This is evident from a closed N cycle and a significantly higher loss of litter C to CO2 fluxes in an annually burned site as compared to an infrequently burned site. Annual burning also reduced the abundance of higher trophic level nematodes, thus altering the structure of the soil food web. The results from this study reveal the mechanisms underlying how frequent burning of grasslands affects trophic transfers of C in the soil food web, soil C and N cycling and SOM formation.

P 3.4.13

Effect of manure composting with biochar on resulting organic matter

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Introduction

Co-composting with manure is suggested as a potential application for biochar as the resulting compost has been shown to promote plant growth when compared to fertilizers with the same nutrient content. Moreover, composted biochar showed a higher sorption capacity for nutrients compared to pristine biochar. However, underlying mechanisms are hardly understood and the effect of biochar on compost-derived natural organic matter (NOM) has been rarely investigated.

Objectives

This study evaluated the effect of biochar on the characteristics of dissolved NOM (dNOM) extracted from mature compost. We also investigated the effect of composting on biochar carbon, nitrogen and iron speciation at the sub-micron scale.

Materials & Methods

We conducted an aerobic manure composting experiment with four large-scale windrows comparing three different biochars added at a ratio of 4.4 % w/w and a non-amended control. We used (1) a sewage sludge char (PS, Pyreg©, 600 °C), (2) a mixed wood waste biochar (PW, Pyreg©, 650 °C) and (3) a wood biochar (KW, Kon-Tiki flame curtain kiln, 680 °C). dNOM was extracted from the mature compost with 0.1 M KCl for 72 h and passed through a 0.45 µm filter. We quantified emission-excitation matrices (EEMs) and specific ultraviolet absorption (SUVA) at pH 2, 5, 7, 9 and 11. Carbon content and electron accepting as well as donating capacities (EAC / EDC) were determined through mediated electrochemical analysis described by Aeschbacher *et al.* (2014) and Klüpfel *et al.* (2014).

In addition, PW biochar was picked manually from mature compost. Individual pieces were prepared for scanning transmission electron microscopy with electron energy loss spectroscopy (STEM-EELS). Measurements were performed on a FEI Titan³ at 60 keV at FELMI-ZFE of the TU Graz in Austria (carbon and nitrogen edge) and Joel ARM at Wollongong Univeristy, Australia (iron edge).

Results

The PS biochar reduced the amount of dNOM by 33±2% compared to the control while biochars PW and KW did not alter the amount of dNOM significantly. EAC, EDC, EEMs and SUVA of the dNOM were the same for all composts irrespective of biochar amendment. STEM-EELS revealed the adsorption of a 10 - 100 nm thick layer of nitrogen-rich organic matter onto the biochar during the composting process, while biochar surface oxidation could not be detected with EELS on the carbon edge.

Conclusion

Biochar amendment did not alter the compost quality with respect to electrochemical properties and aromaticity of the dNOM fraction. Adsorption of OM onto the biochar during composting is suggested to be the reason for improved biochar characteristics such as increased cation exchange capacity.

References:

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P 3.4.14

Effects of biochar application and soil temperature on aggregate-associated carbon and microbial parameters of a loess soil

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Question. A potential climate change-related rise in soil temperature might lead to an intensified decomposition of soil organic matter (SOM) and enhanced emission of CO_2. In contrast, the application of biochar to arable soils is considered as a management option to increase the SOM content. SOM can experimentally be subdivided into fractions differing in their importance for the long-term CO_2 storage because of different mean residence times. For example, aggregate-size fractions are characterized by longer residence times of the associated SOM with decreasing aggregate size. To date, the effect of biochar applications on such SOM fractions in dependence of soil temperature is largely unknown. The objective of this study was to clarify the influence of biochar and soil temperature on the amount and composition of experimentally separated aggregate size fractions, basal respiration rates, and the microbial biomass carbon.

Methods. Four field replicates were taken from four different treatments of the Hohenheim Climate Change experiment (loess soil, cultivated with rapeseed) in 0-5 and 5-15 cm soil depth: ambient and elevated (+2.5 °C, for five years before sampling) soil temperature, each with or without application of biochar (30 t ha^{-1}, one year before sampling) derived from Miscanthus. Bulk soil samples were incubated at 20°C for 14 days to determine the basal respiration and the microbial biomass carbon. Aggregate size-fractions were separated by wet-sieving. The resulting data for each soil depth were analyzed with a two-way analysis of variance and subsequent unpaired t-tests for equal variances in case of a significant interaction.

Results. The results show that the application of biochar, independent from the soil temperature and depth, led to a significant ($p < 0.05$) increase in the basal respiration. Microbial biomass carbon was significantly increased by elevated field temperature in 5 - 15 cm, while in 0 - 5 cm significant increases by elevated temperature and biochar application were found. No effects could be observed on the amount of carbon associated with the different aggregate size-fractions. We expect to detect more distinct differences between the aggregate fractions regarding the composition and turnover of the associated SOM by further spectroscopic and isotopic analyses.

P 3.4.15

The impact of organic amendments on carbon sequestration process in degraded soils

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Industrial activities, including metallurgical and mining industry contributes to the degradation of soils and this most often leads to the depletion and loss of organic matter. The carbon sequestration is the process of increasing the carbon binding in the soil. The phytosequestration process of soil carbon can contribute to the decrease of CO_2 in the atmosphere due to the active uptake this gas by plants, storage of carbon in their organisms, then subsequent decomposition of plants and humification of organic matter in the soil.

The aim of the study was to investigate the impact of the application of organic amendments on improving the quality of soils on degraded areas, deprived of humus and vegetation cover. The aim of this study was to improve the soil organic carbon (SOC) sequestration process using selected soil amendments (sewage sludge, composts, coal mules, lacustrine chalk) and energy crop Giant Miscanthus (*Miscanthus giganteus)*.

The pot experiment was carried out under controlled conditions of phytotron chamber. The soils from two different degraded areas (Poland) were used in the experiment: soil from area affected by a zinc smelter (acidic soil) and soil from outer dumping ground of lignite mine (neutral soil). The soils in the area of zinc smelter are acidic or slightly acidic podzolic soils, and are characterized by a high concentration of heavy metals, low pH is poor in biogenic elements and organic substances. Soil from the area of the lignite coal mine, as a result of mining activity the soil does not have a proper soil profile. Such soil has a neutral or high pH and it has low biogenic element and organic matter content. Organic substances were used in the pot experiment in order to supply organic matter and biogenic elements to the soil, limit the mobility of heavy metals and improve its water conditions. To support the phytsequestration process of soils five organic additives were used: the sewage sludge from the food industry, compost from the biodegradable fraction of municipal waste, compost from sewage sludge from household wastewater treatment plant, coal sludge and lacustrine chalk. The experience was carried out in the growth chamber for 12 months. The chemical and physical analysis of soil and used amendments were determined according to standard methods. This paper focuses on analysis of carbon and organic matter, including TOC (total organic carbon) OC (organic carbon) humic acids, in pore water and soil after different treatments.

Studies have indicated that composts and coal mules were characterized by a similar content of organic carbon and total carbon. By contrast, lacustrine chalk and sewage sludge contained much lower content of organic carbon than the total. In the experiment an increase in OC content in combination with composts, coal mules and plants were noted. However, there was a decrease of TOC in the soil after application of sewage sludge on the acidic soil. Whereas for compost used in acid soil a high content of TOC after a year of research was still remained. For the neutral soil this effect was not observed, on the contrary, the used additives resulted in higher total carbon content of soil. TOC analysis in pore water showed decreasing releasing of carbon into the soil solution. Furthermore, the lowest amount of carbon in the mobile form was observed after application of coal mules. Humic acids content after the application of additives was significantly higher compared to the control samples. However, after one year humic acids content decreased slightly in all combinations (also in controls) in the acidified soil. Moreover, in the neutral soil humic acids content increased after one year of the experiment.

Entering the organic additives i.e. compost and sewage sludge is not justified on acidic soils because it does not cause permanent increase in the content of OC in these soils. However such action is justified on neutral soil. The highest concentration of OC in the soil provide composts and coal mules. Lacustrine chalk and coal mules can be successfully used on acidic soils. For neutral soil , the content of exogenous carbon increases with time. In acidic soil the organic matter content just after the application of additives increases, however one year after its content decreases. Additionally, acidic soils are not retaining introduced exogenous humic acids. The addition of compost compared to the sewage sludge results in higher retention of total carbon in the soil.

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P 3.4.16

Potential of biochar co-composting to increase nitrogen use efficiency and improve biochar properties

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Biochar and composts are valuable soil amendments. However, the production and field application of the single components is linked to shortcomings: Biochar supplies little nitrogen (N) and often has a low cation exchange capacity (CEC) in fresh condition. Composting of N rich materials leads to high N losses via ammonia volatilization. The addition of biochar during compost production may overcome the shortcomings of the single components. The aims were to determine (1) total and hot water extractable C (HWC) and N (HWN) dynamics, CEC and surface area of the compost mixtures and biochars during compost production. To that aim, six compost treatments, among them three different biochars and their uncharred feedstocks (rice husks, corn cobs and sawdust), were co-composted with poultry manure (15 vol-%) and rice straw (60 vol-%) in randomly allocated 1m³ compost bins. To study the effects of composting on biochar properties, fresh biochar particles were filled into litter bags and buried at ¾ compost filling height. BET surface areas of all isolated biochars decreased 3-4 fold during composting, most likely due to pore blocking by organic matter and colonization by microorganisms. Biochar composts left the thermophilic phase earlier than composts without biochar. Total C and N loss rates were higher for charcoal and rice husk char composts than for the composts with their uncharred feedstocks. However, corn cob composts had a similar C and a smaller N loss rate than corn cob biochar composts. HWC and HWN decreased over time, except for corn cob composts where HWC and HWN increased and was highest among all treatments. In addition, corn cob composts had the highest proportion of coarse pores which facilitated aeration. HWC is a labile C pool and usually strongly correlates with microbial biomass-C. Hence, high HWC and HWN concentrations in corn cob composts suggest that N immobilization by microorganisms was the underlying mechanism for the low total N losses. These results highlight that feedstock characteristics can outcompete the benefits of biochar additions to composts to reduce N losses.

P 3.4.18

Effects of biochar on copper immobilization in a metal contaminated soil

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Biochar (BC) is a fine-grained and porous material produced by the slow pyrolysis of biomass at low to medium temperatures (300 to 700°C) under oxygen-limited conditions. The BC production from various biomass sources has attracted research interest because BC added to soils leads to agronomic benefits improving physical, chemical and biological properties and also have the ability to remediate soils contaminated with metals; however, to date the BC application to contaminated soil systems has not been systematically investigated. Therefore, the objective of this study was to evaluate the copper immobilizing impact of BC, and their effectiveness in promoting plant growth in copper contaminated soils.

Two biochars were produced from chicken manure (CMB) and oat hull (OHB). A Cu contaminated sandy soil (338 mg kg^{-1}) was incubated with CMB and OHB (0, 1 and 5 % w/w) for two weeks. Metallophyte *Oenothera picensis* was grown in pots (500 mL) containing the incubated soils in a controlled greenhouse for 6 months. A number of analyses were conducted after the harvest. These include plant biomass weight; microbial basal respiration and dehydrogenase activity, Cu fractions in soil phases, and Cu uptake in plant tissues.

Both BCs increased the soil pH of all treatments. The CMB1 and CMB5 increased the soil pH by ~1 order compared to that of control. The increase of soil pH by OHB was slightly higher than CMB.

The BC addition reduced easily exchangeable fraction and increased the organic matter and residual bound fraction of Cu in all treatments. Copper was strongly bound in the control soil because ~50% of its total content was associated with Fe and Mn oxides, organic matter and residual bound fractions. The CMB1 and CMB5 decreased the exchangeable fraction of Cu by 80% and 90%. Similarly, OHB1 and OHB5 also decreased exchangeable fraction of Cu by 68% and 62 %. In contrast, both CMB and OHB increased the organic matter and residual fraction of Cu; but the performance of CMB was better than OHB.

The CMB1 treatment nearly doubled the shoot and root biomass of *O. picensis* compared to that of the control i.e. NS. This effect nearly tripled for the CMB5 treatment. Both OHB treatments increased the shoot and root biomass of *O. picensis* more than 2 times compared to that of the control. Both CMB treatments decreased root Cu concentration to ~60% (significant) and ~40%, respectively, compared to that of the control. The shoot Cu concentration did not change for CMB treatments. In both OMB treatments root Cu concentrations decreased slightly, whereas in OMB1 shoot Cu concentration increased significantly, while in OMB5 shoot Cu concentration decreased significantly Root and shoot Cu concentrations decreased or changed insignificantly in most BC treatments.

The results show that general, CMB was more effective in immobilizing Cu in soils. The BCs reduced the bioavailable Cu of soils by reducing its exchangeable fraction and increasing its organic matter and residual fractions. The effects of BC on Cu availability in soils varied with the type and dose of BC. The microbial activities and DHA increased in all BC treatments. This suggests that biochars may be utilized to remediate Cu contaminated soils.

P 3.4.19

Impact of soil management on bulk surface properties of two biochars under field conditions

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Biochar has received attention mainly due to its ability to improve soil fertility, sequester carbon and its potential to mitigate climate change. A number of laboratory studies have indicated that biochar's surface chemistry change with time, leading to an increase of CEC and O-containing functional groups and a decrease of pH. However, only few studies have been conducted in field condition and the effects of management practices in an intensive urban agricultural setting on surface property changes is largely unknown. Therefore, the present study investigated the changes of surface properties of rice husk (RH) and corn cob (CC) over a 6 and 12 months period in two field trials in northern Ghana and Burkina Faso. Biochars were pyrolyzed at 500 °C with a slow pyrolysis technology. Ten g of biochar was filled in fine polyethylene mesh and buried at 20 cm depth in a randomized block design with three treatments and four replicates each; (1) normal agricultural practice (NAP), (2) soils amended with 20 t/ha biochar and (3) a control. Biochar litterbags were removed after 6 and 12 months. Preliminary results suggest that RH biochar pHs on NAP and biochar treated plots were further reduced with increasing periods of exposure compared to controls. Volatile matter content of the RH biochars was not significantly changed by all treatments. Rice husk biochars on (NAP) plots recorded higher ash contents with 12M than in 6M exposure periods. Fixed carbon content of the RH biochars was largely decreased on NAP plots with 12M exposure period. On the other hand, the pH of CC biochars largely remained unchanged in 6M exposure period, further exposure reduced the pHs especially on biochar and NAP treated plots with the latter treatment showing some significance. Volatile matter contents of the exposed CC biochars did not show any specific trend in all treatments. Corn cob biochars exposed for 12M period on biochar treated plots recorded higher ash contents than 6M exposed CC biochars. The fixed carbon content of CC biochars declined on both biochar and NAP plots in the 12M exposure period.

The study indicates that field management practices tend to facilitate biochar ageing by reducing pH and FC contents whilst increasing the ash content compared to control plots and that both biotic and abiotic processes could be responsible for the observed trends.

The above results emphasize the impact of field management practices on the ageing process and on biochar recalcitrance to decomposition.

P 3.4.20

Removal of hexavalent chromium in aqueous solutions using biochars: An integrated mechanistic approach

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Hexavalent chromium (Cr(VI)) is known to be very toxic to biota. There is wide exploitation of chromium by industries which extensively discharge Cr(VI) to aquatic environments in addition to the weathering of ultramafic rocks rich in chromium. We evaluated Cr(VI) removal from water by biochars produced from soybean (*Glycine max* L.) and burcucumber (*Sicyos angulatus* L.) biomass. The biochars were produced by slow pyrolysis at 300 and 700 °C. The effect of pH on the Cr(VI) sorption was studied by adjusting the pH in the range of 2-10. Adsorption edge experiments were conducted with 2 g L^{-1} biochar, with 0.01 M $NaNO_3$ as the background electrolyte at 25 °C. Batch adsorption studies were carried out in solution with 1-100 mg L^{-1} initial Cr(VI) concentrations at pH ~ 5. Adsorption showed pH dependence, with the highest adsorption at the lowest pH values. Adsorption decreased ~ 10 fold when pH increased from 2 to 10, with maximum adsorption at pH < 4. Synchrotron-based X-ray absorption spectroscopy studies revealed that the biochar has the ability to reduce Cr(VI) to Cr(III). Therefore, both adsorption and reduction of Cr(VI) on the surface of biochar may have occurred. The maximum sorption capacities of each biochar were calculated using various isotherm models. The overall results showed that biochars produced by soybean and burcucumber biomass could be used to remove Cr(VI) from aqueous solutions. This research was supported by the Basic Science Research Program, through the National Research Foundation of Korea (NRF), funded by the Ministry of Education, Science and Technology (Project number: 2015R1A2A2A11001432).

P 3.4.21

Evaluation of soil organic matter chemical characteristics in Terra Preta de Índio by X-ray photoelectron spectroscopy

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Introduction

Soil organic matter (SOM) quantity and quality are important for several physical, chemical and biological properties of soils. SOM can be stabilized by different mechanisms, but the relative contribution of each mechanism is yet unknown (Mikutta et al. 2006). "Terras Pretas de Índio" (TPI) are anthropic soils with high SOM stocks, rich in some nutrients, ceramic artefacts and other evidences of human activity (Kämpf et al. 2004). TPI are also rich in pyrogenic carbon (pyC) (Glaser et al. 2001) which is highly resistant to thermal, chemical and photo-oxidation (Skjemstad et al. 1996) and has been claimed to be responsible for prolonged SOM stability (Glaser et al. 2001) and assurance of sustained soil fertility (Novotny et al. 2007). (Glaser 2003) suggested the partial oxidation of pyC to create charges that can hold cations in TPI soils. Although pyC occurs within microaggregates (Glaser et al. 2000; Lehmann et al. 2008), it is not clear to what extent pyC interacts with mineral matter (Nguyen et al. 2009). Recently, advanced spectroscopic techniques have been used to study SOM properties that are responsible for both recalcitrance and reactivity of TPI (Jorio et al. 2012; Archanjo et al. 2014; Araujo et al. 2014).

Objectives

Therefore the aim of this study was to use X-ray photoelectron spectroscopy (XPS) to evaluate the chemical characteristics of SOM throughout a method applied to isolate a SOM stable fraction.

Material & Methods

Soil samples were collected at 0-20 depth in a TPI site (TPI) and from an adjacent control soil (ADJ) located in Iranduba, Brazil. Isolation of the SOM stable fraction was performed according to Mikutta et al. (2006). Untreated soil samples (SOIL) and two operationally defined fractions were analyzed in this study: (i) oxidized soil samples (OX) and (ii) oxidized and hydrofluoric acid (HF)-treated soil samples (OX HF). XPS (Omicron Nanotechnology) was used to study the chemical composition and chemical state of the samples. XPS analyses were performed under ultra-high vacuum (10^{-10} mbar) using a Magnesium (Mg) X-ray source, K_α=1,253.6 eV powered by an emission current of 16 mA and a voltage of 12.5 kV. High-resolution spectra were obtained for carbon (C 1s) using analyzer pass energy of 30 eV and 0.05 eV step. The binding energies were referenced to the C 1s level at 284.6 eV. Gaussian/Lorentzian (70/30) line shapes were used to fit the other C 1s peak components after Shirley background subtraction (Araujo et al. 2014).

Results

Soil samples usually contain a variety of elements which can be seen in the survey spectra of each sample (Fig. 1). Sodium (Na) peak in OX samples can be attributed to use of Sodium Hypoclorite (NaOCl) as the oxidant. Aluminum (Al) and Iron (Fe) peaks were no longer detectable for OX HF samples due to the dissolution of soil minerals such as kaolinite ($SiAl_2O_5(OH)_4$) and consequent release of associated hematite (Fe_2O_3) after HF treatment. In the other hand, Quartz (SiO_2) resisted to the HF treatment and therefore Silicon (Si) peak is proportionally increasing from SOIL to OX HF samples. Titanium (Ti) peak are observed for OX HF samples, probably as rutile/anatase (TiO_2) forms.

Fig. 1 XPS survey spectra for untreated TPI (a) and ADJ soil samples (b); oxidized TPI (c) and ADJ soil samples (d); and oxidized and HF-treated TPI (e) and ADJ soil samples (f).

C 1s spectrum (Fig. 2) contain the following functional groups: sp^2-hybridized C (C=C, 284.6 eV), sp^3-hybridized C (C-C/C-H, 285.5 eV), hydroxyl (C-OH, 285.8-286.0 eV), epoxy/ether (C-O-C, 286.4 eV), carbonyl (C=O, 287.0-288.0 eV), carboxyl (HO-C=O, 288.5-289.5 eV), and a shake-up satellite peak ($\pi \rightarrow \pi^*$, 291.4 eV) characteristic of electrons delocalized over aromatic C structures. For C 1s spectra from SOIL to OX HF samples, a decrease in oxidized groups (C-OH, C-O-C and C=O) attributed to the degradation of labile components (e.g. cellulose) can be seen. At the same time, an increase in the shake-up peak ($\pi \rightarrow \pi^*$) attributed to aromatic structures (e.g. pyC) is also observed. Although untreated TPI soil presented higher C content (44,63 g kg^{-1}) than the untreated ADJ soil (26,37 g kg^{-1}), after the method, both samples presented similar C content (18,33 g kg^{-1} for TPI and 15,84 g kg^{-1} for ADJ). In this sense, it seems like the higher SOM content in TPI were mainly labile compounds that were easily oxidized by the method. Therefore other mechanisms of SOM stabilization may be considered in TPI besides the presence of highly stable compounds, such as pyC.

Fig. 2 XPS C 1s spectra for untreated TPI (a) and ADJ soil samples (b); oxidized TPI (c) and ADJ soil samples (d); and oxidized and HF-treated TPI (e) and ADJ soil samples (f).

Conclusion

We concluded that in the soil surface, the chemical characteristics of the isolated stable fraction did not differ greatly from a typical TPI and an ADJ soil. Therefore other studies including soil samples from deeper horizons could improve our knowledge about the mechanisms that explain high SOM stocks in TPI rather than inherent recalcitrance of pyC itself.

Figure 1

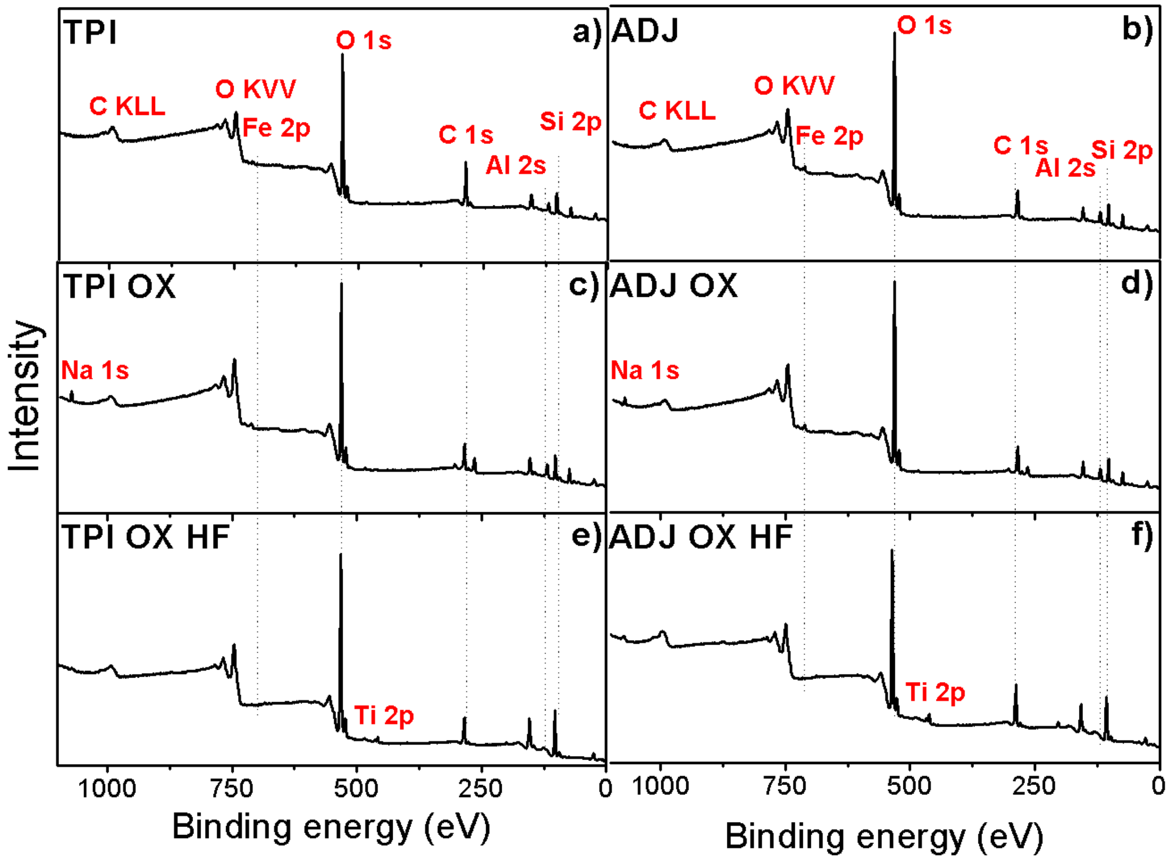
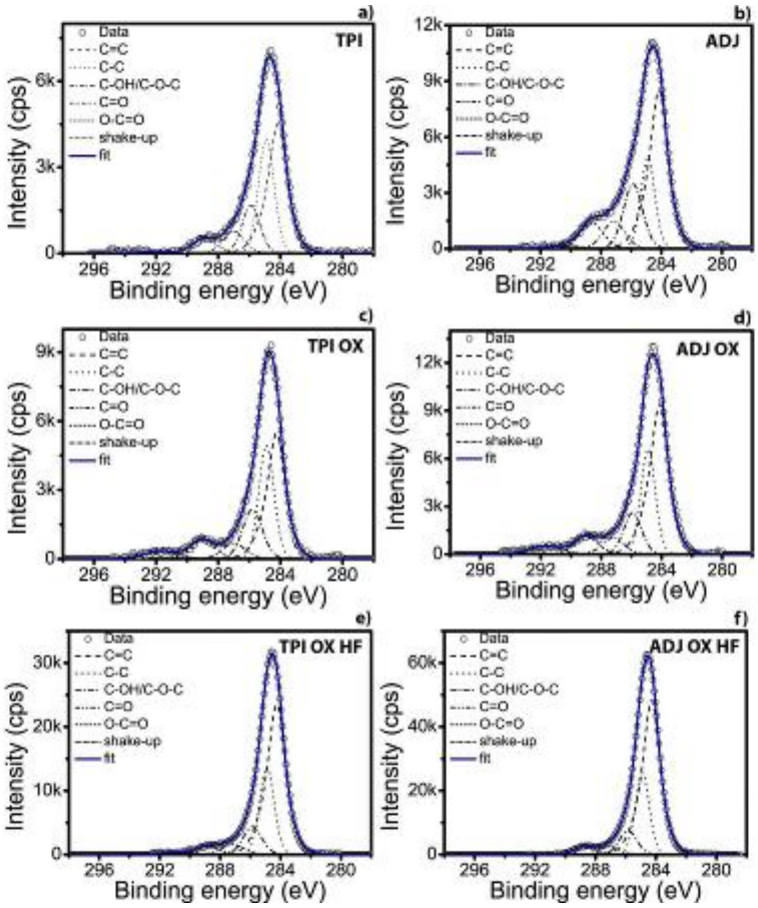


Figure 2


a)
TPI
Data
C=C
C-C
C-OH/C-O-C
C=O
O-C=O
shake-up
fit
Intensity (cps)
Binding energy (eV)
b)
ADJ
c)
TPI OX
d)
ADJ OX
e)
TPI OX HF
f)
ADJ OX HF

P 3.4.22

Biochar application to an Ultisol from Southern Chile improved arbuscular mycorrhizal fungi performance and soil quality parameters

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[3]*CSIC-Centro de Edafología y Biología Aplicada del Segura, Grupo de Sostenibilidad de Sistemas Suelo-Planta, Murcia, Spain*
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Biochar (BC) production from agro-forestry wastes and mycorrhizal symbiosis are potentially of interest in order to improve soil properties as well as maintain soil quality and increase crop performance. However, few studies have considered the effect of biochar on arbuscular mycorrhizal fungi (AMF) and soil properties in volcanic soils. Therefore, a field experiment was conducted with the objective to evaluate the effects of two biochars on AMF propagules, glomalin related soil protein (GRSP) and some physical, chemical and microbiological soil properties in an Ultisol of Southern Chile.

Biochars from oat hull (OBC) and pine bark (PBC) were produced at 300°C and characterized. Doses of 0, 10 and 20 Mg ha^{-1} of BCs were incorporated into soil in a field experiment using wheat as AM fungi host plant. A number of analyses were conducted after wheat harvest, these included AMF spore and mycelium density, glomalin (GRSP) content, water-soluble and total carbohydrates (CH), microbial biomass C and N, Fluorescein diacetate hydrolysis (FDA); pH, electrical conductivity (EC), bulk density, porosity, mean weight diameter (MWD), water holding capacity (WHC) and water stable aggregates (WSA).

The physico-chemical analysis for biochars showed that OBC had higher nutrients content (mainly N, P and K) and more suitable values in the physical parameters (BET, pore volume and pore size) compared with PBC. The AM spore density significantly increased by 44% and 30% with the use of higher doses of OBC and PBC respectively. In the same way, the higher BCs addition increased the AM mycelium density by 48% (OBC) and 28% (PBC) compared to non-amended soil. The same trend was observed with the GRSP content, where this glycoprotein responded to higher BCs doses, increasing its contents by 23.5% with OBC and 33.8% with PBC inrelation to control treatment.

The addition of BCs also increased the water-soluble CH and total CH content as well as biomass C and N and FDA hydrolysis activity when the highest doses of both biochar were applied to the soil.

Improvements in the soil pH, EC, WHC, MWD and WSA were also observed with the application of both OBC and PBC compared with the control treatment, the biochar derived from oat hulls yielding a better effect on these soil properties than pine bark biochar. No significant differences were observed in bulk density and soil porosity. However, a trend to enhance these parematers was observed with the application of higher BCs doses.

These results pointed out that the use of biochar in this volcanic soil can act as an effective amendment in order to stimulate AM fungi activity and to increase GRSP contents; as well as improve other soil quality indicators. Additionally, it can be used as a complementary fertilizer in soils which exhibit low fertility levels or are subjected to degradation processes that limit the sustainability of the agroecosystems.

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P 3.4.23

Effects on humusCarbon contents after applied with biochar

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Biochar(Bc) is the term used to describe a series of high aromatic insoluble solid which is produced by plants biomass through pyrolysis carbonization under complete or partial hypoxia condition. Bc plays an important role in soil carbon sequestration, whereas, nowadays, there are rarely studies on the relationship between Bc and humus carbon, especially the relationship with humic acid(HA), fulvic acid(FA) and humin(Hu).This paper has studied the effect of humus quantity and composition that applied the Bc to field through field trials, embedded trials and culture experiment. Field trials used Nanjing paddy soil. Embedded trials and culture trials used dark brown soil of Heihe. They all applied with $48t\cdot ha^{-1}$Bc, and set the control check. Soil organic carbon was measured by potassium dichromate heating method. Humus quantity and composition was measured by humus composition modification method. The research showed that after Bc was applied into the field trials, the organic carbon content increased from19.46 $g\cdot kg^{-1}$ to 38.50 $g\cdot kg^{-1}$,FA content decreased from 2.73 $g\cdot kg^{-1}$ to 2.49 $g\cdot kg^{-1}$, HA content decreased from 2.74 $g\cdot kg^{-1}$ to 2.51 $g\cdot kg^{-1}$ and Hu increased from 13.92 $g\cdot kg^{-1}$to 33.48 $g\cdot kg^{-1}$.The embedded trials which has been progressed for 6 months, after Bc was applied, the organic carbon content increased from24.80 $g\cdot kg^{-1}$ to 41.28 $g\cdot kg^{-1}$,FA content decreased from 3.55 $g\cdot kg^{-1}$ to 3.29 $g\cdot kg^{-1}$,HA content decreased from 5.66 $g\cdot kg^{-1}$ to 5.62 $g\cdot kg^{-1}$ and Hu increased from 8.55 $g\cdot kg^{-1}$to 23.05 $g\cdot kg^{-1}$.The embedded trials which has been progressed for 12 months, after Bc was applied, organic carbon content increased from23.99 $g\cdot kg^{-1}$ to 40.78 $g\cdot kg^{-1}$,FA content decreased from 3.74 $g\cdot kg^{-1}$ to 2.80 $g\cdot kg^{-1}$,HA content decreased from 5.63 $g\cdot kg^{-1}$ to 4.44 $g\cdot kg^{-1}$ and Hu increased from 7.53 $g\cdot kg^{-1}$to 22.40 $g\cdot kg^{-1}$.After Bc was applied into the culture trials(6 months),organic carbon content increased from21.57 $g\cdot kg^{-1}$ to 32.21 $g\cdot kg^{-1}$,FA content decreased from 3.45 $g\cdot kg^{-1}$ to 3.35 $g\cdot kg^{-1}$,HA content decreased from 5.15 $g\cdot kg^{-1}$ to 4.99 $g\cdot kg^{-1}$and Hu increased from 7.96 $g\cdot kg^{-1}$to 17.24 $g\cdot kg^{-1}$.After Bc applied into the culture trials(12 months),organic carbon content increased from21.25 $g\cdot kg^{-1}$ to 32.19 $g\cdot kg^{-1}$,FA content decreased from 3.25 $g\cdot kg^{-1}$ to 2.87 $g\cdot kg^{-1}$,HA content decreased from 5.24 $g\cdot kg^{-1}$ to 4.26 $g\cdot kg^{-1}$ and Hu increased from 9.97 $g\cdot kg^{-1}$to 19.76 $g\cdot kg^{-1}$. The conclusion was that soil organic carbon content increased, Hu content increased, the soil HA and FA content decreased. PQ had minimal changes in field trials. It increased slightly in embedded trials and also increased with time in culture trials. This is due to Bc adsorbing the HA and FA which were contained in the soil,itspromotion of HA and FA decomposition or the Bc's effect on soils HA and FA were in different levels. Those experiments has proved that after Bc was applied into the soil, Hu content increased and the absorption of HA and FA can increase soil carbon storage. Applied Bc into the soil also has important implications for long-term preservation of soil organic carbon.soil organic carbon.

Key words: biochar; humin; humic acid; soil organic carbon

P 3.4.24

Short-term response of soil respiration and microbial communities after addition of chars - effect of nitrogen and readily available carbon

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Questions

Two chars in soil mixtures and their effects on soil respiration have been studied in 10-day incubation experiments. The focus was on the impact of fermentation post-processing and of readily available nitrogen and carbon sources on the CO_2 release and on its dynamics.

Methods

We used a pyrolysis char and a HTC char derived from maize silage, both raw and fermented. Calcium ammonium nitrate was used as nitrogen source and glucose as additional carbon source. Soil respiration was assessed using a multi-channel infra-red gas analysis system. An ecotyping analysis was performed to inspect the evolution of the population of fungi, *Acidobacteria*, *Actinobacteria*, *α*- and *β-Proteobacteria*.

Results

All treatments with char decreased soil respiration compared to unmodified maize straw. Respiration in soil-HTC char mixtures was higher than in soil-pyrolysis char mixtures, but the fermentation was effective in reducing the CO_2 release. HTC char showed a two-step decay kinetics, which could not be explained with a simple double-pool model. Nitrogen addition did not increase overall CO_2 release in soil-char mixtures, but effects were evident in the respiration dynamics.

Respiration in soil-char-glucose mixtures was higher compared to soil-straw or soil-char mixtures without glucose amendment, but lower compared to the soil-glucose mixture. Thus, an inhibition effect of char upon glucose metabolisation was evident, which was higher for HTC than for pyrolysis char. Ecotyping analysis reported an increase in *Actinobacteria* (+4.6%) and a concurrent decrease in fungi (-4.6%) and *Acidobacteria* (-3.9%) after the addition of glucose. Glucose and pyrolysis char in combination reacted like the glucose only variant except for fungi, which reacted neutral to the combination but negative to either single addition. HTC+glucose showed a clear combination effect which was most pronounced for fungi, where the HTC specific reaction was tripled.

Conclusions

The short-term incubation approach allowed highlighting differences in degradation dynamics between the considered soil-substrates mixtures, and confirmed the effectiveness of the charring process to increase the stability of organic substrates in soil. Ecotyping allowed revealing a major role of *Actinobacteria* in soil respiration and of fungi in the degradation of HTC char.

IT 3.5

Soil organic matter as molecular proxy for past environmental change: opportunities and challenges

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The last decades have seen a dramatic increase in the use of organic matter from soils and sediments as molecular proxy for reconstructing past dynamics of vegetation and climate. Applications range from the use of changes in preserved leaf wax lipid patterns or $\delta^{13}C$ signatures of organic matter to reconstruct shifts in vegetation composition, to the use of changes in d^2H patterns as a past humidity / precipitation proxy. Particularly exciting in this respect are recent developments with respect to combining various molecular proxies. For instance by compound specific $\delta^{13}C$ and δ^2H analysis of selected lipids that themselves are used as vegetation proxy. However, as with all scientific development, all that glitters is not gold. Together with great promise, successful application of molecular proxies to reconstruct past environmental change also comes with several important challenges. For instance, to what extent are plant lipid patterns used for vegetation reconstruction affected by genotypic plasticity of the producing plant species? How might the heterogeneity of environmental and biochemical processes on/in different plant species interfere with the successful use of δ^2H and $\delta^{13}C$ patterns? What is the influence of differences in input routes into a soil or sedimentary archive, e.g. aboveground vs. belowground, on the desired reconstruction? In this presentation I will discuss both the opportunities and the challenges of the use of organic matter as molecular proxy in environmental reconstructions, using several recent examples of research from mine and other groups.

O 3.5.01

GDGT signals in a river catchment as tracer of soil organic carbon export to sedimentary archives

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The transfer of soil organic carbon (SOC) from land to sea by rivers moves significant amounts of terrestrial carbon to deposits in lakes, floodplains and oceans, and plays a key role in the global carbon cycle, as SOC forms a long-term sink of atmospheric CO_2 upon fluvial deposition and burial in marine sediments. However, pathways and duration of transport are largely unknown, mainly due to the lack of suitable tracers for SOC. A novel way to trace SOC in a river system is using the abundance of specific soil bacterial membrane lipids: branched glycerol dialkyl glycerol tetraethers (brGDGTs).The input of soil material into marine systems is quantified by the BIT index (Hopmans et al., 2004), using the relative abundance of brGDGTs to that of crenarchaeol, an isoprenoidal GDGT (isoGDGT) primarily produced by marine archaea. Furthermore, the relative distribution of brGDGTs has been shown to relate to soil pH and mean air temperature (MAT), so that past climatic changes can be reconstructed based on down-core changes in GDGT distributions in river-dominated sediments (Schouten et al., 2013).

Question

So far, SOC transport from land to sea has been interpreted as a passive channel, both in carbon cycle as in paleoclimate studies. However, the effects of erosion and transport by rivers on GDGT signals are largely unknown, although recent studies on the lower Amazon indicated that seasonal and inter-annual variability in the abundance and distribution of GDGTs in river suspended matter, as well as production in the river water, may alter the soil-GDGT signal transported to the delta (e.g. Kim et al., 2012; Zell et al., 2013). Hence, to accurately interpret sedimentary GDGT archives, it is important to understand the effects of upstream dynamics and of (seasonal) hydrological variations on the GDGT signals carried by a river.

Methods

In this study, we analysed the abundance and distribution of GDGTs in POM from the tropical river Madre de Dios and its tributaries (Peru) during the wet and the dry season, as well as in mineral and organic soils from the catchment, to fully trace the fate of soil-GDGT signals during transport. The Madre de Dios drains a 4.5 km elevation gradient on the eastern flank of the Andes into the Amazonian floodplains, where it enters the Amazon [Fig. 1] (Ponton et al., 2014).

Results

BrGDGTs in soils reflect the drop in temperature with elevation (4.0°C/km, R^2=0.76), although reconstructed MAT slightly overestimates measured MAT [Fig. 2]. Also POM-associated GDGTs, particularly in the wet season, shows a similar strong altitudinal trend with a MBT/CBT-derived temperature lapse rate of 3.0°C/km (R^2=0.65). Interestingly, at the transition from the high Andes to the lowlands, reconstructed MATs from river POM are lower than for nearby soils, indicating an imprint by high altitude derived material carrying a colder temperature signal, which persists during the hydrological year. These results suggest that POM carried by the river is mostly of soil origin, also indicated by the high BIT index in soils (0.98 ± 0.02 STD) and POM (0.94 ± 0.02). Subtle distributional differences between brGDGTs in soils, wet-, and dry-season POM, suggest a minor contribution of aquatic produced brGDGTs in the dry season. Nevertheless, POM generally has very homogeneous GDGT distributions throughout the drainage basin, and is not impacted by joining tributaries. Finally, water column profiles indicate no preferential transport of brGDGTs, as the profiles showed no substantial changes with depth (± 0.4 °C, ± 0.1 pH).

Conclusion

GDGTs carried by this river represent an integrated signal of the upstream catchment, and thus support brGDGTs as tracer for SOC transport and their ability to transmit climate signals to a sedimentary archive. However, the Madre de Dios catchment (27830 km^2) constrains a small (upper) part of the large Amazon basin (4618750 km^2). Hence, differential climate dynamics downstream may explain the previously observed variability in GDGT signals in the delta.

This study underlines that insights in the integration of GDGT signals carried by a river are key to trace SOC transport and for accurate interpretation of paleoclimate archives using GDGTs as proxy.

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Fig. 1. Map of Madre de Dios catchment, tributary of the Amazon (inset) (Ponton et al., 2014).

Fig. 2 Correlation between (MBT/CBT-derived) MAT and elevation for soils and POM in the dry and wet season.

Figure 1

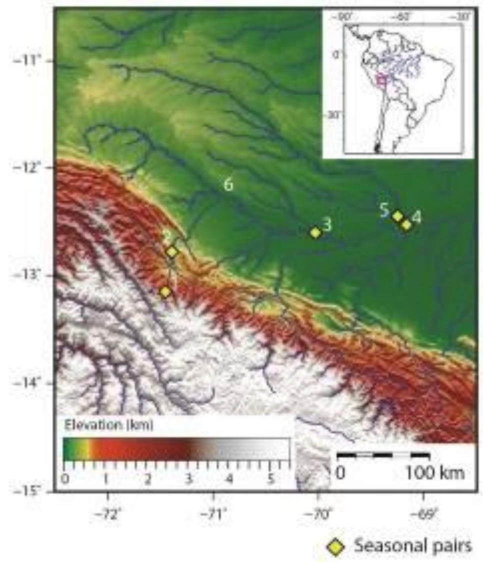
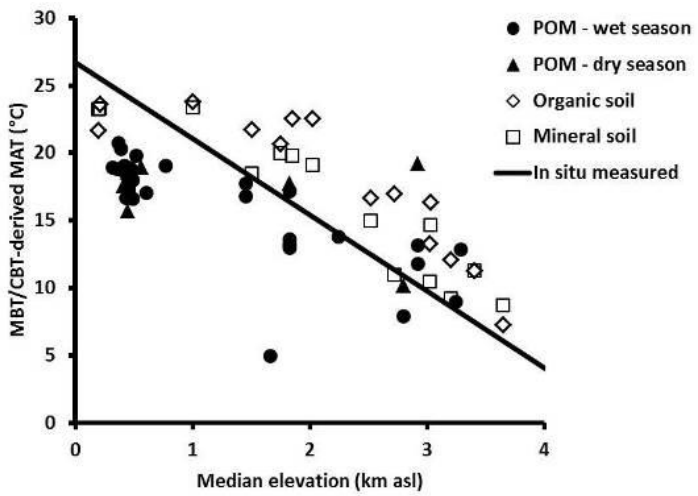


Figure 2



O 3.5.02

$d^{13}C$ and ^{14}C-mean residence time of soil organic matter as a tool for modeling the chronology of forest-savanna changes in Central Africa

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Introduction

Soil organic components are very usefull to reconstruct palaeoenvironmental changes. However, in biologically active soils, ^{14}C dating doesn't give the absolute age of organic matter (SOM), but only its mean residence time (MRT). As a consequence, using only soil archives leads to great difficulties in dating palaeoecosystemic changes.

Objectives

To overcome this limit, we present here two methods allowing dating ecosystem changes such as forest replacement by savanna, based on ^{13}C-^{14}C measurements on SOM.

Materials & Methods

(i) The first method modelizes the changes of the $^{13}C/^{12}C$ ratio of the SOM from the topsoil up to 2m depth. The equation (equ. 1) of the model is:

z = the depth of the sample

t = the age of the forest-savanna change

T = MRT of SOM at the depth z

a = the ratio of substitution of forest SOM by savanna SOM

$d^{13}C_{fz}$ and $d^{13}C_{sz}$ $^{13}C_{sz}$ are the values of $^{13}C/^{12}C$ ratio at the depth z in theoretically stable forest (f) and savanna (s) soil profiles.

The result of the modeling is then compared to real savanna soil profiles from Central Africa (Congo and Gabon), which were sampled in areas where palynological data give the age of savanna-forest change.

(ii) The second one is a graphical method, that plots the $d^{13}C$ vs. the ^{14}C MRT of soil profile. It allows to compare the relative age of forest-savanna changes as registered in different soils.

Results

Fig. 1 gives an example of application of the model approach (i). ELF 1 is the $d^{13}C$ profile of a 3000 years old savanna according to pollen record. The t2000 and t4000 curves are the result of the modeling for t = 2000 and t = 4000 years. A, B and C respectively correspond to a = 1, a = 0.2 and a varying from 1 to 0.2.

Fig. 1. Comparison between 2 modelized and one measured (ELF1) $d^{13}C$ soil profiles

We also tested more complex scenario like forest-savanna-forest changes. The model also gives a good approximation of the age of the real changes.

The comparison of different ages of forest to savanna changes in well-known areas shows that the graphical method (ii) is also suitable (not presented in this abstract).

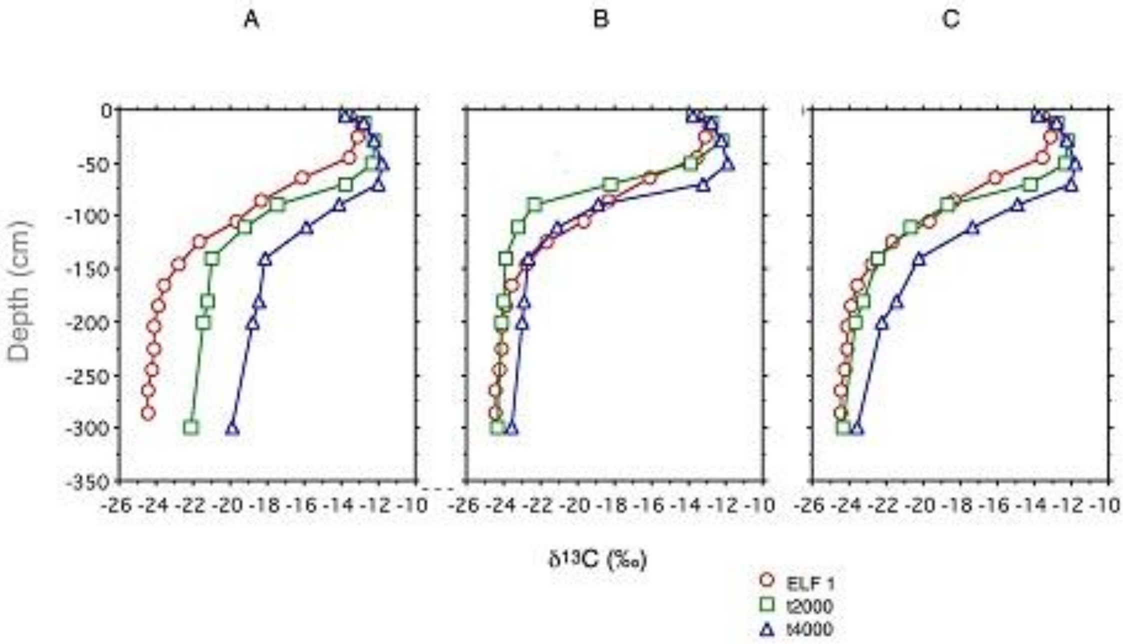
Conclusion

Coupling $^{13}C/^{12}C$ ratios and ^{14}C MRT of SOM allows estimating the good order of magnitude for dating savanna/forest changes. It will be very useful, especially in areas were classical palaeoenvironmental data such as pollen records are only scarce.

Figure 1

$$\delta^{13}C_{mzt} = \frac{\left(\delta^{13}C_{fz} - \alpha.\delta^{13}C_{sz}\right).e^{-\frac{t}{T}} + \alpha.\delta^{13}C_{sz}}{\left(1-\alpha\right).e^{-\frac{t}{T}} + \alpha}$$

Figure 2



O 3.5.03

Compound-specific radiocarbon analysis of organic matter in Arctic soils

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1. Introduction

Radiocarbon dating of soil organic matter (SOM) can give valuable information on organic carbon dynamics in soils. Since several decades various methods have been used to separate SOM into fractions, which are supposed to be composed of organic components turning over on different time scales. In recent years much effort has been put in the use of radiocarbon data of such SOM fractions for testing and parameterization of soil carbon turnover models instead of using the apparent radiocarbon age of bulk SOM (e.g. Sierra et al 2012). However, the results of such studies revealed difficulties because of the still very heterogeneous composition of physically and chemically defined fractions (e.g. Schrumpf & Kaiser 2015). Understanding SOM composition and turnover becomes even more complicated when subsoil horizons and associated vertical radiocarbon gradients are considered. The vertical transformation processes of SOM differ considerably from processes known for surface soils and the current understanding is still very limited (Rumpel et al. 2012). We thus evaluate the application of compound-specific radiocarbon analysis (CSRA) of lipid biomarkers derived from plants and from soil bacteria for tracing SOM dynamics.

2. Objectives

In this presentation we compare CSRA data of plant- and soil bacteria-derived lipids with radiocarbon concentrations of bulk SOM, dissolved organic matter, and size and density fractions to evaluate their usefulness for identifying sources and the turnover of SOM. Results of case studies performed in the high Arctic (Svalbard and Siberia) will be presented.

3. Materials & methods

Samples were obtained from the annually thawing 'active layer' of permafrost soils on Svalbard and in eastern Siberia. Lipids were extracted from selected soil horizons with organic solvents and separated into compound classes. *n*-Alkanes, *n*-carboxylic acids, and phospholipid fatty acids were quantified and isolated using analytical and preparative gas chromatography, respectively. SOM fractions were separated using a combined density and particle size fractionation. Radiocarbon contents were measured of graphite targets (bulk and SOM fraction) and as CO_2 (isolated compounds).

4. Results and conclusions

The usefulness of CSRA could be shown for the permafrost soil near Ny-Ålesund on Svalbard. Here, Tertiary coal is erodes by a nearby glacier and incorporated into SOM resulting in relatively low radiocarbon contents of 0.5 fMC (5,800 yrs BP) decreasing to 0.04 fMC (26,000 yrs BP) in 60-85 cm soil depth. The contribution of coal cannot be excluded from SOM by any chemical or physical separation method (e.g. Rethemeyer et al., 2005) and would result in a significant underestimation of carbon cycling. CSRA concentrations of plant-derived long-chain *n*-carboxylic acids (C26:0, C28:0) are not affected by the coal and range between close to atmospheric values (1.01 fMC) in the organic surface horizon and 0.4 fMC (8,050 yrs BP) in 60-85 cm. The CSRA results suggest a relatively low turnover of plant material particularly near the permafrost table.

Carbon dynamics seem to be faster in the Siberian permafrost soils. Here bulk SOM ranges from 0.9 to 0.7 fMC (870 to 3050 yrs BP) in mineral near surface horizons and near the permafrost table, respectively and are similar to the CSRA results of plant-derived *n*-alkanes (C27:0) and *n*-carboxylic acids (C24:0, C26:0, C28:0). When comparing these results with radiocarbon contents of density fractionations no significant stabilization in aggregates (represented by occluded particulate organic matter) is obvious in these soils. However, compositional changes of free and occluded particulate organic matter with soil depth were identified by lipid distributional and NMR analysis of these fractions confirming their heterogeneous (spatial) composition.

CSRA of phospholipid fatty acids (PLFAs) derived from soil bacteria, which are significantly higher than those of bulk and plant-derived organic compounds, indicate a preferential degradation of relatively fresh SOM. The difference in radiocarbon content between the plant and microbial biomarker is larger near the permafrost table suggesting a younger SOM source is present at greater soil depth potentially dissolved SOM which is leached downward.

Our results confirm the heterogeneity of SOM fractions and reveal that other sources than plant-derived SOM are present at greater depth in the permafrost soils investigated thus emphasizing the potential of CSRA for identifying SOM sources.

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O 3.5.04

Nitrogen availability correlates with $\delta^{13}C$ of microbial biomass across a boreal forest climate transect

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Introduction
Temperature and nitrogen (N) availability can influence microbial activity and substrate use patterns, suggesting that the chemical composition of soil organic matter (SOM) may vary with climate through impacts on microbial activity. Linking microbial processes to SOM chemistry, however, remains difficult because microbial activities fluctuate over short timescales while differences in SOM chemistry are acquired over prolonged timescales (years to centuries). The $\delta^{13}C$ of biomarkers for living microbial biomass, like phospholipid fatty acids (PLFA), can provide a time integrated indicator for microbial substrate use, in particular in cold ecosystems, where microbial biomass turnover is slow (weeks to months). Decreases in lignin decomposition after N fertilization, for example, were found to correlate with elevated $\delta^{13}C_{PLFA}$, however, it remains unclear how $\delta^{13}C_{PLFA}$ varies in natural gradients of temperature and N content, as found in latitudinal transects and expected in future warming scenarios.

Objectives
We aimed to explore patterns in soil $\delta^{13}C_{PLFA}$ with depth and climate in order to provide potential insight into how microbial substrate use may vary. We hypothesized two counteracting effects. Higher temperatures can result in preferentially increased decomposition of high activation energy substrate like lignin; this can promote more negative $\delta^{13}C_{PLFA}$ values due to lignin's general enrichment in ^{13}C. Greater N availability in warmer regions, however, may decrease lignin decomposition, promoting less negative $\delta^{13}C_{PLFA}$ values. Therefore any detectable variation in $\delta^{13}C_{PLFA}$ may signify the relative importance of temperature or nitrogen availability on substrate use in soils.

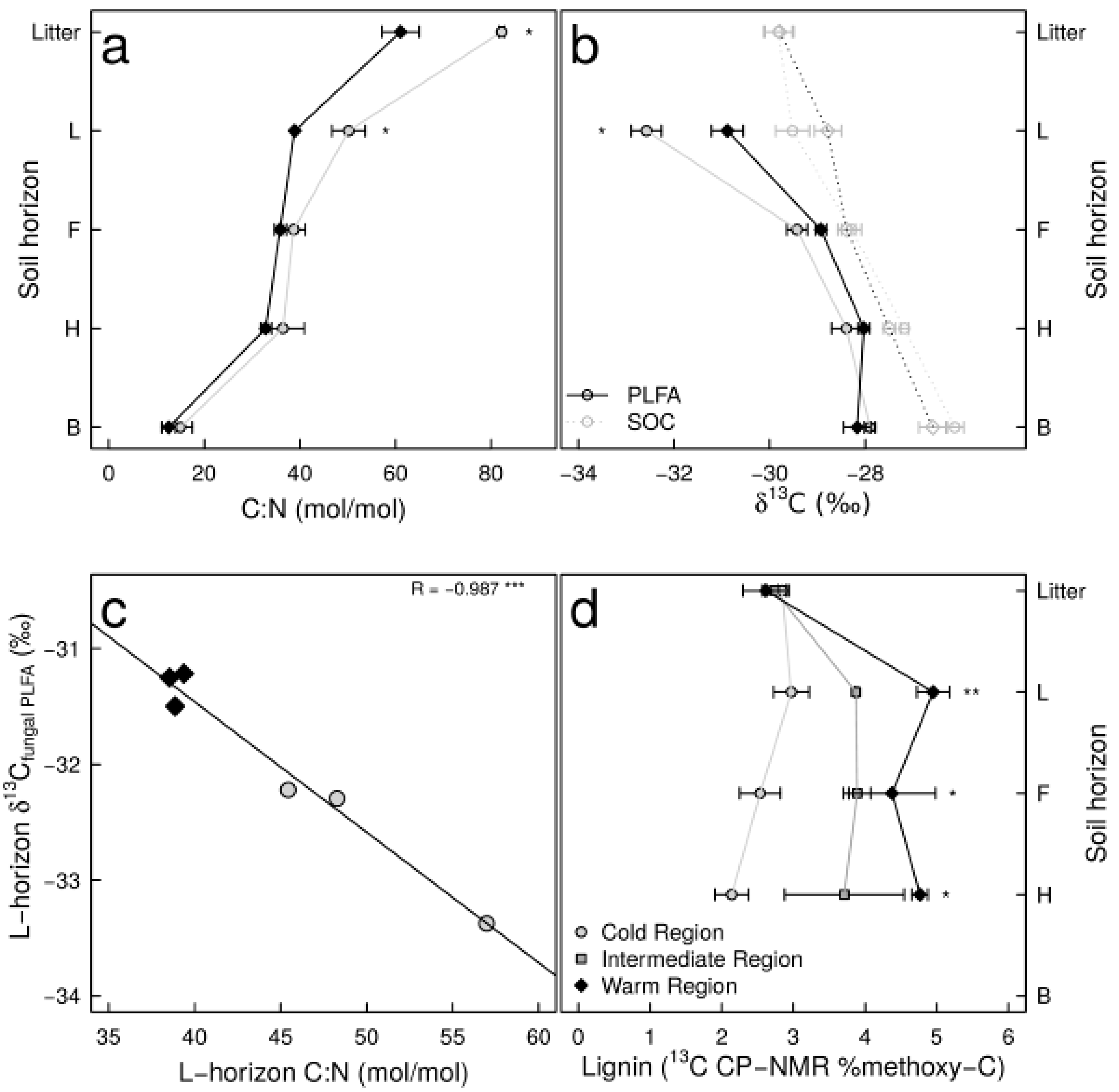
Material and Methods
Samples were collected at nine sites in three regions of a latitudinal transect in Atlantic Canada (Newfoundland and Labrador Boreal Ecosystem Latitudinal Transect; NL-BELT), covering 5° latitude and 5°C mean annual temperature. Sites were selected for similar vegetation, stand age and soil type within similar moisture regimes. Samples were collected from of the organic (L, F, H) and mineral (B; 0-10 cm) soil horizons as well as from fresh litter inputs to soils (litter traps). Samples were analyzed for their chemical composition (elemental analysis, ^{13}C CP-NMR, pyrolysis-GC/MS) and for composition and $\delta^{13}C_{PLFA}$.

Results
Soil C:N was lower in the warmer region due to a higher N content, in particular in fresh litter and L-horizons (Fig 1a). Bulk $\delta^{13}C$ values of litter inputs and SOM increased with depth, but did not differ by region (Fig 1b). PLFA were enriched in ^{13}C by 1.7 ‰ in the warmest relative to the coldest region (Fig. 1b) in L-horizons, suggesting potential differences in substrate use among climate regions. The $\delta^{13}C$ of PLFA produced by fungi (18:2ω6 and 18:3ω3), which dominated L-horizon microbial communities, exhibited a strong negative correlation with the soil C:N ratio, (Fig. 1c) suggesting that fungal incorporation of ^{13}C-enriched substrates due to elevated N concentrations in the warmer region.
Lignin contents, measured as the %methoxy-C in NMR spectra and the ratio between carbohydrate and lignin derived pyrolysis products, were similar across all regions in litter, but ~50% higher in the warmest region compared to the coldest region in L-horizon SOM (Fig. 1d). Enhanced lignin accumulation during fresh litter transformations to L-horizon SOM in the southern region relative to the northern region is consistent with an inhibition of lignin decomposition due to elevated N concentrations and the associated lower $\delta^{13}C_{PLFA}$ at lower latitude.
The regional differences in $\delta^{13}C_{PLFA}$ decreased with depth to less than 0.5 ‰ in F, H, and B horizons (Fig.1b). If differences in microbial lignin incorporation are dominant drivers of $\delta^{13}C_{PLFA}$ in these soils, these regional differences were limited to the interface between litterfall and the most shallow soil horizon. This is consistent with constant lignin contents throughout organic layer (L,F,H) in both regions (Fig. 1d), i.e., no difference among regions in lignin accumulation from L to F and H horizons.

Conclusions
Our results suggest inhibition of lignin decomposition of inputs due to higher N availability in the warmer region likely overrides any possible stimulation of lignin degradation by warmer temperatures in these boreal forests.

Figure 1: C:N ratios of litter (Litter) and L, F, H, and B horizons SOM (a), bulk $\delta^{13}C_{SOC}$, and weighted mean $\delta^{13}C_{PLFA}$ values (b) in two regions of a boreal latitudinal transect; relation between the $\delta^{13}C$ of fungal PLFA (18:2ω6) and C:N ratios in the L horizon (c), and lignin contents, measured as %methoxy-C in ^{13}C CP-NMR (d).

Figure 1


a
b
c
d
Litter
L
F
H
B
Soil horizon
C:N (mol/mol)
δ13C (‰)
PLFA
SOC
R = −0.987 ***
L−horizon δ13C fungal PLFA (‰)
L−horizon C:N (mol/mol)
Cold Region
Intermediate Region
Warm Region
Lignin (13C CP−NMR %methoxy−C)

O 3.5.05

A molecular sieve cartridge (MSC) to collect soil CO_2 for radiocarbon dating - first tests and applications

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One of the largest annual fluxes in the global C cycle is the exchange of terrestrial C with the atmosphere by photosynthesis and respiration, which is faster affected by the present climate change than the oceanic-atmospheric C flux. Consequently, the release of CO_2 by soil respiration and its response to global warming needs to be investigated in more detail, as it is still poorly understood. The radiocarbon analysis of soil-derived CO_2 can give valuable information about the source and turnover rate of the organic C, which is microbially respired. However, collecting the CO_2 for radiocarbon analysis is challenging. A promising approach is the trapping of the soil CO_2 on a molecular sieve, which has the advantage over other approaches (like sampling in glass flasks) that low CO_2 concentrations can be concentrated from large air volumes. Additionally, there is no need for using liquid nitrogen or NaOH solution, which makes it suitable for sampling in remote areas. Difficulties of this approach arise from the incomplete removal of atmospheric CO_2 from the molecular sieve, which can result in memory effects, and the absorption of soil water, which can lead to isotopic fractionation.

The aim of this study is to evaluate the trapping of soil gas on a self-made, stainless-steel molecular sieve cartridge (MSC) and the desorption procedure using a vacuum line. Compared to previous studies we want to show that trapping of very small amounts of C (≤ 2 mg) and the subsequent radiocarbon analysis is possible although these small sample volumes can easily be contaminated. Optimized MSC methods were used for trapping low concentrations of CO_2 respired from a forest soil in northern Germany.

Different methods of loading CO_2 onto the MSC were tested: (1) active sorption with a He flow, and (2) passive sorption (under vacuum) of pure ^{14}C-free CO_2 on the MSC. The CO_2 desorption and the molecular sieve (zeolite type 13X) regeneration were also tested with the ^{14}C-free CO_2 using different methods (variation of heating time/temperature, active vs. passive procedures). Additionally, different amounts of molecular sieve (0.3 g-3 g) were tested to obtain enough CO_2 for the radiocarbon analysis but trap as little water as possible.

To check the reliability of the MSC methods IAEA standard materials (C1, C3 and C7) of different isotopic compositions were combusted or hydrolyzed, trapped on a MSC and desorbed from the sieve for $\delta^{13}C$ and ^{14}C analysis. The fractionation was checked by $\delta^{13}C$ analysis, the memory effect by the loading with different standards, and the sample recovery by the difference between the amount of loaded and recovered CO_2.

The MSC was applied in a pilot study to collect CO_2 soil gas samples for radiocarbon analysis from five depth intervals (0.1 to 1.5 m) from two forest soil pits in northern Germany. The sampled depth intervals have relative low organic C content ranging from 0.97% (0.1 m) to 0.02% (1.5 m). The soil profiles were sampled twice in 2014 during the vegetation period and during the winter season.

The different MSC methods with ^{14}C-free CO_2 resulted in different ^{14}C concentrations. The active method (with a He flow during regeneration, sorption and desorption procedures) showed minimum concentrations of 0.007 $F^{14}C$, whereas the passive method revealed maximum concentrations of 0.299 $F^{14}C$, indicating a contamination of >20% with modern CO_2. Furthermore the active regeneration and sorption combined with passive desorption resulted in higher CO_2 concentrations and even lower ^{14}C concentrations (0.001 $F^{14}C$) compared to the active desorption. The variation of desorption time and temperature revealed only minor differences.

In addition the MSC with zeolite ≤1 g received better results of 0.036 $F^{14}C$/0.007 $F^{14}C$ compared to 0.299 $F^{14}C$/0.010 $F^{14}C$ (for 3 g zeolite) (active/passive method). The results for ongoing test of memory effects, isotopic fractionation, and sample recovery will be discussed.

The results of our pilot study indicate no significant differences in the radiocarbon concentration of the CO_2 sampled during the vegetation period and during the winter season.

During the vegetation period values vary between 1.049 and 1.080 $F^{14}C$ and show no differences (within their analytical errors), between different depth intervals and no correlation between the two profiles sampled. This also applies for the values of the winter period which are slightly lower ranging from 1.031 to 1.074 $F^{14}C$.

In summary, the molecular sieve method seems to be a suitable approach to collect CO_2 out of large air volumes with a low CO_2 concentration. In our study the best results were obtained for (1) active regeneration and sorption and passive desorption, (2) with small amounts of the molecular sieve (<1 g), and (3) with a long heating time ~60 min above 150°C. However, care has to be taken, e.g.: sufficient regeneration time of the molecular sieve, proper loading and desorption of the CO_2 from the sieve, and the use of small amounts of molecular sieve to prevent the adsorption of water.

O 3.5.06

Insights in anthropogenic soil formation in Northern Germany - A biomarker approach

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Ancient soils of anthropogenic origin are interesting research subjects for various reasons because these soils contain important information about e.g. agricultural practices, animal husbandry and livestock or handicraft activities. From an archaeological point of view, studies about land use reconstruction can lead to a deeper understanding of the functioning of life and economy in the historic past. In view of important global topics such climate change and sustainable agriculture, more attention has been paid to anthrosols exhibiting high nutrient and soil organic matter (SOM) stocks. One of the best known examples is terra preta de Índio in Central Amazonia. Modern biomolecular analyses such as faecal sterols, stanols and stanones and bile acids or black carbon analysis are powerful tools to get deeper insights in i) historical environments and ii) in soil formation. Furthermore, phosphate, stable isotopes (d15N and d13C) and amino sugars provide additional information about input materials and microbial contribution to anthropogenic soil formation. Here, we present the results of the investigation of an Anthrosol found during an archaeological excavation of a Slavic settlement (10th/11th C. A.D.) in Northern Germany. The question was, whether the properties of the Slavic soil are comparable to terra preta de Índio in Central Amazonia.

P 3.5.01

Reconstruction of the water temperature variations in Shilianghe Reservoir of Eastern China over half century using branched GDGTs proxy

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Geological archives containing climate-sensitive proxy indicators are used to reconstruct paleoclimate. Temperature (T) is one of the master variables governing climate change and, as a consequence, large efforts have been made to reconstruct its variations in the past. Lake sediments have become one of the prime targets for continental climate reconstructions. Similar to marine sediments, lacustrine sediment records can span long time periods as well as much higher sedimentation rates. Thus, they allow establishing proxy-based records with a comparably high temporal resolution. Here, we tested the applicability of the MBT/CBT-paleothermometer to Shilianghe Reservoir (Hailing Lake) in eastern China, with the catchment of 15,365 km^2. We analyzed the distribution of branched GDGTs in catchment soils and in a dated sediment core from Shilianghe Reservoir, covering the half century. The distribution of branched GDGTs in the surface sediments from this lake is very similar to that from the catchment soils, suggesting a common origin of the lipids. Moreover, the reconstructed mean annual air temperatures (MAAT) using branched GDGTs proxies (MBT-CBT) are in agreement with instrumental values for the reservoir. It is clear that the proxies, extracted from the GDGTs, are capable to reflect paleo-climatic and paleo-environmental information for the lake.

P 3.5.02

Cutin and suberin biomarker patterns in floodplain soils

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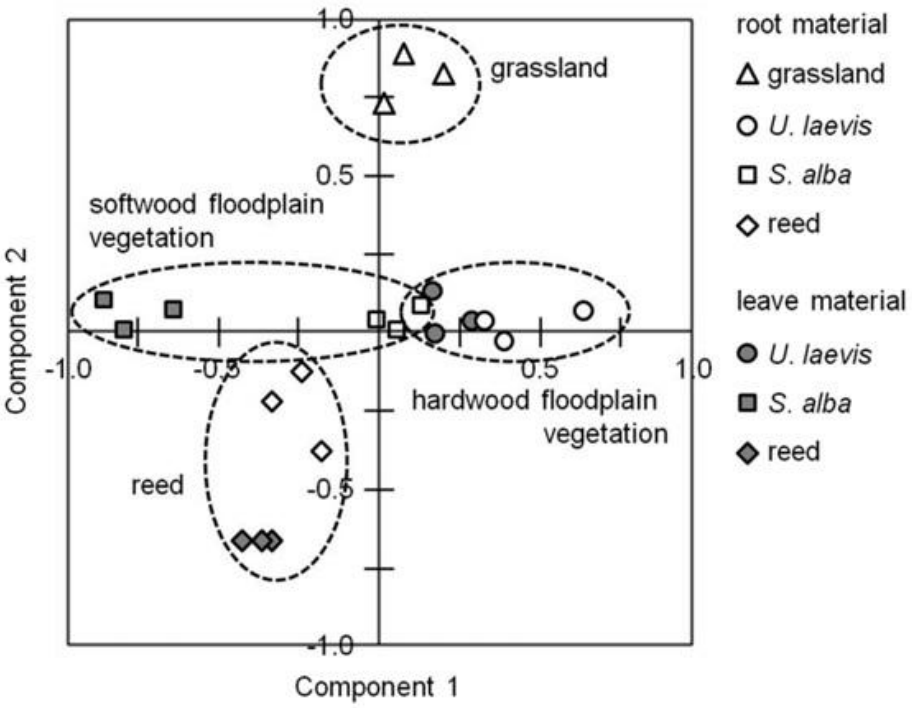
Cutin and suberin are the primary source of hydrolysable aliphatic lipid polyesters in soil organic matter (SOM). They are known as geochemical biomarkers to estimate the contribution of different plant species and tissues to SOM. Despite their potential as biomarkers, cutin and suberin have received less attention as flood plain sediment biomarkers. The objectives of this study were to investigate the efficiency of cutin and suberin as biomarkers in floodplains. Therefore similarities between the lipid pattern in alluvial sediments and in the actual vegetation were considered. Lipids of plant tissues (roots, twigs, leaves) from different species (reed (e.g. Phalaris arundiacea), Salix alba, Ulmus laevis and grassland (e.g. Carex spec.)) and of the un-derlying soils and sediments were obtained and investigated at four sites in the nature reserve Knoblauchsaue (Hessen, Germany). The four sampling sites differ not only with respect to their vegetation, but also within their distance to the river Rhine. Cutin and suberin monomers of plants and soils were analysed by alkaline hydrolysis, methylation and acetylation and subsequent gas chromatography-mass spectrometry. Resulting lipid patterns were specific for the appropriate plant species and tissues. However, the traceability of single selected lipids was decreasing alongside the soil profile, with the exception of monomers in softwood floodplain soils. Selected tissue specific lipid ratios showed a higher traceability due to strong attributions of lipid ratios in soils and roots of U. laevis and Carex spec. and in leaves of U. laevis and S. alba. In contrast, there was no accordance between the suberin specific lipid ratios in soils and roots of S. alba and P. arundiacea. The most robust interpretations were afforded when a set of multiple biomarkers (i.e. a combination of free lipid ratios and ratios of hydrolysable lipids) was used in a principal component analysis (PCA) to collectively reconstruct the source vegetation of different sediment layers.

Fig.1: PCA of selected molecular markers for tissues of the four analyzed plant species.

Figure 1



P 3.5.03

Reconstructed isotopic composition of leaf water provides new insight into hydrological changes in East Africa during the last glacial

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We couple compound-specific δ^2H results of leaf wax-derived *n*-alkanes with compound-specific δ^{18}O results of hemicellulose-derived sugars extracted from the loess-paleosol-sequence Maundi on Mt. Kilimanjaro. This coupling allows the reconstruction of a ca. 100 ka record of isotopic composition of leaf water. This in turn allows (i) using deuterium-excess of leaf water as proxy for palaeohumidity and (ii) reconstructing the isotopic composition of precipitation. Our results suggest that sedimentary $\delta^2H_{leaf\ wax}$ records should not be interpreted directly in terms of reflecting δ^2H_{prec} because variable leaf water evaporative enrichment can strongly overprint δ^2H_{prec} signals. Furthermore, our d-excess record as proxy for palaeohumidity does not support the interpretation of δ^2H_{prec} in terms of an “amount-effect” in East African palaeoclimate studies.

P 3.5.04

Coupling δ^2H and δ^{18}O biomarker results yields information on relative humidity and isotopic composition of precipitation - a climate transect validation study

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The δ^2H isotopic composition of leaf waxes, especially of *n*-alkanes ($\delta^2H_{n\text{-alkanes}}$) is used increasingly for paleohydrological and -climate reconstructions. However, it is challenging to disentangle past changes in the isotopic composition of precipitation and changes in evapotranspirative enrichment of leaf water. In order to overcome this limitation, Zech M. et al. (2013, Chemical Geology 360-361, pp. 220-230) proposed a coupled $\delta^2H_{n\text{-alkane}}$-$\delta^{18}O_{sugar}$ approach. This coupling allows calculating biomarker-based/-reconstructed (i) $\delta^2H/\delta^{18}O_{leaf\ water}$ values, (ii) deuterium excess (d-excess) of leaf water, which mainly reflects evapotranspirative enrichment and can be used to reconstruct relative air humidity (RH) and (iii) $\delta^2H/\delta^{18}O_{precipitation}$ values. Here were present a respective climate transect validation study by coupling new results from δ^2H analyses on *n*-alkanes and fatty acids in topsoils along a climate transect in Argentina with previously measured δ^{18}O results obtained for plant-derived sugars. Accordingly, both the reconstructed RH and $\delta^2H/\delta^{18}O_{precipitation}$ values correlate highly significantly with actual RH and $\delta^2H/\delta^{18}O_{precipitation}$ values. We conclude that compared to single $\delta^2H_{n\text{-alkane}}$ or $\delta^{18}O_{sugar}$ records, the proposed coupled $\delta^2H_{n\text{-alkane}}$-$\delta^{18}O_{sugar}$ approach will allow more robust $\delta^2H/\delta^{18}O_{precipitation}$ reconstructions and additionally the reconstruction of RH changes/history in future paleoclimate research.

P 3.5.05

A first Late Glacial and Early Holocene coupled ^{18}O and ^{2}H biomarkerisotope record from Gemuendener Maar, Germany

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During the last years, we developed a method for compound-specific $\delta^{18}O$ analyses of hemicellulose-derived sugars from plants, soils and sediment archives (Zech and Glaser, 2009; Zech et al., 2014). The coupling of respective $\delta^{18}O$ sugar results with $\delta^{2}H$ alkane results from paleosol and sediment climate archives proved to be a valuable innovative approach towards quantitative paleoclimate reconstruction (Hepp et al., in press; Zech et al., 2013).

Here we present a first coupled $\delta^{18}O$ sugar and $\delta^{2}H$ alkane biomarker record obtained for Late Glacial and Early Holocene sediments from the Gemuendener Maar in the Eifel, Germany. The $\delta^{18}O$ sugar biomarker record resembles the $\delta^{18}O$ ice core records of Greenland. The coupling with the $\delta^{2}H$ alkane biomarker results allows drawing further more quantitative paleocimate information in terms of (i) paleohumidity and (ii) $\delta^{18}O$ of paleoprecipitation.

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P 3.5.06

Deciphering the biomarkers of amber as a tool for the reconstruction of Mesozoic forest environments

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The Cheirolepidiaceae is an extinct family of conifers which was very common in the Mesozoic era (-252 to -66 Ma), and was likely a major contributor to lignite and coal formation. The differentiation of cheirolepids from other conifer families is pivotal to reconstructing the terrestrial paleoenvironments. This should be possible through the chemical characterization of amber, the polymerized fossil form of tree resins that consist of a complex mixture of terpenoids and is often found associated with lignite and coal. As an extinct family, however, the Cheirolepidiaceae has no modern relatives which could permit the direct assessment of specific biomarkers, as is the case with extant families. Here we propose a cheirolepidiaceous 'fingerprint', based on the pyrolysis-GC/MS analysis of 25 samples of various Cretaceous amber from France and Lebanon, and their comparison to a Triassic Italian and a Cretaceous Spanish ambers that almost certainly originated from a cheirolepid based on the associated plant fossils. Thus the presence, simultaneously, of callitrisate, phenolic diterpenes, labdanoic acids, and their respective derivatives, is considered indicative of a cheirolepidiaceous resin. The differentiation of the botanical sources of amber might allow for a refined evaluation of the resin production through geological times and, along with the biological inclusions fossilized in amber, a more accurate reconstruction of Mesozoic forest environments.

IT 3.6

Influence of farming systems on soil organic matter and soil microorganisms as assessed in the DOK long-term field experiment

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Introduction Soil microorganisms guarantee numerous soil functions, such as nutrient cycling, soil structure formation and the regulation of soil pathogens. Restoring soil fertility and increasing stability of soil is an urgent call to farmers. Soils also serve as a habitat for an almost uncountable diversity of soil microbes, which often is closely linked to the above ground one. Active, well-structured soils guarantee sustainable yields and safeguard natural resources simultaneously. Long-term trials are ideal bases to identify effects of agricultural management on the soil microbial communities.

Methods In this presentation we will focus on results gained in a long-term system comparison trial in Therwil (Basel-Land), Switzerland, called DOK experiment. In this experiment, bio-dynamic (D), bio-organic (O), and conventional (K, konventionell in German) farming systems are compared since 1978 in a ley rotation. All three systems are receiving farmyard manure (FYM) at an annual rate corresponding to 1.4 (livestock units) LSU and 0.7 LSU per hectare. In addition one conventional system receives mineral fertilizers exclusively.

Results We found that soil organic matter was higher in soils receiving FYM at 1.4 LSU than in those at lower FYM application rate. The latter were comparable to the conventional mineral fertilizer system. Soil organic matter after five crop rotation periods of seven years was significantly higher in the bio-dynamic system with FYM-compost than in the system with mineral fertilizer only. Among the farming systems that received FYM, soil microbial biomass and soil microbial activities (soil enzymes) were always higher in the biodynamic system as compared to the conventional one, while the bio-organic system took an intermediate position. Lowest biomass was measured in the mineral system. Microbial communities, as assessed by phospholipid fatty acids and molecular finger prints (terminal restriction fragment length polymorphism, TRFLP) were clearly affected by farming systems and crops in the rotation. Diverse microbial populations more efficiently used soil organic carbon sources, as indicated by a lower metabolic quotient (qCO_2). In incubation studies, microbial biomass (chloroform fumigation extraction method) was identified as driver of decomposition of freshly added ^{14}C labeled straw. Biomass was also correlated with soil structure, and to total yield (grain plus straw) of wheat in organic systems, showing its bench mark character for above ground biomass production. Mycorrhizal fungi, associated with most arable crops, play key roles in resilient, sustainable cropping systems. A higher mycorrhizal root colonization, and a higher diversity of mycorrhiza, as determined by spore morpho-typing and by micro-satellite technique, was detected in the organic systems. *Gigaspora* and *Scutellospora* species, known as sensitive indicators for farm management, occurred more frequently in soils of organic systems. A steady increase of mycorrhizal species was identified along with land use intensity from monoculture, to crop rotation, to extensive meadows.

Conclusion It is suggested that the higher nutrient use efficiency and energy efficiency found in organic systems is related to the more active and diverse micro-flora in the soil.

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O 3.6.01

Soil organic matter change due to successional Agroforestry in Tome Acu, Brazil

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Introduction

Tropical soils are often highly weathered and tend to be less fertile. Even though, dense vegetation of rain forests can develop on those soils if climate conditions are favourable. Developing of those forests to farmlands leads to exposure of the vulnerable soil and easily leads to soil degradation. Strategies to maintain production at those conditions are required. Soil organic matter (SOM) is an important indicator for soil fertility. The decrease or increase of SOM can give an insight to which direction the artificial land use is going. In this study the effect of a cacao based successional Agroforestry on SOM will be introduced. The objective of this study is to clarify the influence of successional Agroforestry on carbon cycling, and its effect on SOM.

Material and Method

The study site is located in Tome Acu, Brazil. Three different successional stages of successional Agroforestry were selected of the fields planted in 2008 (6 years old; 6YO), in 2002 (12YO) and in 1980 (34YO). The C flow was analysed by measuring the C contents in aboveground biomass, soil, litter and harvest (fruit plus residue), and the carbon dioxide (CO2) emission from soil. For reference, the C contents in soil and litter and soil respiration were monitored in a nearby secondary forest. The measurements were conducted from September 2012 till July 2014. The C balance was calculated by the difference of all inputs (aboveground biomass increase, litter and harvest residue) and outputs (soil respiration and fruit exported from the field).

Result and Discussion

The increase of aboveground biomass of cacao tree from 2013 to 2014 was 3.2 kg tree^{-1} in 6YO, which was significantly larger than those of other stages (1.5 and 1.9 for 12YO and 34YO, respectively) The yield of cacao fruit was highest in 12YO and contained 3.3 kg-C tree^{-1}. The yields in 6 YO and 34YO were almost same with 1.5 and 1.9 kg-C tree^{-1}, respectively. Litter was highest in secondary forest with 8.2 Mg C ha^{-1} year^{-1}. The litter of 6YO, 12YO and 34YO increased with the age, and were 4.6, 5.6 and 7.1 Mg C ha^{-1} year^{-1}, respectively.

Soil carbon stock from 0 to 30 cm depth was 109.8 Mg ha^{-1} in secondary forest, those for 6YO, 12YO and 34YO were 57.4, 77.7 and 101.3 Mg ha^{-1}, respectively. There was no significant difference among them. But as the agroforestry stages progressed, the amount of litter fall and soil carbon tended to increase.

Soil respiration rate in the litter removed chamber (L-) in secondary forest was 129 mg CO_2-C m^{-2} h^{-1}, those for 6YO, 12YO and 34YO were 81, 84 and 92 mg CO_2-C m^{-2} h^{-1}, respectively. Soil respiration rate in the chamber with litter (L+) in secondary forest was 176 mg CO_2-C m^{-2} h^{-1}, those for 6YO, 12YO and 34YO were 77, 104 and 113 mg CO_2-C m^{-2} h^{-1}, respectively. The soil respiration rate in the removed litter chamber was significantly lower than the chamber with litter in each site except 6YO. The respiration is the sum of root respiration and soil organic matter decomposition. The high soil respiration rate in the secondary forest may be attributed to the litter fall as well as the high amount of roots.

As a consequence, the C balance in 6YO, 12YO, 34YO were 4.1, 4.5, 3.9 ton C ha^{-1} year^{-1}, respectively.

Conclusion

Our results demonstrated that the amount of litter fall and soil C increased as the succession stages progressed, indicating a higher internal nutrient cycling according to the agroforestry age. All Agroforestry stages in this study were found to be a C sink. The applied fertilizer at the younger field may be stored in the crop-plant biomass, as well as in the soil organic matter and stabilize the system.

O 3.6.02

Effects of Long-Term Organic Waste Applications on Agricultural Yields, Nutrient Removal, Soil Microorganisms, and Soil Organic Carbon Accumulation Efficiency

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Evidence suggests that organic soil amendment applications can lead to increases in plant productivity, changes in nutrient cycling, shifts in soil microorganism community structure, and increases in soil organic carbon content. It has also been hypothesized that soil systems can protect and thus prevent organic carbon degradation, but only to a point considered the carbon saturation level. We utilized long-term (i.e. decades) organic waste (biosolids) land application data from production agriculture (fully incorporated), grazed and ungrazed shortgrass steppe (surface application, no incorporation) ecosystems to determine potential connections between plant productivity, nutrient cycling, soil microbial communities, and sustainable carbon saturation levels. Results will be discussed in relation to application rates that suggest maximum carbon storage without compromising environmental quality.

O 3.6.03

Large and sustained applications of compost and slurry - too much of a good thing?

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QUESTION

Agricultural and municipal wastes are commonly added to agricultural soils as a conditioner, nutrient and organic matter sources, and because they need to be disposed of somewhere. In most cases the quantities are determined by availability and agronomic considerations, such as likely nutrient supply and demand. In the work that will be described in this paper, repeated annual, large additions over a decade of municipal compost and slurry have been made to arable (barley) plots to test whether the limits of the soil and understand better the residual nutrient effects.

MATERIALS AND METHODS

The compost additions ranged from zero to 200 t/ha/year and the slurry additions ranged from zero to 40 t/ha/yr. We have then quantities the total soil organic carbon and nitrogen stocks in the plots on a unit area basis (i.e. after correction for depth and bulk density changes), the soil microbial biomass and respiration rates.

RESULTS

The per area estimates of soil properties are particularly important because of the role of organic amendments in altering soil physical characteristics and the relative scarcity of such quantitative data. The soil carbon and nitrogen contents are substantially increased at high addition rates, but in the compost additions, the larger additions led to accumulations above the original soil surface indicating that the capacity to incorporate compost had been exceeded. The biomass and respiration rates both responded positively, as did the yield to the organic additions.

Figure. 1. Areal estimates of carbon following repeated slurry and compost addition.

Figure. 1. Areal estimates of nitrogen following repeated slurry and compost addition.

DISCUSSION

From these data rates of soil carbon accumulation (sequestration) can be estimated, but it is necessary to make a distinction to be made between large organic additions made to improve the soil and the production of the new organic "soil" layer arising from the addition. It is also important when assessing rates of carbon or nutrient accumulation in the field to take proper account of the soil depth and density as discussed by Hopkins et al. (2009 and 2011).

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Figure 1

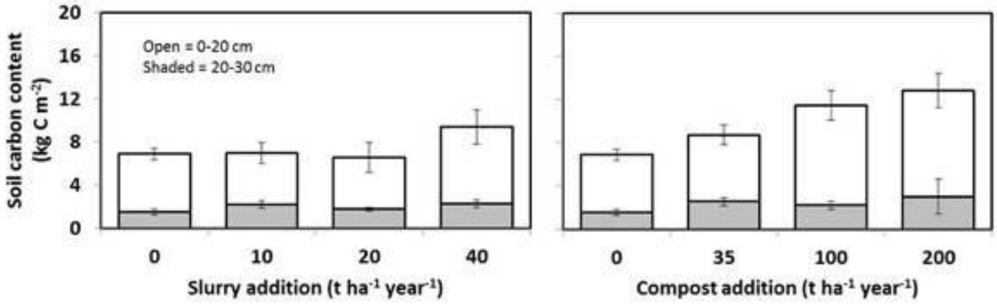
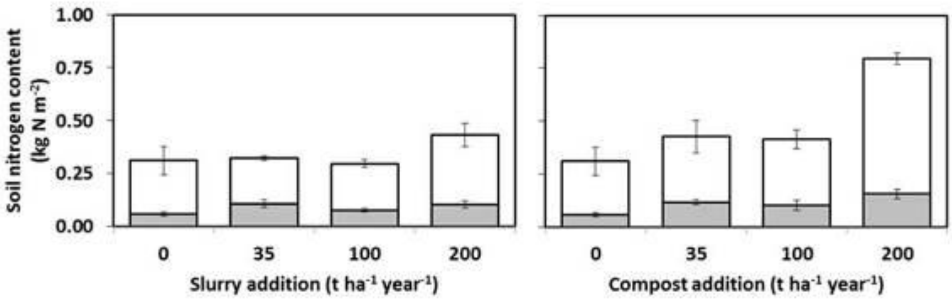


Figure 2



O 3.6.04

Stump harvesting combined with logging residue removal in a boreal conifer stand - what happens to carbon in the soil?

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As a result of changes in international and national energy policy silvicultural treatments, which involve extensive biomass removal from forest stands, are becoming more common in Scandinavia. The Nordic countries have a long tradition of utilizing their forest resources intensively for both industry and energy purposes and the use of forest-derived biomass for energy has steadily increased in the region during the past 15 years. In the Nordic countries clear-cutting in combination with site preparation is the predominant method before planting after final felling of Norway spruce stands.

Stump harvest combined with logging residue removal causes severe soil disturbance, such as mixing and relocation of the organic material and the mineral soil within the soil profile. In addition, stump harvest removes large quantities of biomass from the forest stand. Stumps are long-term carbon and nitrogen storages in a typical boreal forest stand, due to their slow decomposition process. This has raised concerns that stump harvest and logging residues removal could result in large changes in the nutrient dynamics of a forest stand and could eventually lower its site productivity. In this study, the effects of stump harvesting on soil C and N mineralization, and soil surface disturbance were studied at two different clear-felled Norway spruce stands in Southern Finland.

Treatment effects clearly manifested themselves in the humus layer; the rates of respiration and nitrogen mineralization were both consistently higher at all surfaces in the top most layers of the soil after stump harvesting. The results indicate that stump harvest can have an effect on soil carbon and nitrogen dynamics, particularly on the surface layers of the soil.

O 3.6.05

Improvement in theory of soil productivity decrease phenomenon in paddy field converted to upland

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The theoretical explanation that was established is that decrease of crop production during conversion from paddy to upland condition in paddy field results from decrease of natural nitrogen supply due to exhaustion of easily degradable soil organic matter in lasting aerobic condition. But, this theory can not explain no response of top dressing of chemical nitrogen fertilizer. Different opinion on reasons for decrease of natural nitrogen supply exists, such as change of soil nitrogen composition while conversion to upland. Therefore, improvement of established theory was required for understanding decrease of soil productivity in paddy field converted to upland. The objective of this study was suggestion of improved hypothesis on decrease of crop production in paddy soil converted to upland.

Changes in soil chemical properties during summer crop cultivation were compared among field in first year after conversion up to fourth year, and the chain of causal relationship was made a deduction from discontinuance of soil submerging to decrease of soil productivity. The analyzed chemical properties were pH, EC, available phosphate, exchangeable cation, total nitrogen, organic carbon, organic phosphorus, fractionation inorganic phosphate and active Fe.

The significant results of change of soil chemical properties were summarized as follow; (1) organic and total N changed little, (2) organic phosphorous decreased rapidly and was stabilized, (3) reduced soluble P increased field in first year but remained a few content in field of fourth year (4) active Fe decreased consistently.

The new hypothesis depicted from chemical analyses and literature investigation was summarized as follow; when soil submerging discontinued, soil chemicals oxidized and phosphate adsorption capacity of soil increased. Consequently, soil microorganism underwent lack of phosphate in soil solution and mineralized organic phosphorous and phosphate of phosphate in soil solution increased, but was adsorbed in soil. This pathway was repeated until phosphate adsorption capacity of soil decreased due to changed mineralogical properties of soil mineral matter. As a result, soil organic phosphorous decreased rapidly and was stabilized. And imbalance in ratio of soil organic C:N:P:S deteriorated and material circulation in soil ecosystem decreased. According to this hypothesis, reason of no response on top dressing of chemical nitrogen fertilizer could be explained as decrease of soil nitrogen supply and crop productivity are the disturbing phenomenon of material circulation in soil ecosystem resulting from a rapid decrease of soil organic phosphorous.

O 3.6.06

Manure, Straw and Biochar Amendments on Aggregation and Erosion in a Hillslope Ultisol
To determine the effect of different organic amendments on aggregate stability, agronomic performance, runoff, and erosion. Five treatments are CK, NPK, NPK+Str, NPK+BC, and NPK+OM. Our results show that biochar did not improve aggregation and reduce erosion.

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Soil erosion is a serious problem in subtropical China where the hillslope red soil (Ultisols in US soil taxonomy) is intensively cultivated. Manure and amendments have been reported to improve crop growth and soil structure stability in long-term fertilization experiments. We hypothesized these two roles might eventually reduce soil erosion. In this study, our objectives were to determine the effect of different organic amendments on soil aggregate stability, agronomic performance, runoff, and erosion. Five treatments were imposed of CK, NPK, NPK+Str, NPK+BC, and NPK+OM, located on land with a 9-14% slope planted with peanut (*Arachis hypogaea L.*). During the peanut season, soil erosion was about 2600 ton km^{-2} in the NPK. The NPK+OM reduced it down to 627 ton km-2 ($P < 0.001$) but NPK+BC did not ($P > 0.05$). As compared with the NPK, the NPK+OM increased the above-ground biomass ($P < 0.05$), the dry MWD ($P < 0.05$), and the SOC ($P < 0.05$). In contrast, rice straw-derived biochar did not improve soil acidity, crop growth, and aggregation ($P > 0.05$) except the SOC, because it was susceptible to erosion. Although the lowest erosion was observed in the NPK+Str (225 ton km^{-2}), the straw mulch did not improve the agronomic performance and soil structure stability ($P > 0.05$). We recommend that the application of organic manure has an efficient and feasible practice in hillslope Ultisols for sustainable agriculture whereas biochar is not.

O 3.6.07

Relationship of soil organic matter with nutrient availability in dry aggregate-size fractions under contrastingly managed long-term grain cropping systems

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Introduction

Soil organic matter (SOM) and soil structure are key indicators of soil quality. The quantity and dynamics of SOM are closely related to nutrient availability. SOM decomposition and nutrient release dynamics may vary with soil aggregate-size fractions and management practices. We have a general understanding of the influence of management and SOM on soil properties; however, our knowledge of SOM functionality in relation to soil processes at soil aggregate levels, and how management practices impact SOM fractions in aggregates and soil functions is limited. We hypothesised that (i) C mineralisation and available nutrients will be higher in macro-aggregates than in micro-aggregates, as the former soil fraction contains relatively labile SOM; and (ii) available nutrients will be higher in conventional tillage (CT), reduced tillage (RT) or stubble retained (SR) treatments because of higher soil microbial activity than in no till (NT) or stubble burnt (SB) treatments.

Objectives

The objectives were to (i) assess microbial activity and potentially available N, P and S in various aggregate size fractions; and (ii) quantify the relationship of SOM in soil aggregates with C and nutrient (N, P and S) mineralisation dynamics.

Materials & Methods

A laboratory incubation experiment of whole soil and three aggregate fractions from 0-10 cm depth was conducted in a closed, well-sealed, one litre bucket at 22 ± 0.5°C and 60% water holding capacity (WHC) for 18 weeks. Cumulative soil C mineralisation (C_{min}), potentially mineralisable N (PMN) and S (PMS), and Colwell-P were measured three times (0, 30 days and 18 weeks) during the incubation. The soils were collected in 2014 from three long-term (16−46 years) regional sites in Australia, *i.e.* Red Chromosol from the Southern (Condobolin, NSW) and Western (Merredin, WA) cropping regions, and Vertosol from the Northern (Hermitage, Qld) region, comprising fifteen different management treatments. In the Condobolin site (established in 1998), the five treatments were four factorial combinations of CT and RT with wheat crop or pasture in rotation, and one perennial pasture. In the Merredin site (established in 1987), the two treatments were continuous wheat-legume sown *via* direct drilling under SR (standing) or SB (autumn burn) [Hoyle and Murphy (2006), Aus J Soil Res 44, 407-423]. In the Hermitage site (established in 1968), the eight treatments comprise factorial combinations of CT, NT, SR, SB, with or without N fertilisation [Dalal et al. (2011), Soil Till Res 112, 133-139]. Soil samples were sieved through 6.5 mm mesh and air dried at room temperature for ~24 h to about 20 to 25% WHC. The air dried samples were then dry-sieved using a sieve shaker with a nest of sieves to obtain the following aggregate sizes: Large macro-aggregates (>2−6.5 mm), small macro-aggregates (2−0.25 mm) and micro-aggregates (

Results

The C_{min} was similar across the soil types and varied from 0.02 to 1.7 g kg^{-1} soil across the treatments. However, Colwell P in the Vertosol was 0.011 - 0.13 g kg^{-1} soil *versus* 0.002 - 0.05 g kg^{-1} soil in the Red Chromosols. The C_{min} over 18 weeks from all the sites and PMN over 30 days from the Condobolin site were significantly different among the aggregate-size fractions: large macro-aggregates < micro-aggregates ≤ small macro-aggregates. Management practices affected C_{min} and Colwell P in the Condobolin and Hermitage sites but not in the Merredin site. In the Condobolin site, the CT or RT (*vs.* perennial pasture or pasture phases) had generally higher C_{min} and Colwell P in all aggregate-size fractions.

In the Hermitage site, the C_{min} over 18 weeks was higher in the CT with SR than in the CT with SB, or in the NT with SR or SB, across all aggregate-size fractions. Colwell P in the Hermitage site was higher in the CT with SR or SB than in the NT with SR or SB for up to 30 days but thereafter P immobilisation was higher in the CT *vs.* NT treatments.

Conclusions

Preliminary results suggest that CT (including SR) increased SOC mineralisation and nutrient availability in all aggregate-size fractions relative to the other management treatments. However, CT may have decreased aggregate stability and SOM. Thus there could be a trade-off of enhancing SOC turnover through disruption of aggregates and exposing SOM for microbial attack *via* CT *versus* slowing SOC loss and nutrient turnover while improving soil structure *via* NT. Further analyses of microbial metabolic quotient, PMN, PMS, Colwell P, and total C and nutrients (N, P, S) in the soil aggregate fractions are underway and will provide insights into the relationship of SOM with nutrient availability and its fertiliser value in grain cropping systems.

O 3.6.08

Effect of SOM on crop yields and nitrogen use efficiency assessed using field nutrient response trials

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Soil organic matter (SOM) is broadly recognized as an important soil component which contributes to a number of soil properties and maintains soil productivity. Previous research generally indicates that SOM has positive effects on crop yields, but in many studies it is difficult to separate the effect of nutrients supplied by SOM from the effect that SOM has through other mechanisms. The aim of this study was to analyze whether the SOM content, in itself, has a significant effect on potential yields. The study draws on historical data sets from the Danish national field trials consisting of 560 winter wheat (*Triticum aestivum* L.) trials and 309 spring barley (*Hordeum vulgare* L.) trials conducted over the past 20 and 17 years, respectively. In order to tease out the effect of the nutrients contained in the SOC we calculated the potential yields by fitting a curve to the yield response to increasing mineral fertilizer N application and finding the potential (maximum) yield from this function. A simple relation between SOC and potential yields indicated a negative effect of SOC on yields. However, there were many potentially confounding variables in the current data set. An important one is clay content, which is well-known to affect crop yields positively, mainly due to its influence on plant available water; however in the datasets used there is also a negative correlation between clay and SOC content because in Denmark, dairy farms with prevalence of perennial clover grass and high land application of manure (both contributing to high organic matter inputs) are predominantly found on sandy soils. Therefore, a positive effect of clay could potentially end up looking like a negative effect of SOC. For this reason, a statistical model was developed to explore the relationships between SOC and potential yields including as many confounding variables as possible. After correcting for all the confounding variables, no significant effect of SOC on potential winter wheat yields was found, whilst for spring barley, only a borderline significantly positive effect of SOC on potential yields was found for the coarse sandy loam soil type. Based on the large dataset analyzed, we conclude that we could not provide evidence for the importance of SOC in contributing to potential crop yields. Based on the dataset we speculate that in situations where nutrient limitation does not occur, SOC levels above 1% may be sufficient to sustain yields. In light of the findings presented in this study, further work should be conducted which can further elucidate the effect of SOC on yields.

O 3.6.09

The importance of soil organic matter for sustainable organic crop rotations in north-eastern Germany

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Soil organic matter (SOM) plays a decisive role for the productivity of organic farming systems especially in North-eastern Germany (NEG) with mostly sandy soils, low annual precipitation and farms with low livestock densities and manure availability. Due to the renunciation of mineral nitrogen (N) fertilizers in organic farming (OF), N-mineralization out of the different SOM pools, beside the limited manure applications, has to supply the N demand of the non-legume crops within rotations. Legumes and especially legume-grass leys have a high potential to increase SOM and the N availability. Therefore sustainable organic crop rotations should be based on sufficient legume portions taking into account the phytosanitary restrictions of different legumes. This requires a sophisticated crop rotation planning.

To foster a sustainable development of organic farming in NEG we i) established long term monitoring trails (MT) to analyze the temporal SOM development of a legume rich organic crop rotation and ii) developed the crop rotation planning tool ROTOR to calculate N- and SOM-balances.

The MT were established on an ‘experimental farm’ converted to OF in 1993 with an eight-course crop rotation. The soils of the MT are from glacial deposits and, therefore, the soil texture has high spatial heterogeneity with sand (S), loamy sand (lS) and sandy loam (sL). In addition to the crop yields, topsoil samples were analyzed annually since 1995 to investigate the long term influence of OF on the soil organic carbon (SOC) and soil organic nitrogen (SON) concentration. MT with soil texture S showed a more pronounced increase of SOC (23 %) and SON (45 %) as the MT with soil texture lS or sL grouped together (SOC 11%; SON 27%). Yields of the non-legume crops remained stable.

ROTOR is a static rule-based model to generate and evaluate crop rotations site specifically including assessment modules for i) preceding crop specific yields, ii) N-balance including N-removal, N_2-fixation and NO_3-leaching, iii) SOC-balance including straw harvest, manure application and cover crops, iv) different weed infestation risks and v) phytosanitary restrictions. ROTOR was found to support the complex crop rotation planning in organic farming and has been adapted to new environments. Examples of well-balanced rotations will be presented.

O 3.6.10

Dynamics of changes in the soil organic matter, functional diversity and C and N fluxes after shift in agricultural practices of an annual crops rotation under conventional agriculture.

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Introduction and objectives

Agricultural practices (e.g. crop rotation, tillage) lead to profound changes in soil properties, ecosystem structure (e.g. biodiversity) and functioning (e.g. ecosystem services). Whereas this has been very often characterized in the medium and long terms, little is known so far about how fast soil properties respond to changing practices at the time scale (year to several years) in which farmers take their decision in the management of their crops. In agricultural systems, increasing consideration is given to soil biodiversity, whose role has long been overlooked by agronomists, but whose preservation in now recognized as key for maintaining soil functioning capabilities, such as litter decomposition and nutrient cycling. In this context, the SOFIA project addresses the short-term impact of agricultural practices on the soil chemical and physical properties (e.g. soil C and N, pH), the taxonomic and functional diversity of soil communities and the consequences on some soil functions related to organic matter cycling (N mineralization, N_2O production, C storage).

Materials & methods

The SOFIA experiment was held on the SOERE experimental platform of Estrées-Mons (Northern France) dedicated to the study of long-term anthropogenic disturbance on biogeochemical cycles and biodiversity. This experiment, started in 2010, is characterized by a series of treatments comprising different crop rotations (annual, perennial and energy-based crop rotations), rate of N fertilization, deep and reduced soil tillage. These practices are known to affect soil organisms by modulating the amount, chemical nature and location of their food resources and by modifying their habitat. During four years (2010-2014), the induced-differentiation of the agrosystem was characterized every year for plant biomass production and soil physical, chemical and microbiological properties (bacterial and fungal communities, nitrifying and denitrifying communities). Concomitantly the taxonomic and functional diversity of the earthworm, macroinvertebrates, microfauna and bacterial and fungal communities were determined. The CO_2 and N_2O emissions were continuously measured using automatic chambers. We used the Random Forest method to identify physicochemical (11 variables) and biological (56 variables) parameters which are were able to predict soil functions (organic matter decomposition, greenhouse gas emissions, primary production) as a first step toward the development of indicators in cultivated soils. General trends of global soil biodiversity were assessed based on the number (richness) and assemblage of all sampled families.

Results and discussion

We observed an early differentiation of the experimental treatments, notably a significant stratification of organic carbon, microbial biomass and enzymatic activities in treatments with reduced tillage compared to conventional tillage. Soil communities' differentiation was less affected by residues management and not affected by N fertilization rate after 4 years. The N_2O fluxes were low (max 2.5 kg N-N_2O over 3 years), with peaks mainly after N fertilization in spring. Differentiation in N_2O emissions was however mainly related to N input, with 2 to 3 times lower emissions with the reduced N fertilization. Our results showed that functional groups of nematode (omnivores and predators), the microbial biomass carbon (C) and the soil soluble carbon C contents best explained organic matter mineralization (C-CO_2 and gross N mineralization) in the top first five centimeters of soil which was the most affected by practices. We observed a slow but effective differentiation of soil invertebrate with globally higher diversity values in reduce-tillage systems.

Discussion

Significant changes in the soil chemical and biological properties were observed already two years after shift in agricultural practices. The main response was observed with the reduction of tillage, which led to significant modification in the stratification of soil total C and N, soil microbial C, enzymatic activities, which affected gross N fluxes, N_2O emissions and functional groups of nematodes in the upper 20cm of soil. At the scale of the experiment (4 year-differentiation), no significant effect of plant residues removal (vs. recycled) and of reduced N fertilization were observed, except on N_2O emissions. Soil organisms varied in their response to agricultural practices and our study highlighted that trophic interactions likely contributed to the observed dynamics. Most of the changes in soil pools and soil communities were significantly correlated to changes in soil C.

Acknowledgement

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O 3.6.11

Characterization and Productivity of Gwaasi Soils in Homa Bay County, Kenya

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This study provides an assessment of soil properties and land use potential in Gwassi Division, Homa Bay County that provides an understanding of soil fertility and land use system for forestry and agri-business investment. The objective of this assessment was to determine the physical and chemical properties of soils and match different soil types to appropriate land use. A total of 449 sites were identified,each soil sample comprised three sub-samples(0 - 20 cm, 21 - 40 cm and 41 - 60 cm soil depths) and six soil types were identified.

Results indicated that smallholder farms/blocks of farms had deep soils (≤ 40 cm); positive correlation existed between soil moisture content and soil type, while soils with high sand content had low soil water content. Blocks of farms had higher soil moisture content compared to smallholder farms. The mean maximum water infiltration depth for smallholder farms was much lower than in blocks of farms. Trust lands had low water infiltration capacity mainly due to underlying rock substrate which limited their soil depth.

Results of pH values ranged between 6.0-8.6, with a mean of 6.9, indicating that soils were neither acidic nor alkaline, suitable for agricultural production. Most soils were generally deficient in P and N, and had the recommended K and soil organic C. Trust lands were deficient in P, N and N;. Blocks of farms had higher levels of N, probably due: (a) long period of fallow before they were planted with trees, enabled biomass transfer to take place, which lead to nutrient build-up in the soil; and (b) blocks of farms had trees and tree roots often penetrate into deeper soil layers and pumps soil nutrients from the deeper soil layers to the top soil.

It was found that soils with high clay content are appropriate for long farming period because they are able to hold moisture for longer periods of time (require crops/tree species that withstand high moisture content); Soils with high sand content are poor at retaining moisture and require fast-maturing crops that are synchronized with the rainfall cycle; Soils with a mixture of sand, silt and clay (Loamy soils), support most crops and trees, depending on the prevailing soil nutrient status.

Key Words: Soil Assessment, Soil pH, Soil Moisture Content, Sand, Silt, Clay, Soil Nutrient Status

O 3.6.12

SOM drives evolution of loess-derived soils across a topoclimatic gradient

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1. Introduction

Primary loess in arid or semiarid regions has little organic matter, however, when these silty soil materials entrained by wind were deposited in alpine regions, the situation would be different. We constructed a topoclimatic soil sequence in the Qilian Mountain regions, northeast border of the Qinghai-Tibetan plateau. SOM varies greatly across the environmental gradient rendered primarily by difference in altitude (from 3800 m to 1800 m), while soil particle size distribution (PSD) is quite homogenous due to the long-term deposition of aeolian dust. This offers us an ideal scenario to understand the role of SOM in conditioning soil evolution and functioning.

2. Objectives

This objective of this research is to explore the systematic variations and co-variations of multiple soil properties in responding to the changing environment and how these soil properties are related to soil eco-hydrological functions.

3. Materials & methods

Twenty three surface soils within 5-15 cm were sampled along the topoclimatic gradient. Bulk soils were sampled for determining soil nutrient-related properties including total nitrogen, C/N ratio and cation exchange capacity (CEC). Soil cores were sampled to measure soil bulk density and functioning pores in different sizes that were defined as total porosity (0-oven dry), macropores (0-0.1 bar), mesopores (0.1-15 bar) and micropores (15 bar-oven dry) based on water retention method.

4. Results

Soil PSD varies little and the common peak value at ~37 µm indicates aeolian origin and genetic links among our soil samples. SOM content varies from 0.7 g kg^{-1} in mountain front regions to 204 g kg^{-1} in alpine forest soils. SOM has good relationships with total nitrogen (r^2=0.98), C/N ratio (r^2=0.85) and CEC (r^2=0.96). Also, SOM is closely related with bulk density (r^2=0.81), total porosity (r^2=0.87), macropores (r^2=0.57) and micropores (r^2=0.40).

5. Conclusion

SOM is the determining factor for soil ecological and hydrological properties.

SOM drives the evolution and eco-hydrological functions of loess-derived soils.

Fig.1 Variations and co-variations of multiple soil properties along the topoclimatic gradient

Fig. 2 From uniformity to diversity: a genetic view of loess-derived soil evolution

Figure 1

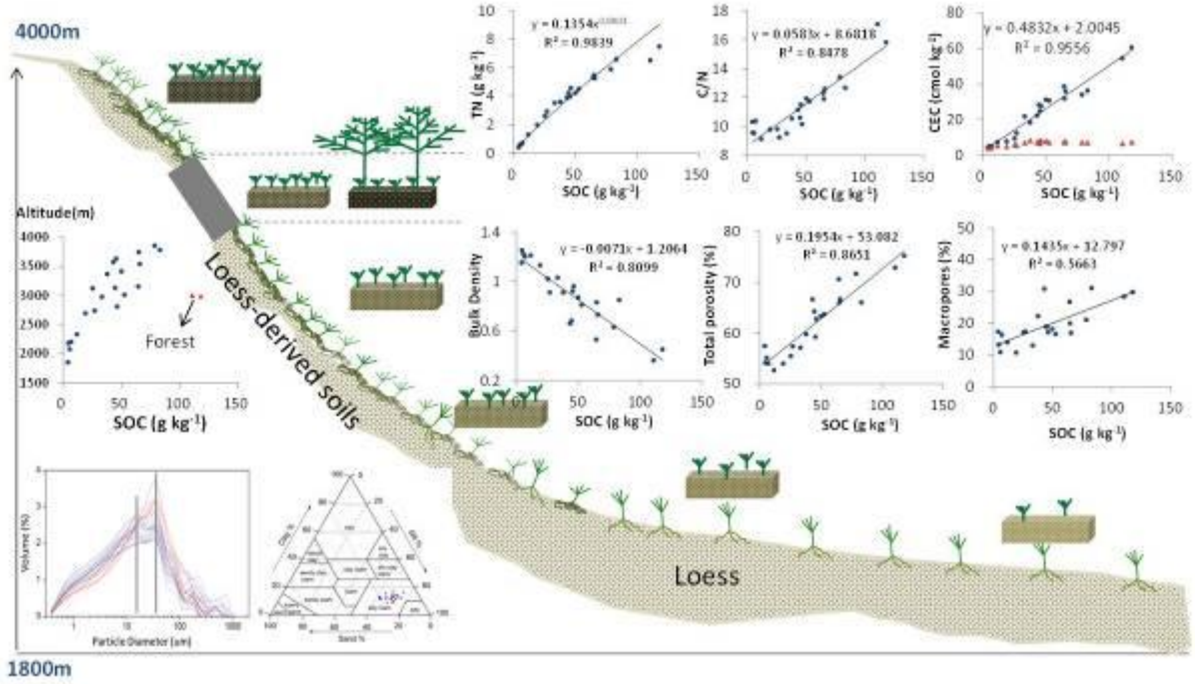
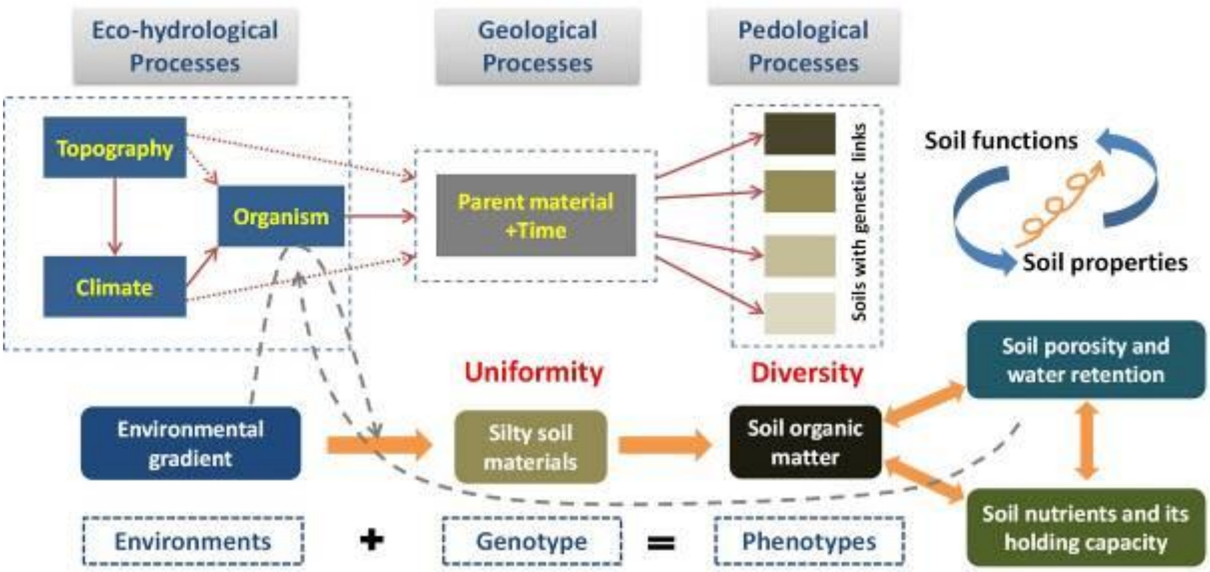


Figure 2



O 3.6.13

Dissolved organic carbon as a key factor in general disease suppression by soils

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1. Introduction

General disease suppression is an important natural aspect of soils that protects crops from soil-borne plant pathogen diseases. It has been ascribed to competition for substrate between pathogens and other soil microorganisms,and to production of pathogen-inhibitory secondary metabolites by soil microorganisms.It is commonly accepted that arable soils exhibit a certain, yet variable, degree of suppression against soil-borne pathogens.

Soil microorganisms consume dissolved organic carbon (DOC) to fuel various metabolic processes, and the rate of consumption, or the nature of these processes, may be influenced by the quality of DOC available. We hypothesized that the composition and size of the DOC pool is related to general disease suppression, and that, as a result, general disease suppression can be managed through management of DOC. Since DOC is a heterogeneous mixture of compounds, some fractions of DOC are potentially more relevant for microbial processes than others. It therefore stands to reason that DOC composition, via an influence on microbial function, may contribute to general disease suppression.

2. Objectives

Our objectives were to

find out if soil DOC can be manipulated through organic matter amendment;

determine the relationship between DOC composition and microbial processes associated with general disease suppression, and

explore DOC as an indicator of a soil’s capacity for general disease suppression.

3. Materials & methods

A rapid batch procedure was used to fractionate DOC from composts and soils into fulvic and humic acids, hydrophobic neutral and hydrophylic compounds.

46 arable soils varying in texture (1-45% clay), organic matter content (1-41%), pH (4.7-7.4) and management were analysed to relate DOC to various soil attributes and soil microbial processes including general disease suppression through multiple-linear regression modelling.

4. Results

Eleven composts ranging in input materials and processing techniques were analysed; DOC concentrations varied >15 fold. The range in proportion of DOC fractions was highly variable, too. The concentrations of the four fractions of DOC analysed varied 10-60 fold among the composts, the hydrophylic DOC fraction (low-molecular weight sugars and amino acids) being the most variable. Longer composting time and higher temperatures corresponded with a depletion of hydrophilic compounds, suggesting a preferential turnover of these compounds during the thermophilic composting phase.

A different rate of addition and proportion of compost DOC fractions resulted in different microbial activity rates, but only within 4 d after addition to soil. Addition of compost DOC with a higher proportion of hydrophylic compounds resulted in higher soil respiration, confirming its relatively labile nature. A more surprising result was the depletion of the humic acid fraction by as much as one-third over 35 d after addition. Humic acids are generally considered an aromatic, recalcitrant fraction of DOC but our results suggest that they can be a readily available C source to the microbial community. After 4 d, it was no longer possible to relate the soils' DOC concentration and composition, and microbial respiration to the DOC added.

The survey on arable soils revealed that organic matter management did not account for differences in DOC. The fact that this management treatment had been applied the previous growing season, suggests its effects are short-lived. The hydrophilic fraction of DOC, together with the humic acid fraction, explained the largest proportion (33%) of the variation in soil respiration among the soils.

The soils were used to assess their capacity to produce disease-suppressive volatile organic compounds. All soils showed volatile-mediated suppression of mycelial growth for the pathogens *Rhizoctonia solani*, *Fusarium oxysporum* and *Pythium intermedium*. However, the range of effects and the significant edaphic variables explaining the level of suppression differed per pathogen. Analysis of the growth suppression of the three pathogens identified soil microbial activity, DOC concentration and cropping history as the most explanatory variables.

5. Conclusions

Organic matter amendment has a transient effect on soil DOC concentration and quality.

Humic acids are not necessarily recalcitrant. Together with the hydrophilic fraction of DOC, they explain most of the variation in soil respiration.

The size of the soil DOC pool (but not its composition) is one of the three key factors in volatile-mediated suppression of multiple plant pathogens.

O 3.6.14

Long -Term Influence of Crop and Pasture Management Practices on Soil Organic Matter and the nutrient supply Potential of a Silt Loam Soil

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Introduction

Soil organic matter (SOM) tends to decline when long-term pasture soils are converted to continuous arable cropping. Implementing soil and crop management practices that conserve SOM may be crucial to sustaining soil fertility and crop production under continuous arable cropping while simultaneously avoiding adverse effects on the environment.

Objectives

The aim of this study was to evaluate the effects of continuous arable cropping under different tillage regimes (i.e., intensive, minimum and no-tillage) on the content, composition and bioavailability of soil organic matter and associated effects on soil fertility parameters compared to long-term pasture. Our objective was to improve understanding of how differences in SOM status affect changes in soil fertility that support sustained production of high yielding crops.

Materials and Methods

A long term trial was established on a Wakanui silt loam soil (Udic Dystocrept) near Lincoln in Canterbury, New Zealand (43°40'S lat. 172°28'E long.)to quantify the effects of tillage intensity and cover crop management practices on soil quality, crop production and N leaching following the conversion of long term pasture to arable cropping. In 2013, soil samples were collected (0-7.5, 7.5-15, 15-25 cm depths) from the three main arable cropping treatments (i.e., crops managed continuously under intensive, minimum and no-tillage practices) as well as the continuous (sheep grazed) pasture and permanent (chemical) fallow treatments. Nitrogen (and C) mineralisation potential were determined by incubating samples for 98 d (25^{o}C, -60 kPa water potential). Particle size fractionation was used to quantify the partitioning of C and N to soil physical fractions. The effects of the treatments on chemical fertility were evaluated by using standard soil tests (Olsen P, pH, available cations, cation exchange capacity (CEC)).

Results

After 13 years of arable cropping, soil C stocks (0-25 cm) were 13.7 t/ha less than in pasture soil. The decline in SOM (16% less C, 16.5% less N) following conversion of pasture to arable cropping appeared to be mainly due to decreased inputs of organic matter (roots and above-ground residues). Carbon (and N) stocks were not affected by the degree of tillage disturbance but tillage did affect the vertical stratification of SOM and partitioning of C and N to SOM fractions. In contract to total N, N mineralisation potential declined by 22-28% under continuous arable cropping compared with long-term pasture. Tillage type had little effect on total N mineralisation potential in the top 25 cm, but it did also affect the vertical distribution of mineralisation. Mineralisation was least in the long-term permanent fallow (67% less than in pasture), which had negligible inputs of fresh organic matter in the 2000-2013 period. As a result of a decline in soil organic matter under arable cropping and long-term fallow, there was a decrease in CEC (pH 7) of up to 22% at 0-7.5 cm depth. There was substantial decrease in available cations under arable cropping, with K decreasing by 46-73% and Mg by 36-52%. Over all three sample depths, differences in CEC were strongly correlated to soil C concentration (g/kg). Although most indicators of nutrient availability were low in the fallow treatment, it had highest levels of Olsen P, presumably due to accumulation of mineralised P.

Conclusion

Land use (pasture v. arable cropping) had a dominant influence on soil biological and chemical fertility of the soil in this study. Although the type of tillage employed to establish arable crops did strongly influence the vertical distribution of SOM and fertility parameters, it did not affect the overall nutrient supply potential of soil in the primary root zone (0-25 cm), above the maximum depth of cultivation. While there was no clear evidence that the vertical stratification of SOM affected nutrient losses under arable cropping with different tillage practices, further research is needed to understand its role in affecting the risk of nutrient leaching.

O 3.6.16

Soil organic carbon and total nitrogen responses after 34 years of tillage of a sandy Ultisol

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Conservation tillage and crop management strategies are available to increase soil organic carbon (SOC) and total nitrogen (TN) contents, but long-term (> 30 yrs) field results quantifying these increases are sparse. Our objectives were to quantity above ground biomass inputs and changes in vertical (0 to 90 centimeters, cm) distribution and accumulation (0 to 15 cm) of SOC and TN after growing row-, small grain, and cover crops for 34 years on a Norfolk loamy sand (Fine-loamy, kaolinitic, thermic, Typic Kandiudult) using either conservation or conventional tillage operations. The research site is located in the Coastal Plain region of South Carolina and was initiated in 1979, but this study focuses on results collected between 2002 and 2014. Composite soil samples were collected annually from 0 to 5, 5 to 10, and 10 to 15 cm depth increments, while bulk density samples were collected from shallow excavation pits. Subsoil samples (15 to 90 cm) were collected in 2002, 2008 and 2014. Overall, mean topsoil (0 to 15-cm) SOC and TN contents measured during the corn (*Zea mays*) and soybean (*Glycine max*) phases were significantly higher (8.23 versus 6.68 Mega-grams per hectare) for conservation vs. conventional tillage treatments. Conservation tillage resulted in significant vertical stratification in SOC and TN in both topsoil and subsoil samples. There was a weak linear relationship between annual biomass inputs with both SOC and TN contents ($r2 = 0.01$ to 0.09; $P > 0.05$), but, mean SOC and TN concentrations were significantly correlated ($r2 = 0.27$ to 0.56; $P < 0.08$). This means that simply increasing topsoil SOC contents through conservation tillage translates to greater soil TN contents, and hence more nitrogen available for crop growth. Our results confirm that even on sandy Ultisols, 34 years of conservation tillage increased SOC and TN in the surface 15 cm by 4 and 2 Mega-grams per hectare, respectively, compared to conventional tillage practices, thus supporting its use to revitalize fertility and soil health of Southeast USA Coastal Plain soils.

O 3.6.17

Relations between the soil organic carbon pools and crop yield in long term no-till system

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The benefits of the soil organic C (SOC) accumulation to soil quality are well known. However, there is still little information relating the effect of SOC in crop yield. As the crops yield is restricted by the most limiting factor to each kind of culture and situation specifically, it's not possible to generalize results, and it's necessary to study each case individually to after expand results. So, the aim of this study was to analyze the relationship between the SOC pools and yields of soybean, corn and wheat on a farm in the Campos Gerais region, in Paraná state that has been managed under no-till system for 30 years. Deformed samples were collected in five depths in all major soil types on the farm (Oxisols, Inceptsols and Entisols, by USDA soil taxonomy) at all landscape positions (Upper third, middle third and lower third of the ramp), totalizing 98 places of sampling. SOC, total N (TN), permanganate oxidized C (OXP-C), hot water extracted C (HWE-C), soil texture and chemical soil variables were analyzed and was calculated the C management index (CMI) and the soil resilience index (SRI) to relate with the yields of soybean, corn and wheat. The data were analyzed through a principal components analysis and were adjusted regressions between crop yields and other variables. The yields of soybean and wheat showed a positive relation with the SOC and the TN. The corn yield showed a positive relation with the HWE-C. The positive effects of SOC on soil aggregation and cation exchange capacity can explain the observed relations for soybeans and wheat and the mineralization of the organic N can help to explain the relation observed in corn. In adjusted regression, between the soil variables and the wheat yield, the SOC and the TN was the organic matter variables that contributed most and of the chemical variables the Ca was the variable that contributed most to explain variations in wheat yield. The SOC had a positive effect in crop yields and the N mineralization helps to explain these effect. The wheat yield showed a greater correlation with the total amount of N in soil and the corn yield showed a greater correlation with the HWE-C (that present a great correlation with soil microbial biomass).

P 3.6.01

The effects of the change of usage of the forest lands in to agricultural lands in North of Iran

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In this study, eighteen plots of the forest, agricultural and residential areas were chosen randomly (all of these areas were on the same slope, aspect and parent material). In any point of the surface layers of the soil (0-30cm), the samples were taken, while the determination of the geological characteristics and identification of the plant species were carried out, and the samples of the soil were analyzed physically and chemically. the results of the experiments showed that because of the change of usage of forest lands into residential and agricultural lands, the specific gravity of the surface soil has increased, the space of the pores of the soil decreased, the percentage of the organic mater also decreased , and the acidity of the soil in this area has guided from the weak acidity to the weak alkalinity. According to the results of the experiments, the change of the usage has no effect on the change of the texture of the soil in this area.

Key words: soil chemical, soil physical, agricultural lands, land use change.

P 3.6.02

Determination of the condition of the existing food elements in soil And leaves of natural side of yew tree in north of Iran

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Abstract

For investigation of this research , the net stocks and also mixed stocks with hardwood were chosen in vaz research forest , then in each of these stocks , we determined plots of 500 squares meters .in the center of each of these plots ,we dug a profile while were determining some of the specifications of the soil such as structure ,color, texture ,consistency, depth of soil , and carried out sampling out of each horizon. Then we transported the soil samples together with samples of leaves of yew tree to the laboratory ,and the experiments of the rate of N, P,K,Ca, Mg,pH and Ec were carried out on each of the soil sample and also the experiments of the percent rate of N,P,K,Ca and Na on the leaves samples and the rate of Zn and Fe on the leaves samples were determined .the results of the experiments showed that the yew stocks located in the North of Iran grew mostly on the soil slight acidic pH up to alkaline. In terms of technical specifications of soil texture, this plant grew on the soils having texture of loam and silt loam. The rate of their N,K,Ca and Mg was rather satisfactory, but in terms of the rate of P,we observed some deficiency in some of the natural sites.in terms of the rate of the existing food elements in leaves in series which were in the form of net stocks of yew trees ,the of rate their K and P were less than the rate of the mixed stocks with hardwood trees, , and also in terms of the rate of the quality and quantity of the growth ,the mixed stocks with hardwood trees were in better condition of growth in comparison with the other net stocks.

Key words: Nutrient, North of Iran, leaf, soil, yew tree

P 3.6.03

Effect of two organic fertilizers on metribuzin herbicide degradation in agricultural soil

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Herbicides due to their expanded usage around the world have a high potential for contaminating of soil and water sources. The objective of this investigation was to study the influence of two organic fertilizers on metribuzin herbicide degradation in agricultural soil. Experiment was conducted in completely randomized design with 3 replications in Ferdowsi University of Mashhad-Iran. Experimental factors included 2 organic fertilizers (municipal waste compost (MC) and sheep manure (SM)), in 2.5 percent rate (w/w) with control treatment (non organic fertilizer application (NF) and incubation periods (0, 5, 15, 30, 50, 90 and 120 days). Soil samples was mixed with metribuzin at a rate of 5 $mg.kg^{-1}$ soil. Metribuzin residue was measured with HPLC. Data were fitted to the first order kinetic equation for analysis. Results showed that both organic fertilizers had a significant effect on metribuzin degradation and half life in soil. Metribizin degradation coefficients (K) in MC and SM treatments were 1.36 and 1.17 times NF treatment respectively. Metribuzin half life in mentioned treatments was 87 and 109 days respectively, that were significant lower than NF treatment (119 days). It seems that application of organic fertilizers have an important role on metribuzin bioremediation from agricultural soils.

P 3.6.04

Study of herbicide degradation in agricultural soil as influenced by organic fertilizers

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In order to the effects of organic fertilizers on metribuzin persistence and degradation in soil, an experiment was conducted in completely randomized desing with factorial arrangement and 3 replications in research field of Ferdowsi University of Mashhad-Iran. Experimental factors included 2 different organic fertilizers (municipal waste compost (MC), poultry manure (PM)), application at 40 ton per ha^{-1} with control treatment (non organic fertilizer application (NF)) and metribuzin application rate (525 and 1050 a.i g. ha^{-1} (WP %75)). For determination of metribuzin residue, soil sampling was taken from 0 to 15 cm soil depth at 0, 3, 7, 15, 30, 55, 90 and 120 days after application of metribuzin. Metribuzin residue was measured with High Performance Liquid Chromatography (HPLC). Results showed that metribuzin degradation rate increased with organic fertilizers application. increasing metribuzin application rate increased residue in soil, but it had not effect on metribuzin half life significantly. So that metribuzin degradation in MC and PM treatments was higher than other treatments. Metribuzin half life 525 g. ha^{-1} was 66 days in NF treatment and 46 and 50 days in MC, PM treatements respectively. Based on this results application of organic fertilizers affect the microbial populations and their activities may have an important role in metribuzin biodegradation in soil.

P 3.6.05

Tillage, Crop Rotation, and Cultural Practice Effect on Dryland Soil Nitrogen

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Management practices may influence dryland soil N cycling. We evaluated the effects of tillage, crop rotation, and cultural practice on dryland crop biomass (stems and leaves) N, surface residue N, and soil N fractions at the 0-20 cm depth in a Williams loam from 2004 to 2008 in eastern Montana, USA. Treatments were two tillage practices (no-tillage [NT] and conventional tillage [CT]), two crop rotations (continuous spring wheat [*Triticum aestivum* L.] [CW] and spring wheat-barley [*Hordeum vulgaris* L.] hay-corn [*Zea mays* L.]-pea [*Pisum sativum* L.] [W-B-C-P]), and two cultural practices (regular [conventional seed rates and plant spacing, conventional planting date, broadcast N fertilization, and reduced stubble height] and ecological [variable seed rates and plant spacing, delayed planting, banded N fertilization, and increased stubble height]). Nitrogen fractions were soil total N (STN), particulate organic N (PON), microbial biomass N (MBN), potential N mineralization (PNM), NH_4-N, and NO_3-N. Crop biomass N was 30% greater in W-B-C-P than in CW in 2005. Surface residue N was 30 to 34% greater in NT with the regular and ecological practices than in CT with the regular practice. The STN, PON, and MBN at 10-20 and 0-20 cm were 5 to 41% greater in NT or CW with the regular practice than in CT or CW with the ecological practice. The PNM at 5-10 cm was 22% greater in the regular than in the ecological practice. The NH_4-N and NO_3-N contents at 10-20 and 0-20 cm were greater in CT with W-B-C-P and the regular practice than with most other treatments in 2007. Surface residue and soil N fractions, except PNM and NO_3-N, declined from autumn 2007 to spring 2008. In 2008, NT with W-B-C-P and the regular practice gained 400 kg N ha^{-1} compared with a loss of 221 kg N ha^{-1} to a gain of 219 kg N ha^{-1} in other treatments. No-tillage with the regular cultural practice increased surface residue and soil N storage but conventional tillage with diversified crop rotation and the regular practice increased soil N availability. Because of continuous N mineralization, surface residue and soil N storage decreased without influencing N availability from autumn to the following spring.

P 3.6.06

Integrated use of biogas slurry and biofertilizer: A promising approach for sustainable agriculture and environment

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Solid wastes management is an emerging issue all over the world including Pakistan. Thousands of tons of agricultural wastes are produced in Pakistan and are deteriorating the environment. These wastes are good source of nutrients and are successfully be used for biogas production. This approach not only useful for managing solid wastes and biogas production but biogas slurry obtained as by-product can also be used as soil conditioner and source of nutrients in agriculture. Some plant growth promoting rhizobacteria (PGPR) have the ability to improve plant growth through different plant growth promoting traits. The dependence on costly chemical inputs could be reduced by the integrated use of organic sources, chemical and biofertilizers. Combined use of chemical, biofertilizers and manures is important to sustain high crop yields without deterioration of soil fertility. A pot experiment was conducted to study the effect of integrated use of PGPR and biogas slurry in the presence of chemical fertilizers for sustainable production of maize. Results showed that combined application of PGPR and biogas slurry improved maize growth and soil fertility. It increased the plant height (33%), root length (14%), shoot fresh weight (75%), shoot dry weight (57%), root fresh weight (92%), and root dry weight (90%). It also increased the macronutrient concentration both in plant and soil. The integrated use of PGPR strains PsJN + 6K along with biogas slurry in the presence of chemical fertilizer was better as compared to other treatments. It may be concluded that combined use of these PGPR strains and biogas slurry may be explored in extensive field trials for improving maize growth and soil fertility in semi-arid conditions of the region. This approach not only improves agricultural productivity but also saves environment from deterioration.

P 3.6.07

Quality Management Practices in Cocoa Production in South - Western Nigeria

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The main objective of this study was to investigate quality management practices in the major cocoa production areas of Nigeria. Socio-economic surveys covered resource quality, agronomic practices, and constraints to agricultural production, whereas soil sampling and analyses were carried out to assess contribution of soil to yield. Farm budget analysis was used to determine the profitability of the two major management options of sampled farmers. Linear multiple regression was used to relate biophysical and agronomic data to cocoa yield.

Owing to high level of multi-collinearity, independent variables were reduced to six which are organic C, age of farm, plant density, proportion of dormant plants replaced, crop variety and ECEC. Among the variables in the model, two (organic C and age of farm) were negatively related to cocoa yield, whereas other variables were positively related to cocoa yield. However, soil variables were not significant to the model ($p > 0.05$), whereas three management variables (plant density, proportion of dormant plants replaced and crop variety) were significant ($p < 0.1$).

All the variables explain 97% of the variability of yield and the model can be used to predict yield at 99% confidence level. Results indicated variability in yield across the three main locations studied. The highest yields were obtained in areas where farmers have access to training in management practices.

Soils of the three locations were not significantly different from one another in terms of chemical properties. This probably reflects similarity in the parent materials from which the soils have developed. Farm budget analysis revealed that minimal management involving fertilizer and pesticide use was less profitable than extensive management. For sustainable cocoa production in the study areas, a high premium should be placed on the quality of cocoa product for export.

Keywords: Cocoa production, farm budget, linear multiple regression, management, quality

P 3.6.08

Characterization of Humic substances extracted from submerged rice soil

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Humic substances are the most active components of soil organic matter and have been shown to have an hormone-like activity thus stimulating plant growth. To elucidate the effects of humic substances, several hypotheses suggesting the formation of a complex between these substances and mineral ions, their involvement in the enhancement of enzyme catalysis, their influence of stimulating respiration, photosynthesis and nucleic acid metabolism, and their hormonal activity have been reported. All these functions are governed by the functional groups present in the humic substances. Field experiment was conducted during kharif 2009 and 2010 with rice as the test crop using different vermicomposts under integrated nutrient management at Regional Agricultural Research Station, Anakapalle, Andhra Pradesh of India to study the behaviour of functional groups of humic substances extracted from the soil treated with vermicompost under submerged conditions. Humic acid content extracted from different treatments varied from 0.20 to 0.37 per cent during 2009 and 0.18 to 0.43 per cent during 2010. Highest humic acid content was recorded in the treatment which received 75 % recommended dose of nitrogen fertilizers + vegetable market waste @ 2.5 t ha^{-1}. In both the years vegetable market waste vermicompost performed better than other sources of vermicomposts and it was on par with 75 % chemical fertilizers + weed compost @ 2.5 tha^{-1}, 50 % chemical fertilizers + vegetable market waste vermicompost @ 2.5 tha^{-1} and 100 %. Micronutrient availability also more in these treatments. Total acidity of humic acid was 422 cmol (p+) kg^{-1} and that of fulvic acid was 674 cmol (p+) kg^{-1} indicating that fulvic acid had higher total acidity than the corresponding humic acid. The carboxyl group content of humic acids was 237 cmol (p+) $kg^{-1}$and that of fulvic acid was 362 cmol (p+) kg^{-1}. The carboxyl group content was higher in fulvic acid than in humic acid. The phenolic -OH groups of humic acid and fulvic acid were 185 and 312 cmol (p+) kg^{-1}, respectively. The potentiometric titration curves of humic and fulvic acids were sigmoidal in nature indicating the weak acidic character and buffering capacity of the soil was increased with vermicompost application by evidenced through potentiometric and conductometric titration curves of the soils.

P 3.6.10

Promoted soil bioactivity with carbon stabilization under long term rice cultivation: Lesson from a tidal marsh derived rice soil chronosequence

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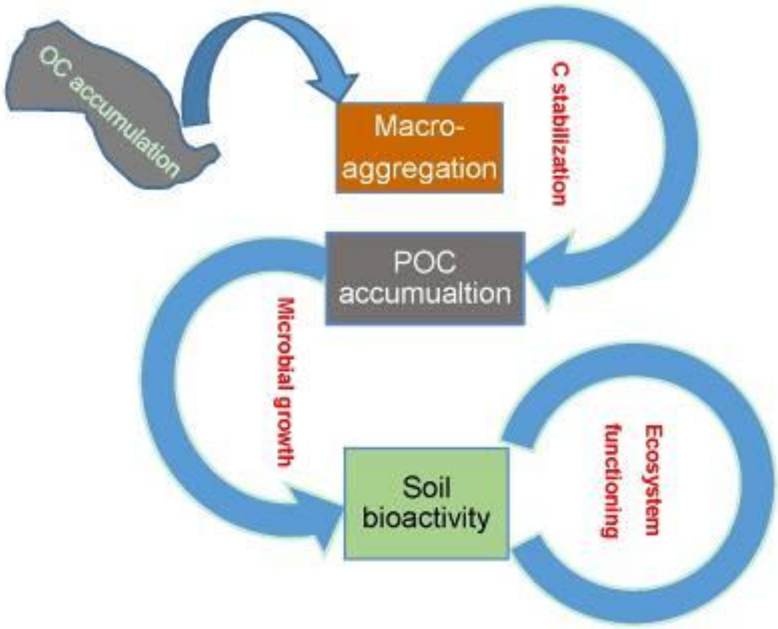
Soil organic carbon (SOC) sequestration with enhanced stable carbon storage has been widely accepted as a prestige ecosystem property. Yet, the knowledge gap between carbon stability and bioactivity for ecosystem functioning with OC accumulation in field soils has not yet been quantitatively characterized. In this paper, we assessed the changes in microbial activity versus C stability of a soil chronosequence of rice cultivation over centuries from East China. Topsoil samples were collected of a series of soils under rice cultivation of 0, 50, 100, 300 and 700 years. Soil basic properties, aggregate distribution, carbon pools, carbon sequestration potential as well as microbial biomass, community structure, soil respiration and enzyme activities were assessed were analyzed. We used mean weight diameter (MWD) for addressing soil aggregation, normalized enzyme activity (NEA) for microbial bioactivity and carbon gained from exotic input for soil C sequestration functioning. In addition, a response ratio was employed to infer the changes in all analyzed parameters with rice cultivation. While stable carbon pools in line with SOC accumulation, soil respiration and both bacterial and fungal diversity were almost constant in the rice soils. However, bacterial abundance and NEA were positively but sharply correlated to SOC accumulation, indicating an enhanced bioactivity with carbon stabilization. This could be linked to a prominent enhancement of particulate organic carbon pool (POC), which was shown in a function of MWD. Soil respiration, microbial biomass and soil properties showed an insignificant or slight response to prolonged rice cultivation. In contrast, both labile and stable carbon pools and enzyme activity exerted steady positively logarithmic responses, and bacterial abundance, bacterial to fugal ratio and microbial C use efficiency showed sharply linear responses to prolonged rice cultivation. This study found that carbon sequestration and stabilization could provide high bioactivity for ecosystem functioning where POC was preserved due to physical protection with enhanced soil aggregation in agricultural soils (Fig. 1).

Figure 1



P 3.6.11

Does Soil Amendment with Biochar and Compost Enhance Soil Quality and Reduce Contaminant Bioavailability/Leaching?

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Recent studies endeavor the application of *in-situ* metal stabilization via low-cost amendments of contaminated soils using biochar and compost. Depending on the site conditions, it is uncertain whether the soil qualities can be enhanced and metals/metalloids can be immobilized in the long term. This study explored the potential use and role of soil amendments by various types of waste-derived biochars and green waste compost after chelant-enhanced metal extraction. Two types of contaminated soils were investigated: e-waste recycling site in Guangzhou, China that was contaminated by Cu, Zn, and Pb; and timber treatment site in Papanui, New Zealand that was contaminated by As, Cr, and Cu. After 2-h soil washing with a biodegradable chelant for metal extraction, 10 wt% of different biochars and/or coal fly ash were mixed with e-waste soil, whereas 10 wt% of green waste compost and/or acid mine drainage sludge were blended with timber treatment soil. The stabilized soils incubated for two months and analyzed with respect to the leaching potential under acidic rainfall, standard leachability, phyto-availability, bioavailability, microbial toxicity, and enzyme activities. This study revealed interesting yet mixed influences of soil amendments with biochars and compost in terms of soil quality and contaminant bioavailability and leaching potential, depending on the characteristics of metals/metalloids, types of amendments, and performance indicators / biological endpoints of concern.

P 3.6.12

Impact of Changing Land-Use and Hydrology on Soil Organic Carbon Dynamics in Beef Cattle Agroecosystem

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Basic information on the ecological understanding and the responses of systems to water regime change is essential for maintaining ecosystems environmental integrity and productivity. Flooding of formerly drained areas is common practice in wetland restoration. Such practice could profoundly affect microbial and chemical processes underlying nutrient transformations, especially pathways for soil organic carbon (SOC) formation and accumulation. There is a major need to understand the historical condition and chemical/biological functions of the ecosystems following a conversion of wetlands to agricultural functions. To better understand SOC dynamics during reconversion of former beef cattle pastures to wetland, soil core samples were collected from both systems in the southeast area of Florida, USA. This region has a long history of beef cattle production on formerly wetland soils. Soil core (0-20; 20-40; 40-60 and 60-100 centimeter) samples were collected from 11 locations in the beef cattle pasture and four locations in the adjoining natural wetland with a hydraulic sinker drill sampler. The total SOC in the upper meter of soil under a wet condition (164 milligram per kilogram) was significantly higher than the total SOC in soil under dry condition (45 milligram per kilogram). Over 50 years, we found that draining these natural wetlands to sustain grazed pastures resulted in very pronounced reduction of SOC from 180.1 to 5.4 gram per kilogram. The concentration of SOC was reduced by 96% over the periods of land use conversion. It appeared that conversion of wetland was proceeding toward a soil condition/composition similar to that of mineral soils. The concentration of SOC was seven-fold higher in wet condition than in dry condition in the surface soil, but there were no differences below the 20-centimeter soil depth. Concentrations of SOC for both the wet and dry conditions generally decreased with soil depth. These results are important in establishing baseline information on soil properties in pasture and wetland prior to restoring and reconverting pasture back to wetland conditions. The results further suggest that changes in SOC due to changing land use and hydrologic conditions could provide long lasting information affecting ecosystem productivity.

P 3.6.13

Soil fertility limitations of straw use for bioenergy provision on different temporal and spatial scales

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How can biomass for energy be provided without competing for agricultural production areas and corresponding land use change effects? One solution is the activation of previously nearly unexplored agricultural co-products and residues like cereal straw for bioenergy supply. Against this background, it is likely that the removal of organic matter from croplands will increase. But straw is, especially in cash crop regions, the main responsible for humus reproduction and thus important to preserve the fertility of arable soils. Therefore, sufficient return of organic matter is necessary to ensure long term availability of this energy source.

Several studies highlight the potential contribution of straw to renewable sources of energy while sustaining soil fertility and found remarkable CO_2 reduction potentials in comparison to fossil energy provision. However, different limitations can influence the theoretical, technical, ecological and economic potential of cereal straw. These restrictions, in particular for soil fertility, can vary strongly on different spatial and temporal scales.

A comparative study on the different scales of region, farm and field over one decade will illustrate the prospects and limitations of straw provision for bioenergy. Additionally the application of compensatory measures will be evaluated on farm and field scale within this framework.

P 3.6.14

Effect of Biogas Bio-slurry Application on Improving Yield of *Tef (Eragrostis tef)* and Properties of Cambisols, northern Ethiopian Highlands

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Biogas technology was introduced to Ethiopiasome fifty years ago. However, benefits expected from the technology are not yet fully explored. A field experiment on the effect of bio-slurry on *Tef* yield and soil properties was carried out on Cambisols during the 2013 and 2014 rainfed seasons. The experimental layout was a randomized complete block design with treatments of three levels of nitrogen (0, 23, 46kgN/ha), three levels of phosphorus (0, 23, 46kgP/ha) and three levels of bio-slurry (0, 9, 12t/ha) fertilizers set to a total of 11 treatment combinations, and all replicated three times. The soil had pH 7.18, organic carbon of 1.09%, total N of 0.11%, available P of 4.68mg/kg, and exchangeable K of 0.1mg/kg. The bio-slurry used had pH of 8.14, organic carbon of 33.45%, total N of 1.43%, total P of 1.05mg/kg and total K of 1.81mg/kg. The results indicate that biomass and grain yield, plant height, tillers per plant, seeds number per head, and spike length of *Tef* with application of 46kgN, 46kgP and 12ton of bio-slurry per hectare were significantly (*pp) higher than that on the control while soil pH, electrical conductivity, and exchangeable Na and Mg were non-significant. These results imply that biogas technology can have multiple benefits for enhancing nutritional security and soil health especially for countries in the sub Saharan Africa.*

Keywords: Biogas bio-slurry use, *Tef* yield, Partial budget, Soil property,Ethiopia

P 3.6.15

Effect of Spring-Sowing Rye(*Secale cereale* L.) as SOM to Produce Soybean in Korea

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This study was carried out for a scientific verification of organic soybean farming system by private practice using the Rye(*Secale cereale* L.) from 2006 to 2007 at the experimental-field in Anseong-si, Korea.

A highest yields of soybean was achieved at the plot which the Rye was sowed on 20th March with two-hollow and 70cm row-space. It can be seen that there was no significantly differences on soil properties between the Rye treatments. Weed control values and soybean yields were the best on 20 March. It's because the better biomass of rye showed the better weed suppression rate. Second year of experiments, main plots consisted of rye sowing season (autumn and spring sown), and sub plots consisted of rye cultivate treatments (living mulch, conventional rotary, mowing rye) and planting conditions (dense and wide planting). Autumn and spring sowing of rye suppressed weeds effectively. However spring sowing must be sown earlier in order to have sufficient biomass. Living mulch was more effectively suppressed weeds than rotary or mowing treatments. Dense planting was effectively suppressed weed than wide planting. Overall weeds control value using rye intercropping was about 80% or higher. Incidence leaf rate of frogeye leaf spot, bacterial pustule, rust, anthracnose and powdery mildew with rye intercropping was 34.4%, 19.2%, 0.8%, 0.2% and 0.1%, respectively. The damaged grain rate appeared by bugs was higher with rye intercropping(19.2～39.1%) than untreated control(17.2%) and that by pod borer was higher with rye intercropping(0.8～4.6%) than control(0.6%). The frogeye leaf spot survey result in vinyl cover and topping existence and nonexistence lowly appeared 15.8% of vinyl cover and topping more than 55.8% of not topping and vinyl cover. However the damage grain rate of bugs and soybean pod borer not significant difference in vinyl cover and topping existence and nonexistence. We investigated effectively control of environment-friendly agricultural materials by soybean principal disease of insect pest. In case of frogeye leaf spot appeared 19.2～39.1% of Sillus treated lower than 17.2% of untreated. However the damage grain rate of insect was ineffective by field test of five environment-friendly agricultural materials.

Consequently could not keep principal disease and insect pest of soybean, introduction of rye intercropping. However if treatment of environment-friendly agricultural materials with vinyl cover and topping effectively prevented principal disease and insect pest of soybean.

Figure 1

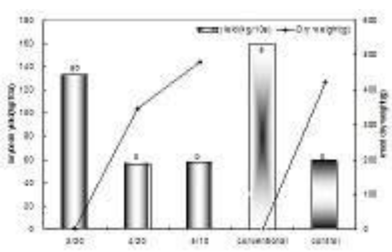

Figure 2

P 3.6.16

Change of soil organic matter composition and stability against microbial degradation over time as a response to wood chip ash fertilization

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Introduction: Recirculation of nutrients from wood chip combustion by ash fertilization in forest eco-systems has been used to re-introduce nutrients that are otherwise lost, to counteract depletion due to whole tree harvesting. It is unknown how this affects SOM composition and stability against microbial degradation over time.

Objectives: The aim of the study is to investigate how ash fertilization of forest soils affects SOM composition and stability over time.

Materials & methods: O-horizon and 0-5 cm mineral soil samples were collected from two coniferous forest sites in Finland and in Denmark where ash had been spread at different times. Sampled treatments included: no ash applied (Finland), and three treatments with increasing time since ash fertilization of 3-4 t ash ha^{-1} of 3 (Denmark), 14+3 (Denmark) and 23 years (Finland). Changes in SOM biodegradability was estimated based on cumulated CO_2-C respired after a 78 days incubation experiment; expressed as a % of initial C. Change in SOM composition was characterized using CO_2 evolved during thermal analysis by heating the soils from ambient to 800 °C at a rate of 10 °C min^{-1} under CO_2-free air atmosphere and by Fourier transform mid infrared photoacoustic spectroscopy (FTIR-PAS) analysis on bulk soil samples. Principal component analysis (PCA) was used to reveal the thermal analysis and FTIR-PAS features explaining main differences in SOM composition across treatments. Partial least squares regression (PLSR) was used to relate SOM composition, as characterized by thermal analysis and FTIR-PAS, to biodegradability of SOM.

Results: Ash fertilization significantly increased the pH and the % of initial C mineralised in the O-horizon, while the mineral horizon only displayed significantly greater pH in the ash treated soil compared to no ash applied in the Finish site. Ash fertilization had no effect on the total C or N content for both sites and horizons. Thermal analysis and FTIR-PAS revealed that ash fertilization changed the composition of SOM in the O-horizon but not in the top 5 cm of the mineral soil. The focus is therefore on results from the O-horizon in the following. PCA analysis based on FTIR-PAS data revealed an increased absorbance in the spectral range 800-600 cm^{-1} attributed to Fe- and Al-oxides/hydroxides in ash fertilized soil, independent of time since ash application. The thermal stability of SOM was likewise changed as SOM was less thermally-stable the longer time since the soil had received ash. This was seen as a peak in the PCA loadings based on the thermal analysis curves at 325-425°C.

PLS regressions based on FTIR-PAS and thermal analysis data revealed that changes in SOM biodegradability due to ash fertilization were related to changes in SOM composition similar to the changes evidenced by PCA analysis and thermal analysis presented above. These relationships were likely due to a covariance rather than to a direct correlation, as changes in SOM biodegradability were more likely due to an increase in soil pH rather than to changes in SOM composition. As SOM mineralisation rate increased, the microbially processed fraction of SOM probably increased; thereby increasing the thermally labile fraction of SOM, an effect seen to increase over time since ash application. We hypothesise that the long-term effect of ash fertilization to forest soil on SOM biodegradability can either be due to an initial increase in soil pH right after ash application, promoting SOM turnover with an ongoing effect even 23 years after ash application; or, due to a continuous and slow buffering of the natural acidification in the forest soil from decomposing needles over time. This slow buffering capacity of ash is possible as a chemical stabilisation of the ash occurs naturally as reactive oxides in the ash are slowly being transformed into more stable compounds like hydroxides and later-on carbonates doing reactions with water and CO_2.

Conclusion: Ash fertilization of forest soils had an effect on SOM composition in the O-horizon but not in the top 5 cm of the mineral soil. The pH and biodegradability of SOM were significantly increased in the O-horizon. Changes in SOM composition were evidenced, consisting of an enrichment in Fe- and Al-oxides/hydroxides and a lower thermal stability in soils with older ash application. The increased pH due to ash fertilization likely stimulated SOM turnover, which in turn increased the labile fraction of SOM whereby the thermal stability of SOM decreased as more simple compounds were formed.

P 3.6.17

Influence of some soil parameters on comparability of two methods of soil organic carbon determination

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1. Introduction

Soil organic carbon (SOC) is a crucial part of soil organic matter (SOM); it represents an important component of the overall C-Pool and as a SOM component is an important parameter in assessing the quality of soil. The SOC determination ranks-according to the analytical method used-either to risky or relatively costly methods. Using the "classical" volumetric method by application of oxidizing action of chromic acid in sulfuric acid the laboratory staff is exposed to very aggressive solutions. In addition, potassium dichromate is being considered as carcinogenic, mutagenic and teratogenic substance. From this point of view it is possible to similarly characterize the spectrometric determination of SOC. Determination of a "total" content SOC (C-total analyzers) is considered as a highly productive and accurate method, if it is ensured a perfect homogeneity and representativeness of the soil sample. In the case of carbonaceous soils, this requires the preliminary removal or simultaneous determination of carbonate content. The crucial factor is, of course, the affordability of this analyzer.

However, even relative simple combustion of the soil sample in the muffle furnace and application of a loss-on-ignition method (LOI) is not without problems and methodological uncertainties. Essentially, overall protocols unify the maximal combustion temperature near to 530 °C, especially in presence of soil carbonates ($CaCO_3$ decomposition, respectively $MgCO_3$ which starts thermally dissociate even at a lower temperature). Often it is discussed the over-estimating influence of structural water from clay mineral present in larger quantities in the soil sample, which can be released at combustion temperature above 400 °C.

It seems within SOC determination there are still yet some ambiguities and its parameters should be rather targeted at a specific soil set than to develop a universal protocol.

2. Objectives

The framework of the project, aiming to other issues, characterizes the quantitative and qualitative parameters of SOM, it arose an issue of the objective assessment an economical and environmental-friendly method to quantify the SOM concerned.

The aim of this work was to compare two frequently used methods of SOC determination, namely volumetric Walkley-Black (W-B) and the LOI method evaluating their efficiency under different soil parameters.

3. Materials & methods

Both methods have been applied to not too populated (n=42), however as for as soil parameters heterogeneous enough set of soil samples. The content of soil carbonates ($CaCO_3$ or $CaCO_3.MgCO_3$) in some samples ranged from 1 % to 38 % with average of 11 %. Clay content varied from 9 % to 51% with average 26 %.

In LOI method, 10 grams of a soil sample grounded to pass 0.25 mm sieve was weighed into a porcelain crucibles and these ignited in muffle furnace for 1 or 10 hours (h) at 373 °C, for 8 h at 460 °C and for 6 h at 530 °C. Experimental results were evaluated graphically and statistically.

4. Results

There is a close correlation between SOC determined by W-B and LOI method at any ignition temperature (Figure 1). On the other hand, the W-B method appears as very little effective even comparing with the lowest ignition temperature. From inverse function to dependence LOI at 373 °C on W-B method results that this volumetric method determines only 67.6 % of the SOC, evaluated by this low temperature LOI mode.

However, additive gain for LOI at this temperature and 10 h ignition was only small (by 7.6 %) but significant. From this point of view, W-B method shares, comparing the LOI temperatures 460 °C and 530 °C only 51 % and 47 %, respectively.

On the other hand, none statistically significant bias, especially towards LOI enhancement values due to a positive influence of carbonates or/and clay's structural water was detected. This held true even at LOI ignition temperature of 530 °C. It seems that even LOI temperature as low as 373 °C is significantly more efficient at SOC determination comparing it with W-B method for this soil set. Correction factor about 1.5 should be introduced to equalize results of both methods for this case.

5. Conclusion

Two common methods of SOC determination were applied within soil set having parameters potentially possible to influencing accuracy and reproducibility this determination. It has proved that LOI ignition temperature up to 530 °C probably did not affect soil carbonate decomposition and clay's structural water releasing. On the other hand, the W-B method accounted for only 67.6 % of the SOC value determined by the lowest ignition temperature of 373 °C.

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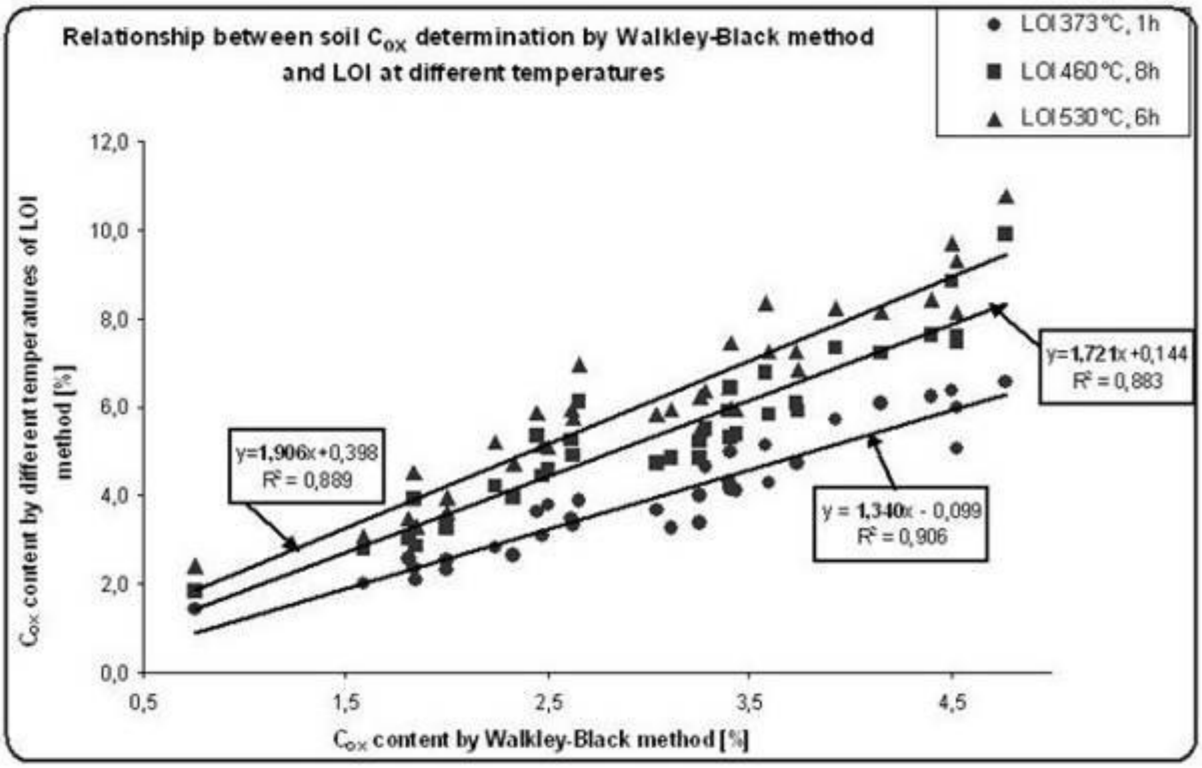
Figure 1



P 3.6.18

Recouvery of Soil Carbon Stock after Three Decades under No-Till Management in Southern Brazil

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In soils under undisturbed ecosystems as native vegetation (NV), the soil carbon content (C) is in stable state where the input of organic residues is in equilibrium with C losses. The conversion of NV to agricultural systems causes a sharp decline in soil C stock especially when soil management is based on intensive and frequent tillage operations and limited crop residue input. However, the adoption of conservation system based on minimum soil disturbance and intensive cropping system can restore in some level the soil C stock. This study aiming evaluate the intensity of soil C stock recovery after three decades of no-till (NT) adoption in a cropland previously managed under conventional tillage in Palmeira das Missões, Rio Grande do Sul State, Brazil. The NT system was initiated in 1978 in a clay Typic Haplorthox with 600 g kg^{-1} of clay. Soil samples were collected in 5 soil depths in a soil profile (0-100 cm). The treatments were: a) mature NT with 33 years with the following crop rotation: maize/forage radish/wheat/soybean/black oat; b) reference= NV (Paspalum notatum). The soil C content was determined by dry combustion using a C/N analyzer. The soil C stock was calculated based on equivalent soil mass. The NT system associate with crop rotation after three decades was able to full restore the C stock in the topsoil (0-5 cm) considering the NV as reference. This soil layer is a key component to soil quality because concentrate the biological activity, crop root system and concentrate nutrients. The percentage recovery of the C stock from NT compared to NV was 114, 87, 79, 81, 81 and 83% for layers 0-5, 5-15, 15-30, 30-45, 45-60 and 60-100 cm. In the 0-100 cm the NV had 19% (26.1 Mg ha^{-1} C) more soil C than NT. Probably this result is associate to deeper root system of NV. Approximately 76% of the soil C was storage in the layer of 15-100 cm after. Therefore, NT associate with the intensification of cropping systems for long term was an efficient tool to restoration of soil C, playing a crucial role in ecosystem productivity, environmental and soil quality.

P 3.6.19

Impacts of Tourist Disturbance on Soil Properties and Plant Communities in Kanas World Natural Heritage Site

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The different disturbance of tourism on the species composition, species diversity and soil physicochemical properties of the Abies sibirica, Rosa acicularis and grassland communities were studied by methods of sampling in Kanas. The results showed that the species composition of the shrub layer and herb layer were different on the different tourist disturbance in the Abies sibirica communities, and finally the species diversity was lower with the increasing tourism disturbance intensity. The different disturbance caused the different Simpson index and Pielou index in different Rosa acicularis communities. The Shannon-Wiener diversity index trend down was affected as the disturbance increasing in grassland. The content of water and organic, the total nitrogen and the total phosphorus in soil decreased with the increasing intensity of tourist disturbance, but soil bulk density and the value of PH and the total potassium increased.

P 3.6.21

Glomalin in agricultural soils in the Czech Republic

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Introduction

Soil organic matter affects, among others, sorption capacity of soil, positively affects soil structure formation and thus influences water and air soil regime and susceptibility to erosion; represents a significant pool of soil carbon. Soil organic matter (SOM) is defined, most frequently, by Cox and Corg parameters, although these parameters do not provide any information about the quality of soil organic matter. There are other parameters which are more suitable for the qualitative description of SOM - ratio HA:FA or colour index Q4/6. The latter methods are more time-consuming and expensive than the former and they are not used massively in agriculture. At the turn of the millennium a new parameter, glomalin, came into awareness of the scientific community. Determination of glomalin is relatively easy and therefore we are thinking about its usage for soil quality evaluation. Glomalin is a glycoprotein creating hyphal wall of arbuscular mycorrhizal fungi (AMF). After hyphal decomposition glomalin is released and accumulated in soils and this fact seems to have very important consequences for soil. Glomalin in soil works as soil “glue”, forms large soil aggregates and in this way supports the creation of soil structure, erosion resistance, optimises water and air soil regimes. Glomalin content in soil is stable - decrease of glomalin is continuously compensated by dead hyphae and, essentially, it depends on the intensity of symbiosis between AMF and plants. AMF improve plant nutrition and plants supply them with the necessary carbon. The better the symbiosis between fungi and plants works, the more glomalin is produced.

Objectives

The study was aimed at obtaining data on glomalin content in agricultural soils in the Czech Republic, and evaluating glomalin content depending on land-use and soil types.

Materials and methods

For this study the data from Basal soil monitoring system programme was used. This monitoring programme was set up in the Czech Republic in 1992. The programme is focused on agricultural soils, monitoring the state and progress of various physical, chemical and biochemical parameters. The area of the monitoring plot is 1000 m^2 (25 x 40 m) and each plot is defined by geographical coordinates in terrain. Plots with unchanging land management from 1992 and plots on which no space changes were done were sorted out for data evaluation. Finally, 177 monitoring plots were assessed. Glomalin-related soil protein content was determined by Bradford assay in soil samples collected from topsoil in 2013.

Results

Data set for descriptive statistic and basic statistical analysis was divided according to land-use (arable soil, grassland, vineyard, orchard, hop-garden) and soil types typical for the Czech Republic. Median of the glomalin content in agricultural soils in the Czech Republic is 2,54 mg/kg. The highest median was determined for hop-gardens (3,28 mg/g), the lowest for arable soils (2,42 mg/g). Statistically significant difference was detected between arable soils and hop-gardens, esp. grassland. Maximum glomalin content (9,21 mg/g) was determined on plot with grassland, technosol. The technosol is created by backfill from tannery and slag from smelting shops.

Distribution of soil types in our monitoring data set copies the distribution of soil types in the Czech Republic. Cambisol is the most frequent soil type in the Czech Republic (45 %), followed by haplic Luvisol (12,7 %) and Chernozem (11,4 %). In the monitoring data set Cambisol is the most frequent soil type, too, followed by haplic Luvisol, Fluvisol and Albeluvisol. The distribution of glomalin content in individual soil types is highly variable and significant differences were determined between various soil types. For example, in Cambisols, the widest-spread soil type in the Czech Republic and soil monitoring programme, too, the range of glomalin content is0,5 - 5,24 mg/g (median 2,48 mg/g). A narrower interval of glomalin content values can be found in Chernozems (2,42 - 4,96 mg/g; median 3,37 mg/g), haplic Luvisols (0,91 - 3,28 mg/g; median 2,25 mg/g) and Albeluvisols (0,5 - 2,64 mg/g; median 1,91 mg/g).

Conclusion

Glomalin content was determined in soil samples from Basal soil monitoring system for the first time in 2013. Glomalin-related soil protein content was determined by Bradford assay. The range of glomalin content is 0,14 - 9,21 mg/g; median 2,54 mg/g. Glomalin was evaluated according to land-use and soil types. Significant differences were found for land-use and soil types, too.

P 3.6.22

Effects of biochar amendments on soil microbial biomass and nematode communities

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Soil microbial and nematode communities have been used as bioindicators of ecosystem and influenced by the soil environment. Multiple benefits of biochar addition to the soil physical and chemical characteristics have been reported. A greenhouse experiment was conducted to investigate the effects of biochar application on soil microbial biomass, nematode communities and cucumber production. The results showed biochar application significantly improved cucumber root growth and root biomass. Biochar addition increased soil microbial biomass carbon and nitrogen, and rate of microbial biomass carbon to nitrogen. The total nematode numbers and communities varied in the soil amended with 1% and 2% biochar. The relative abundance of bacterivorous nematodes decreased, while the abundance of plant parasites nematodes increased.

Key words: Biochar, soil nematode communities, soil microbial biomass.

P 3.6.23

Responses of soil properties, microbial community and crop yields to inorganic and organic amendments in a Swiss conventional farming system

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1. Introduction

Long term cultivation without organic fertilizers usually leads to a decrease in soil organic carbon (SOC) and in crop yield. However, with the increased accessibility to chemical fertilizers and farm specialization, the use of organic fertilizers has declined dramatically in some regions of Switzerland over the last decades. This raises the question of the maintenance of SOC content on farms without livestock.

2. Objectives

In a Swiss conventional farming system, we studied the long term (50 years) effects of different organic and inorganic amendments on soil properties and crop yields. The specific objectives were to (i) evaluate the influence of organic amendments on physic-chemical and biological soil properties and (ii) analyze the impact on crop yields.

3. Materials & methods

Three main fertilization practices were tested in a split-plot design: (i) mineral fertilization (*MIN*), (ii) crop residues incorporation with reduced mineral fertilization (*RES*) and (iii) farmyard manure application (10 t ha^{-1} $year^{-1}$) with reduced mineral fertilization (*FYM*). Two N rates were also tested as sub-treatments: an optimal dose of 120 kg N ha^{-1} according to the Swiss fertilization guidelines for wheat production (*N120*) and a limiting dose of 50 kg N ha^{-1} (*N50*). For the plough (0-20 cm) and subsoil (20-50 cm) layers, a set of physic-chemical soil analyses were performed (*i.e.* SOC, bulk density, different macro- and micronutrients fractions), whereas soil biology was characterized on the basis of microbial community (*i.e.* PLFA analysis and microbial fumigation) and earthworm population (*i.e.* characterization of eco-morphological groups). Statistics were performed according to linear mixed effects models.

4. Results

After 50 years, SOC was significantly higher in the plough layer (0-20 cm) when organic amendments were applied (P-value = 0.003). N-fertilization rates affected SOC as well: in N-limiting conditions, SOC content tended to be lower. Farmyard manure application improved chemical properties in comparison to mineral fertilization. Soil biology was significantly affected by the different fertilization practices. In the case of organic amendments, C, N, P microbial biomasses were higher and the total PLFA content was significantly increased (P-value = 0.018). No differences in the structure of microbial community were observed according to PLFA analysis. Earthworm populations reacted positively to N-fertilization in terms of biomass, whereas the nature of fertilizer had an impact on the community structure. An increase of the relative proportion of endogeic species was reported in case of farmyard manure application. In comparison to the common fertilization practice *MIN*, the highest crop yield (+3.5%) was observed in *FYM*, while *RES* presented variable but similar crop yield over the whole experiment.

5. Conclusion

In the long term, organic amendments improved the overall soil properties in relation with SOC. Biological communities reflected quantitative and qualitative differences in SOM. Crop yields significantly increased with farmyard manure application, but not when crop residues were incorporated.

P 3.6.24

The assessment of carbon management index in maize-based cropping systems

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Preservation of soil organic carbon (SOC) has become an essential task for maintaining soil productivity and yield stability. The influence of the individual management practice on the soil carbon are fairly understood, however the interaction and aggregate effects of cropping systems are more difficult to predict. Heterogeneous light fractions of the soil carbon are dynamic in their nature that impedes their interpretation. Carbon management index (CMI) is considered as sensitive indicator for assessing the quality of soil management systems and their effects on physical, chemical and biological soil attributes. To evaluate CMI arable soil samples were collected from the maize-based cropping systems in a long-term experiment in 0-20 and 20-40cm soil depth. The following maize treatments were analyzed: Control - monoculture - no fertilization; monoculture + NPK fertilization; monoculture + NPK + crop residue incorporation; monoculture + NPK + manure; maize + spring barley + manure; maize + spring barley + NPK + manure. Maize growing was based on conventional tillage including mouldboard ploughing. The result showed values of CMI ranged from 36 to 121 and higher were values were obtained for 20-40 cm soil depth compared with the top soil. This indicated that the processes of intensive carbon transformation are related with root activity. A 2-year maize rotation with barley and manure had CMI value of 121 that was significantly higher compared to all maize monocultures. Lower values of CMI index was observed at maize monoculture with NPK fertilization (36) and control (40) in the top soil. Crop residue incorporation and manure was found to be significantly correlated with CMI. Hence, higher moisture content of the 20-40cm soil layer could favor the microbiological activity. Therefore, a practice that involves residue retention and organic fertilizer that are playing a crucial role in SOC preservation in maize cropping. Likewise, CMI assessment showed that monocultures were a highly unsustainable option for maize growing. Obtained result could contribute to the understanding of C change in Chernozem related to the cropping management and could help in the preservation of soil organic carbon.

P 3.6.25

Effects of crop rotation and 10 years of biogas digestate application on POM fractions in an agricultural field trial under organic management

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Digestates from biogas production using grass clover, crop silage, maize and manure as feedstocks are becoming increasingly important as highly soluble organic fertilizers in organic agriculture systems in Germany. The influence of biogas digestates on soil organic carbon dynamics with respect to the different utilization efficiencies of different crop rotations (CR) for biogas production is not yet fully understood. The objective of this study was to analyse the transformation and decomposition dynamics of biogas digestate in organic farming CRs by means of an investigation of the particular organic matter (POM) fractions accumulating organic matter from biogas digestate.

Soil samples were collected in February 2014 from an agricultural field trial established in 2004 and situated on a Cambic Luvisol at Viehhausen near Freising. For this study, two CRs in an organic farming system for biogas and food production were compared (CR 5.2: grass clover - winter wheat - maize - sunflower; CR 6.2: grass clover - winter wheat - grass clover - grass clover), each CR divided into fertilized and unfertilized plots. The samples (0-10 cm) were taken in winter wheat.

The POM fractions (free POM, occluded POM) were isolated using density fractionation and ultrasonic dispersion. In addition to CPMAS ^{13}C NMR spectroscopy, an elemental analysis (C, N) of all fractions and total soil was conducted.

The C/N ratio of total soil in both CRs was higher (> 10) in the unfertilized plots than in the fertilized plots (< 10), while the organic carbon content was higher in the fertilized plots.

The amount of free POM was higher in the fertilized plots of both CRs than in the unfertilized plots. The increase was even higher for the amount of occluded POM in the fertilized plots. The fertilized soils and their fractions in both CRs had higher amounts of aromatic components (aryl C) than the unfertilized plots.

All samples showed a higher degree of degradation (alkyl C to O-alkyl C ratio) of the occluded POM compared to the free POM. A particularly high degree of degradation was found in free and occluded POM in the fertilized plots in CR 5.2 compared to the fertilized plots in CR 6.2.

The results indicate that fertilizing with biogas digestate affects composition, degradation and stabilization of organic matter in soil, but that the effects are dependent on crop rotation. These results can be used as the basis for more detailed investigation of the deposition of organic matter from biogas digestate in soils and the effects of CR.

P 3.6.26

Relationship between initial soil microbial diversity and the quality of exogenous organic matter: Effect on carbon stability of Soil Organic Matter

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In a context of global climate change, carbon management is an important point. Therefore, the strategy of sequestration of stable carbon in agricultural soils is the preferred option to offset emissions of greenhouse gases. In addition, from an agronomic point of view, changing agricultural practices by Exogenous Organic Matter (EOM) inputs, allows to significantly increase the organic carbon storage in soils.

The objectives of our work were to understand: i) the respective relationship between the chemical composition of Organic Waste Products (OWP) and the diversity of soil microbial communities, and ii) the effect of those communities on the degradation of organic matter.

This study concentrated mainly on four organic waste products: green waste compost, green waste-sludge compost, sewage sludge and cattle manure mature. The degradation of these OWP was studied by incubation at 20°C for 6 months, in two agricultural soils that have different microbial diversity status (Permanent Grassland PG, Arable Cropping AC). The OWP were made at constant carbon (4g carbon/kg dry soil).

The physicochemical characterization of the organic matter of the OWP and the soils was conducted to determine the total carbon and total nitrogen. Furthermore, thermal analysis has been proposed in order to assess their level of stability. Soil functional activity was measured through i) enzymatic activities including cellulase, xylanase, lipase, and alkaline phosphatase and ii) potential metabolic activity of heterotrophic bacteria with Biolog™ ecoplate well system (average well color development (AWCD) and Richness (R)). In parallel, the dynamic of carbon mineralization was followed.

Thermogravimetric analysis showed different levels of stability between the OWP. Indeed, the weight losses between 200 and 760°C was higher in order of importance, for the sewage sludge, green waste-sludge compost, cattle manure and green waste compost. These weight losses occurred mainly in two steps. At 210-320°C range, the peak observed was attributed to the combustion of carbohydrates, which were more important for sewage sludge (41%), even though the thermal degradation of the aromatic structures occurred at 400-679°C for green waste compost (16%). Moreover, the combination of these two results seemed to indicate that the organic matter is slightly more transformed in the first case than in the second. These results are in agreement with those obtained on the Van Soest biochemical fractionation of the OWP, and with *Organic Matter Stability Index (OMSI).*

Preliminary results during the first 21 days of incubation indicated changes in microbial functions depending on the time of incubation, the nature of the OWP and the initial status of microbial diversity of soils. Indeed, the monitoring of the measured variables often indicated significant changes at 8 and 14 days of incubation. Moreover, the microbial community from the PG soil was more active than from the AC one, if we consider the functional activities or the carbon mineralization. Finally, adding the OWP favored carbon mineralization in both soils. However, the effects on microbial functions were more nuanced. In fact, in the PG soil, the EOM input did not change functional activities. In contrast, in the AC modality, the metabolic activity was generally higher when the OWP were added. However, the enzymatic activities were not stimulated by inputs. Green waste-sludge compost was hardly degraded by cultivable bacteria. We found that the metabolic activity (R, AWCD) was low and equivalent to the AC soil. The same result was observed with the dynamic of carbon mineralization.

In summary, the first results of this study show that depending on the composition of the microbial communities of both soils and composition of the OWP, microbial activities seem to respond differently and more significantly for the AC soil and for stable OWP. To complete our study, it is necessary to conduct additional measurements on microbial community such as abundance (total DNA, carbon biomass) and diversity (bacterial and fungal DNAs) up to 6 months of soil incubation.

P 3.6.27

Adsorption of arsenate on a volcanic soil after organic matter reduction and thermal activation

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Extensive zones from different part of the world are exposed to high levels of arsenic due to geological conditions. Running and underground waters may be contaminated by As, being the population exposed to arsenic levels over the safety limits established by the OMS. In this work the change in the adsorption of arsenate from aqueous solution on a volcanic soil, after reduction of the organic matter content and thermal activation was studied. The soil sample was obtained from 20-45 cm depth of an Andisol soil namely Santa Barbara (SB, geographical coordinated: 36°50'S - 71°55'W). The organic matter (OM) content was determined by the Walkley-Black method [2]. Activation treatment was carried out by heating the soil sample in an oven at 350 °C (SB-350 sample). Arsenate adsorption was monitored through adsorption kinetic and isotherm assays. Arsenate in solution was analyzed by cyclic voltammetry using a gold electrode, a platinum counter-electrode and an Ag/AgCl reference electrode. As a result of the temperature treatment, the OM content decreases significantly (from 4.1 ± 0.5 to 1.0 ± 0.1). The arsenate adsorption kinetic for SB and SB-350 samples follows a pseudo-first order model; the maximum adsorption is achieved after 5 and 7 min, respectively. For SB sample the adsorption isotherm was well fitted by the Langmuir model, with a calculated maximum of arsenate adsorption of 18.0 mg g^{-1}. For SB-350 sample, the adsorption isotherm was fitted by the Freundlich model showing an experimental maximum of arsenate adsorption of 26.0 mg g^{-1}. The soil organic matter reduction associated to thermal activation increase in 44% the soil arsenate adsorption by increasing the positive surface charge of soil and exposing Fe-OH active surface sites of soil, where specific adsorption of arsenate occurs.

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P 3.6.28

Relationship Between Dissolved Organic Carbon and Dissolved Nitrate in Bukit Dua Belas National Park, Indonesia

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Background

Dissolved organic carbon (DOC) appears to be larger in the tropical forest soils than in the temperate forest soils because of the greater precipitation, substantial substrate supply, and related rapid decomposition (Kalbitz*et al*., 2000; Fujii *et al*., 2009). The DOC in the tropics is important because of its contribution to the soil organic matter formation. Excessive DOC leaching will lead to a decrease in soil fertility, and contaminate water bodies.

The vast majority of soils in the tropical forest are highly weathered and acidified because of intensive leaching over long periods of time (Eyre, 1963). As a result organic carbon loss and nutrients leaching from land ecosystem causes soils deteriorated and water pollution, in turn it would impact on ecosystem equilibirium as well as local community livelihood. One of the nutrient which very important for plant is nitrate. In soil, nitrate is produced by nitrification process. It is very mobile in the soil and easily leached by water percolation. The DOC and nitrate leached by water percolation in the soil profile will be affected by the position in a toposequence transect. The amount of leached DOC and nitrate and their relation should be evaluated because their leaching will lead to soil degradation.

The objective of this research was to evaluate the correlation between the amount of DOC and the dissolved nitrate leached within soil profiles in a toposequence transect.

Materials and Methods

Sampling site was located at Bukit Duabelas National Park, Jambi, Indonesia. We made six soil profiles with different position in 2 toposequence transect. Soil Solution was collected by lysimeters, draining a surface area of 200 cm^2, beneath the AO, AB, and B horizons. Then, the percolated water was collected by a precipitation collector in each soil profile under toposequence on the upper, middle, and lower forest slope.

The content of DOC and dissolved nitrate in the soil solutions were determined. Sample solutions were filtered through a filter with a 0.45 µm pore size (Minisart RC 15, sartorius, Hannover, Germany) before each analysis. The DOC concentration was determined by Non-Particulate Organic Carbon method using TOC-VCPH (Shimadzu). While, the dissolved nitrate was determined by UV spectrophotometry method using l 210 nm corrected by 275 nm. The amount of DOC and nitrate were calculated by multiplying each concentration with the volume of related percolated water.

Result and Discussions

The total amount of DOC and dissolved nitrate toposequently from June 2014 to January 2015 are presented in Figure 1. The results shows that toposequently the total amount of both DOC and nitrate are higher at the lower than at the middle and upper soil profile. In June and August 2014 when the rainfall was short, the value of DOC and nitrate are significantly different toposequently. While, in November and Januari 2015, the difference is not significant.

Figure 2 presents the different of total amount of DOC and nitrate between horizons. The data suggested that AO horizon is significantly have higher total amount of both DOC and Nitrate than AB and Bt horizons respectively. From June to October, the total amount of DOC and nitrate show decreasing trend. On the AO Horizon, total amount of DOC and nitrate was highest in November.

Figure 1. Total amount of DOC and Nitrate toposequently from June 2014 to January 2015

Figure 2. Total amount of DOC and Nitrate within soil profile from June 2014 to January 2015

The total amount of DOC and nitrate showed positive correlation (0.86). This suggested that the higher the total amount of DOC leached from the soil, the higher the total amount of nitrate leached.

Conclusions

Toposequently the total amount of leached DOC and nitrate were higher in the lower than in the middle and the upper profiles. Within soil profile, DOC and nitrate was higher in AO horizon than that in AB and Bt horizons. The total amount of DOC and nitrate show positive correlation (0.86).

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Figure 1

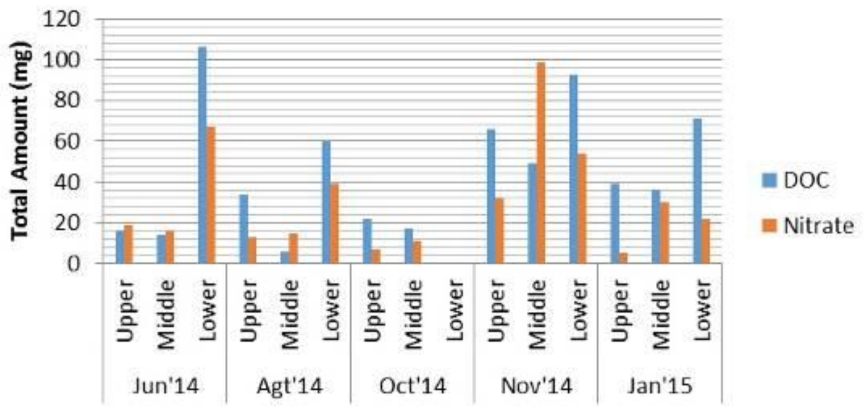
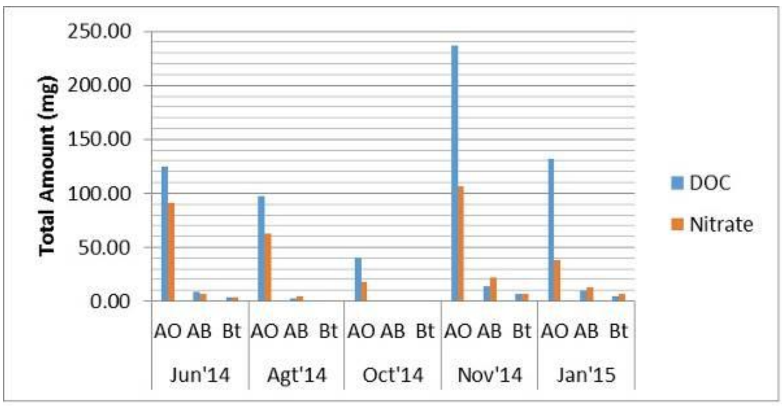


Figure 2



P 3.6.29

Ratios of chemically extractable and biologically active pools of organic matter in gray forest soil under different fertilizing systems

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Introduction

The content of soil organic matter (SOM) depends on the farming system. The use of different fertilizing systems affects the quality of SOM by changing proportions of the various fractions. The effect of mineral and organic fertilizers on chemical fractions of SOM isolated by water or salt and alkali solutions is well known. The active pool of SOM is responsible for short-term dynamics of carbon and for the implementation of most physicochemical, environmental and agronomic functions of SOM. The influence of different fertilizing systems on the active pool of SOM is less known and is still a challenge.

Objectives

(1) Determine the effect of long-term application of different fertilizing systems on the size of SOM active pool in gray forest soil.

(2) Find correlations between content of total organic carbon (C_{org}), chemically extractable and biologically active organic matter in gray forest soil.

Materials and methods

The study was carried out with gray forest soil, sampled from twelve fields at five farms in Tula region, practicing organic, organo-mineral and mineral systems of fertilizers under crops. The controls for each fertilizing system were long-fallow lands located at a distance of 50-200 m from the crops. Determination of active (potentially mineralizable) SOM (C_0) was carried out by a biokinetic method. The amount of C_0 in soil at the beginning of incubation period was calculated on the cumulative C-CO_2 released during the time of incubation using the equation of first-order kinetics. The content of the total C_{org} and labile carbon (C_{lab}) extracted by 0.1N NaOH was determined by a Tyurin method. The dissolved carbon fraction (C_{diss}) extracted by 0.5N K_2SO_4 was determined by a colorimetric method using various concentrations of glucose as a standard.

Results

The content of C_{org} in fallow soils ranged from 1.4 to 2.2%; in arable soils under various fertilizing systems - from 1.2 to 2.1%. The amount of C_{org} in fallow land soil and in soil with organic fertilizers were almost the same, while in those under organo-mineral and mineral fertilizing systems were 1.7-1.8 and 1.9-2.2 times less. The percentage of C_0 in arable soil was 3.8-5.3% C_{org} and in fallow soil - 6.0-8.2%.

The highest content of C_0 among the arable lands was in soil under organic fertilizing system, and the lowest - in soil with cultivation of vegetables crops and potatoes by a Mittleider method. As it is known, the main feature of this method is the use of mineral fertilizers only in high doses, which are applied to the soil rows, whereas the spaces between the rows are unfertilized. The amount of C_0 in soil rows was significantly lower than in spaces between them.

The percentage of C_{lab} in fallow land soils was 18-24% of C_{org}, and in arable soils - 12-17%, respectively. In gray forest soil, the content of C_{diss} was 6-15 times lower than the labile C, constituting only 1.4-2.0% of C_{org}. Differences between the content of C_0 in arable and fallow soils were much higher than those between C_{org} or C_{lab}, demonstrated a high sensitivity of active pool to agrogenic impacts. Only 22-40% of C_{lab} could be mineralized during the growing season, and dissolved organic matter was 19-57% of C_0.

The C_{lab} and C_{diss} fractions did not correlate with each other but had a significant link to C_{org} (r = 0.622, $p < 10^{-4}$ and r = 0.291, p = 0.04, respectively). The regression equations indicated that the increase of C_{lab} by 100 mg/100 g in gray forest soil would be associated with the growth of the C_0 content by 30 mg/100 g, while increasing the C_{dis} by 10 mg/100 g led to increase of C_0 by 23 mg/100 g content in soil. The C_{diss} had a significant correlation with the easily mineralizable fraction (k>0.1 day^{-1}) of active soil organic matter (r = 0.475, $p < 10^{-3}$). On the contrary, the C_{lab} correlated with the hard mineralizable fraction (r = 0.686, $p < 10^{-4}$).

Conclusion

The active organic matter is a more sensitive diagnostic indicator of quality of soil organic matter than C_{org} total content. Operative increase of amount of active organic matter in arable soil is achieved by applying of organic fertilizing system, and radical increase - by conversion from arable soil to fallow land. Not all labile soil organic matter is biologically active. At the same time, the labile fraction is the closest reserve of active organic matter in soil. Only a small portion of the active organic matter exists in the dissolved state.

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P 3.6.30

Improvement of Green Manure Value by Mixed Hairy Vetch and Barley Cultivation in Temperate Paddy Soil

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Legume hairy vetch and non-legume barley mixture is broadly cultivated to increase biomass and nutrient productivities in mono-rice paddy. Nevertheless, the effect of mixing conditions of the two cover crops as a green manure on biomass and nutrient productivities, as well as on yield characteristics of subsequent crop rice has not been well studied. In order to evaluate the effect of mix-seeding legume and non-legume cover crops on biomass and nutrient productivities in paddy soil, barley and hairy vetch were sown at rice harvesting stage as pure crops at the recommendation rates (180 kg ha^{-1} of barley, B100; 90 kg ha^{-1} of hairy vetch, V100), and as mixtures, two cover crops were mix-seeded with varying seed ratios according to the replacement principle. The mixed seeding of the two crops has significantly increased the total biomass and nutrient productivities as compared to single barley and hairy vetch cultivation. Biomass productivity was linearly increased with increasing barley seeding level, but it was not affected by hairy vetch seeding rate. Different with hairy vetch in the mixed biomasses, total N content of barley biomass clearly increased with increasing hairy vetch proportion on the total biomass, and then significantly improved the green manure value of cover crop biomass. Biomass produced in the pure barley seeding could not produce the nutrients by the recommended chemical fertilization level ($N\text{-}P_2O_5\text{-}K_2O$=90-45-57 kg ha^{-1}) for rice, but the biomass increased by the mixed seeding of two cover crops produced enough nutrients to substitute the recommended fertilization level. The highest biomass and nutrient productions were observed by the mixed seeding of barley and hairy vetch with 25 and 75% (B75V25) of each recommended seeding rate, respectively. This increased nutrient input stimulated rice plant growth and significantly improved rice yields. The highest yields were achieved in the B75V25 treatment. In conclusion, the mixed seeding of legume hairy vetch and non-legume barley could be very useful agronomic practice to increase cover crop biomass and its nutrient productivity, and to improve the productivity of subsequent rice crop in a temperate rice paddy.

Key words: *cover crop, rice, biomass productivity, nitrogen production*

P 3.6.31

Impact of different cutting and fertilization regimes on soil organic C and N sequestration in a mowed grassland

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Introduction

Soil organic carbon (SOC) stored in grassland may affect in conjunction with the stored soil nitrogen (N_t) the fertility and productivity of grassland ecosystems. In general, temperate grassland soils are typically rich in SOC because of rhizodeposition and the activity of soil fauna that promote the formation of aggregates and stabilize soil organic matter. Storage and turnover of SOC and N_t under mowed grassland are mainly affected by management intensity. The objective was to test if varying cutting frequency in combination with fertilization and no fertilization has an impact on SOC and N_t storage, soil microbial biomass and the distribution of water-stable aggregate size-classes.

Materials and Methods

The study site of the Christian Albrechts University, Kiel is located in north-west Germany close to Kiel. The field was converted in 2004 to grassland and the dominant soil type was a stagnic Luvisol. The experiment was established in 2004 in a randomized block design with 3 field replicates and included the following treatments: three cutting cycles (3C) and five cutting cycles (5C), without and with N fertilization (fertilization: 360 kg N ha^{-1} $year^{-1}$ (Calcium ammonium nitrate)). Soil samples were taken on each of the 4 treatments in three soil depths (0-10 cm, 10-30 cm and 30-60 cm) in 2014. SOC and N_t stocks, concentration of water-stable aggregate size classes (> 2000 µm; 1000-2000 µm; 250-1000 µm, 53-250 µm; < 53 µm) as well as microbial and fungal biomass were determined. The data were analyzed using a two-factorial ANOVA.

Results

In soil depth 0-10 cm significant higher SOC stocks were detected for 5C (mean ± SD: 25 t ha^{-1} ± 1.8) in comparison to 3C (21 t ha^{-1} ± 2) as well as for N unfertilized (31 t ha^{-1} ± 5.8) compared to N fertilized (22 t ha^{-1} ± 2.8) treatments. The N_t stocks were also significantly higher for 5C (2.17 t ha^{-1} ± 0.13) than for 3C (1.96 t ha^{-1} ± 0.17) in the top soil layer. In the soil depth 0-10 cm significant higher amounts of large macro-aggregates (> 2000 µm) were located in 5C (44% ± 7) in comparison to 3C (33% ± 2), whereas the amount of smaller macro-aggregates (250-1000 µm) was lower in 5C (5C: 30% ± 4; 3C: 38% ± 1). Under the 5C regime microbial and fungal biomass were significant higher (by the factor 1.5) in comparison to the 3C regime in the top soil layer.

Conclusion

The 5C regime led to an increased SOC and N_t stock in comparison to the 3C regime presumably because of an increased root biomass which was influenced by a changed plant species composition. Under the N unfertilized treatments the SOC stocks were higher because N was stronger limited under the N unfertilized than under the N fertilized treatments resulting in an increased root growth of plants under the N unfertilized treatments. The shift from small to large macro-aggregates under the 5C regime is promoted by roots, fungal hyphae and microbial excretions. This study shows that a 5C regime caused in comparison to a 3C regime a higher input of SOC and had positive effects on soil fertility and SOC sequestration. The conventional N fertilization had slightly negative effects on SOC stocks after 9 years.

P 3.6.32

The soil acidity on *Wugong* Mountain's meadow degradation areas

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Introduction：

Soil acidity directly affects physical, chemical and biological properties, even affects the nutritive element which is necessary for the plant and makes it in poor growth. Phosphorus is the essential element for the plant growth. When it is involved in cell division and the synthesis and transport of characteristics and energy, it has the functions that can't be replaced and it is also an important part of soil nutrients, even the available phosphorus is the main phosphorus resource for the plant. The soil available phosphorus has become the limitation factor of the soil nutrient for the plant. The PH of soil is one of the important properties of soil, changes some properties of soil and is closely related to the formation, transformation and validity of soil nutrient.

Methods：

Sampling methods: respectively take different samples at different elevations, such as 1600 m, 1650 m, 1700 m, 1750 m, 1800 m, 1850 m and 1900 m in *Wugong* Mountain. There are three repeatedly experimental samples in different elevations of the mountain meadow area (the vegetation coverage is less than thirty percent). The size of experimental sample is one hundred square meters. It has 21 samples at seven elevations. We choose five points at each sample with drilling samples in soil along the two diagonals. The buried depth of one sample is from 0 to 20 cm, and another is from 20 to 40 cm. Each soil sample is about 1 kg. There are 42 samples which need dry and sifting before the experiment.

Test method: 1) The soil available phosphorus: the dried samples through the mesh about 1mm with using acid ammonium fluoride to soak the dyke and molybdenum antimony colorimetric method to determine the soil available phosphorus; 2) The soil hydrolysis of total acidity: the method of the neutral titration of the sodium acetate hydrolysis; 3) Exchangeable acidity: the method of the neutral titration of potassium chloride exchange; 4) The soil pH value: the method of pH potentiometric.

The experimental data uses *Excel2003* and *SPSS17.0* software for analysis.

Results：

The variational rang of the soil hydrolysis of total acidity, exchangeable acid and soil active acidity (pH value) at *Wugong* Mountain meadow degradation areas is respectively 14.8 ~ 30.6cmol/kg, 5.1 ~ 9.8cmol/kg and 4.4 ~ 5.0.

Analysis of variance showed that the available phosphorus in soil, the hydrolysis of total acidity and exchangeable acid are significantly higher at 0-20cm soil layer than 20-40cm. The altitude has extremely remarkable influence on water acidity in Soil, but it has no influence on available phosphorus in soil.

PH, the hydrolysis of total acidity in soil and exchangeable acid show a remarkable negative correlation.

Conclusion：

1)The depth of *Wugong* mountain meadow degradation areas will has influence on the content of organic in soil, temperature, humidity and other factors, and thus it has a remarkable impact on the hydrolysis of total acidity in soil and exchangeable acid.

2) Exchangeable acid mainly include exchangeable hydrogen and exchangeable aluminium, the acidity at the study's area more relies on the impact of exchangeable acid, to be precise, it's restricted by the content of exchangeable aluminium.

3) The available phosphorus in soil at the study's area is mainly affected by the exchangeable acid, and the next is the hydrolysis of total acidity. when the variational range of pH is small, it has little influence on the available phosphorus in soil.

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P 3.6.33

Thermal analysis (DSC), FT-IR and ^{13}C CPMAS NMR spectroscopy to assess organic amendments applicable in soil remediation

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Mixing organic amendments with different plant species can be useful in phytoremediation of heavy metals polluted soils, such as mining soils, because they can reduce pollutants mobility and bioavailability. So that it is very important to clarify the mechanisms and functional groups which are involved in metal retention as well as the stability of organic amendments.

The objective of this work is to study the chemical composition of different organic materials (commercial humic acids, sheep and horse manure compost, pine bark compost, vermicompost and pruning waste compost) by ^{13}C CPMAS NMR and FT-IR spectroscopy, and to analyze their stability by DSC (Differential Scanning Calorimetry) to establish its potential use in phytoremediation of metal polluted soils.

Materials and Methods

Organic amendments

Sheep and horse manure compost (M); Pine bark compost (Wood fiber and peat) (P); Humic Acid of leonardita HUMITEC (AH); Vermicompost (VC); Pruning waste compost (PW)

^{13}CPMAS NMR Spectroscopy, FT-IR and Thermal Analysis (Differential scanning calorimetry, DSC)

- The analysis to characterize the labile and stable organic matter moieties of amendments were performed in a Calorimeter DSC Q100, TA Instruments.

- FT-IR spectra were obtained using a FT-IR Bruker IFS66v spectrometer.

- ^{13}CPMAS NMR spectra were were performed in a Bruker WB-400.

Results

The DSC curve of humic acids (HA) is different from the other studied organic amendments since it shows a first endothermic peak associated with moisture loss and other volatile substances. The horse and sheep manure is the amendment which has the highest labile organic matter content, mainly comprising carbohydrates, cellulose, lipids and amino acids among others, while the sample with the topmost highly recalcitrant organic matter is the pruning waste compost. The ^{13}C CPMAS NMR spectra showed that humic acids (HA) and vermicompost (VC) contained larger proportions of phenolic, carboxyl and aromatic groups, which play a key role in the interactions between soil and metals, particularly with Cu(II), and complex formation. The FT-IR analysis shows peaks corresponding to different functional groups that allow adding further information about the composition of the organic amendments studied, so that it could support the evidence obtained from ^{13}CPMAS NMR analysis that both humic acids and vermicompost have higher content of phenolic and carboxylic groups than the rest of amendments.

Conclusions

These results indicate that the peculiar chemical composition of humic acids (HA) and the presence of some functional groups determined by ^{13}C CPMAS NMR show that the combination of humic acids with different plant species could be a very useful tool to phytoremediate polluted soils with high metal concentration due to their likely great immobilization capacity. The thermal analysis of the amendments by DSC shows a different composition of organic matter (labile, recalcitrant) among them. The pruning waste compost seems to be the most stable amendment.

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P 3.6.34

Long-term effects of Pinus taeda and Eucalyptus grandis on soil carbon and nutrient status of a Dry Forest in Mozambique

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Planting of fast-growing exotic tree species is promoted by the Government to increase economic growth on soils of low natural fertility in Mozambique. The knowledge on how plantations influence soil organic carbon (SOC) and other soil properties is limited. The aim of this study was to compare the effects of *P. taeda* (PT) and *E. grandis* (EG) to dry miombo woodland on SOC, soil acidity, cation exchange capacity (CEC) and extractable phosphorus. We investigated relatively old (ca. 35 years) first-rotation forest stands of PT and EG to adjacent dry miombo stands on three sites of the mountain region of Manica, central Mozambique. The study area receives more than 1300 mm of precipitation per year and the soil is of Ferralsol type. A mixed-effects two-way Anova model, at significance level of 5% and Dunnet' s post hoc Test was used to evaluate the model. Our results show that the sampled sites did not differ relative to soil texture ($p > 0.1$) and bulk density ($p = 1$). SOC were higher in both PT (21.16 kg C×m^{-2}) and EG stands (21.66 kg C×m^{-2}) ($p < 0.01$ for both stands) as compared to the dry miombo stands (14 kg C×m^{-2}). PT had greater CEC in the 10 cm depth ($p < 0.001$), but had no effect on soil acidity ($p = 0.9$). EG had higher soil pH (pH 5.93; $p = 0.001$), higher base saturation (BS) (47.9 %; $p \leq 0.03$) and low extractable phosphorus (3.65 kg×m^{-2}; $p = 0.01$) relative to native forest (pH: 5.25, BS: 36.2% and 4.69 kg×P m^{-2}, respectively). The main conclusions to be drawn from this study are that PT and EG had higher SOC than dry miombo stands, corresponding to increment rates of about 200 g C×m^{-2} per year assuming similar levels before the stands were planted. EG stands decreased soil acidity and reduced the availability of extractable phosphorus. PT stands had higher CEC in the top soil layer, but there was no significant difference on soil acidity and extractable P compared to the dry miombo stands. Further studies are planned for identification of the ecosystem processes that has resulted in the observed effects on the soil properties.

Keywords: Dry miombo woodlands, *Pinus taeda, Eucalyptus grandis*, carbon sequestration, soil acidity, soil nutrients, Ferralsol

P 3.6.35

Changes in carbon stock, respiratory and enzymatic activities in Luvisols during the post-agrogenic evolution

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Abandonment of cultivated lands results in vegetation succession accompanied by changes in carbon stock, soils properties, and microbial activity. When cultivated lands were withdrawn from agriculture, they usually accumulate carbon and nitrogen, both in the vegetation and in the soil (*Poulton et al., 2003*).The abandonment lands induced also the significant shifts in quality of soil organic matter and structure of microbial community. This study was focused on the investigation of changes in carbon stocks, respiratory and enzymatic activities in *Haplic Luvisols* of Central Russia during the process of natural self-restoration.

The representative chronosequence was selected in deciduous forest area (Moscow region, Russia; 54°49N' 37°34'E; *Haplic Luvisols*) and included current arable, abandoned lands of 7, 11, 20, 35-yr old, and secondary forest plot. The mixed soil samples were collected on 5 points from each site in the former arable layer (0-5, 5-10, 10-20, 20-30-cm depth). Soil organic carbon (SOC) and nitrogen content (C_{org} and N_{org}) were measured by automatic CHNS analyzer. The soil organic carbon (SOC) stock was estimated based on C_{org} content and bulk density for the corresponding soil layer. Basal respiration (V_{basal}) and carbon immobilized in microbial biomass (C_{mic}, SIR) were determined in accordance with *Anderson (1978).* Enzymatic activity was measured using fluoregenically labeled substrates (*Marx et al., 2001*).

During the post-agrogenic evolution (or process of natural self-restoration), the content of organic C_{org} and N_{org} as well as C_{mic} in *Haplic Luvisols* increased progressively. The most significant changes in observed parameters were found in the top 0-5 and 5-10 cm layer. The SOC stock in the upper 10-cm layer increased from 13.5 Mg ha^{-1} in arable soil to 26.3-27.9 Mg ha^{-1} in 35-yr abandoned land and forest plot (Fig. 1). N_{org} dynamics during the post-agrogenic evolution showed a close positive correlation with C_{org} concentration. Conversion of arable to the natural vegetation induced also the progressive accumulation C_{mic} and acceleration respiratory activity (V_{basal}) in the topsoil (Fig. 1). After 35 years of abandonment, C_{mic} content and V_{basal} in the upper soil layers (0-5 and 5-10 cm) increased by 90 and 160% compared to arable plot. Enzymatic activity accelerated also during the post-agrogenic evolution of soils. The close correlations between C_{mic}, V_{basal}, SOC stock, and enzymatic activity in topsoil were observed (R^2= 0.61-0.79; P

Therefore, we can conclude that land use change from cultivation to natural vegetation led to restoration of arable Luvisols, significant increase of SOC stock, respiratory and enzymatic activities in the topsoil.

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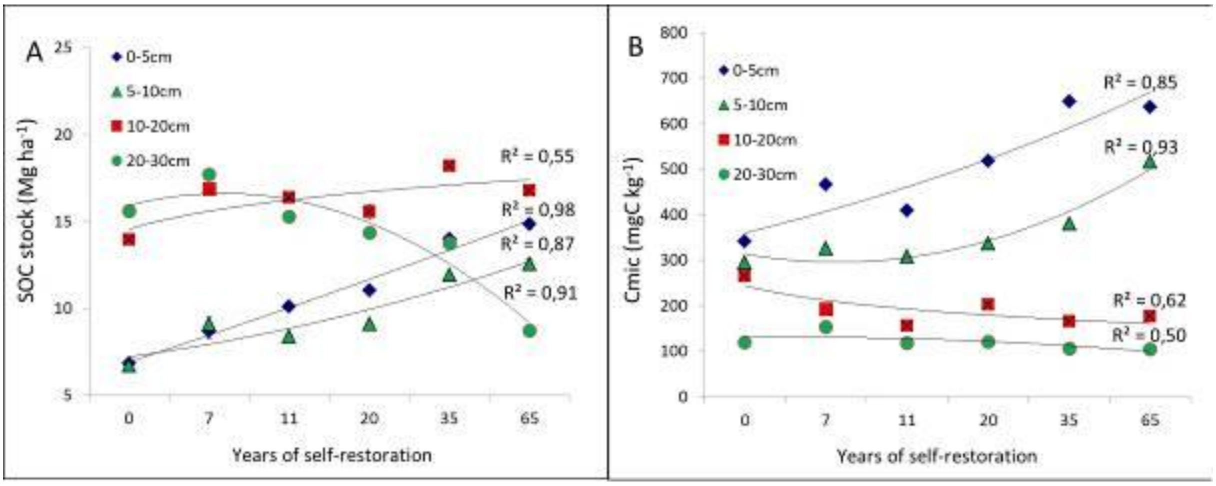
Fig.1. Changes in SOC stock (A) and microbial carbon (B) in the top 0-10 cm layer in *Haplic Luvisols* during post-agrogenic evolution

Figure 1


A
B
SOC stock (Mg ha-1)
Cmic (mgC kg-1)
0-5cm
5-10cm
10-20cm
20-30cm
R² = 0,55
R² = 0,98
R² = 0,87
R² = 0,91
R² = 0,85
R² = 0,93
R² = 0,62
R² = 0,50
Years of self-restoration
Years of self-restoration

P 3.6.36

Critical Soil Organic Carbon Range For Optimal Crop Response To Mineral Fertiliser Nitrogen on a Ferralsol

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Soil organic carbon (SOC) is a major indicator for soil fertility in the tropics and underlies variability of crop response to mineral fertilizers. Critical SOC concentrations that interact positively with N fertilizer for optimal crop yield are less understood. A study was conducted on Ferralsol in sub-humid Uganda to explore critical range of SOC concentrations and associated fractions for optimal maize (*Zea mays* L.) yield response to applied mineral N fertiliser. Maize grain yield response to N rates applied at 0, 25, 50, 100 kg N ha^{-1} in 30 fields of low fertility (SOC<1.2%), medium fertility (SOC=1.2-1.7%) and high fertility (SOC>1.7%) was assessed. Soil was physically fractionated into sand-sized (63-2000 µm), silt-sized (2-63 µm) and clay-sized (<2 µm) particles, and SOC content determined. Low fertility fields (<1.2% SOC) resulted in the lowest responses to N application. Fields with >1.2% SOC registered the highest agronomic efficiency and grain yield. Non-linear regression models predicted critical SOC to be 2.204%, at 50 kg N ha^{-1} rate. The critical range of SOC concentrations corresponded to 3.5-5.0 g kg^{-1} sand-sized C and 9-11 g kg^{-1} for clay-sized C. Overall, fields with SOC concentrations >1.2% registered the highest agronomic efficiency, and 2.204 % was the critical amount for optimal maize yield to N application

P 3.6.39

Soil Organic Matter Decline in Ukraine and Practices for Its Restoration

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Introduction. Ukraine is well-known in the world as a country with soils rich for humus. Approximately 68 % of arable soils in Ukraine have been classificated as chernozem. Insufficient fertilization, intensification of industrial crops growing, processes of soil degradation, all these lead up to the process of overmineralization of humus in soils. Cultivation, a common practice in agroecosystems, also has been linked to reductions in soil organic matter. Ukrainian soils have been loose more than 20 % of total humus reserve since 1882. From one hectare of agricultural land up to 0.5-0.6 ton of humus is lost annually. It means that restoration of soil organic matter should be the option number one for Ukraine. It is necessary to select the most perspective combinations of cultivation and fertilization systems adopted to conditions of Ukraine.

The objectives of the present study was to evaluate the effect of different cultivation and fertilization systems on organic matter transformation of chernozem typical.

Materials & methods. This study was conducted in long-term field experiment on chernozem typical heavy loamy in Poltava region, Ukraine. Types of tillage - combined and shallow subsurface (0 - 12 cm) tillage. Experiment was conducted with seven fields alternating of crops: corn for silage, winter wheat, sugar beets, barley, peas, winter wheat, corn for grain. Sown area - 175 m^2, accounting - 100 m^2. Samples of soil were obtained from 0 - 20 cm deep layer. Analytical researches with soil samples were carried out in certified laboratory by conventional methods. Evaluation of humus state of the soil was carried out by a system of indicators according to D. Orlov, O. Biryukova, M. Rozanova.

Results. A quantity and quality of organic matter that applied in a soil is the major factor of mineralization, synthesis and resynthesis of humic substances. Long-term manure application in chernozem typical led to increasing of humus content and amelioration qualitative characteristics of humus substances in soil (table 1). The use of shallow tillage of soil contributed to enrichment of soil organic matter by nitrogen, which was not happened in case of combined tillage. Enrichment of soil organic matter by nitrogen was more intensive on organo-mineral fertilization systems. The degree of humification of organic matter was higher on variant with combined cultivation. Nevertheless, ration Cha/Cfa in chernozem typical was better on variant with shallow tillage. Increasing of mobility of humus substances system under the effect of organic fertilization system was observed.

Conclusions. Analysis of agricultural soils quality in different agro-climatic zones of Ukraine proofed the process of soil degradation in the country. Insufficient fertilization mainly for decreasing in times livestock number and manure applied on land results in soil exhaustion. Long-term use of organic and organo-mineral fertilization systems on chernozem typical led to increasing of humus content, degree of humification of organic matter and enrichment of soil organic matter by nitrogen. According to long-term research the most perspective for chernozem typical type of cultivation due to soil organic matter preservation should be combination of shallow tillage with moldboard plowing every 3-4 years.

Figure 1

Table 1 – Transformation of organic matter of chernozem typical under the effect of different cultivation and fertilization systems

Index of humus status	Variant					
	Combined tillage			Shallow tillage		
	Without fertilizer (control)	Manure (40 t/ha)	Manure (40 t/ha) + NPK	Without fertilizer (control)	Manure (40 t/ha)	Manure (40 t/ha) + NPK
Ctotal, %	2,95	3,11	2,92	2,85	3,06	3,06
Cha,% to Ctotal	38	48	49	41	40	42
Cfa, % to Ctotal	30	22	28	24	11	20
Cha/Cfa	1,3	2,2	1,8	1,7	3,7	2,1
HA-1, % to HA	7,1	8,7	6,3	8,0	4,0	8,0
HA-2, % to HA	85	74	85	72	77	79
HA-3, % to HA	8	17	9	20	19	13
Chumin, % to Ctotal	31	30	23	35	49	38
C/N	16	14	10	10	11	12

P 3.6.40

Cyprofluoxacine Adsorption on Humic Acids extracted from Soils Derived Form Volcanic Materials using Electrochemical Method

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1.Introduction.

Over the last decade, at both national and international level, the amount and fate of pharmaceutical residues in the environment have become of public interest. The reason why these residues have environmental impact is because many of them maintain their active pharmaceutical properties affecting in most cases negatively the global ecosystem. Among these types of pharmaceutical wastes, veterinary pharmaceuticals (VPs) are physiologically active substances, used in animal breeding, mainly for parasites control, to prevent and treat bacterial diseases as well as for acceleration of meat production. On the other hand, at international level, antibiotics are one of the most important groups of veterinary drugs, with sales volumes of more than 200 million euros in 1999. The amounts of antibiotics imported by Chile to be used in veterinary medicine, including salmon, far exceed the import of these same antimicrobials for use in human medicine. On the other hand, soil organic matter (OM) consists of fulvic (FA), humic and humin acids (HA). The HA's may interact with organic substances, either by adsorption thereof on its surface or by their inclusion within HA micelles. In this sense, the existence of substances that may decrease the availability of these antibiotics in the soil matrix would represent an important tool to tackle the harmful effects of these molecules in the ecosystem. This allows establishing that HA may alter the availability, transport, fixation, and toxicity of environmental contaminants.

2. Objectives. To evaluate the adsorption of Cyprofluoxacine antibiotic(Cypro) on different humic acids.

3. Materials & methods . HAs, were extracted from volcanic soils through multiple solubilization-precipitation processes utilizing pH changes. All electrochemical experiments were conducted on a Volta-LabPGZ100 potentiostat system in a three-compartment/three-electrode glass cell, under Ar atmosphere. Glassy carbon electrode was used as working electrode, Pt wire was the counter electrode and an Ag|AgCl reference electrode. Electrochemical adsorption experiments were performed in 10 mL of Cypro solutions from $3.0\acute{}10^{-05}$ to $3.0x10^{-04}$ mol L^{-1} in phosphate buffer solution (pH=7.0). Cyclic voltammetry work was performed by scanning within a -300 and 400 mV window at 100 mV s^{-1} scan rate. Prior to adsorption studies, concentration (mol L^{-1}) was attained from a current *vs*. concentration calibration plot (evaluated between the same concentration range). Subsequently, 10 mg of HA was added to each cell containing 10 mL of Cypro solution in the considered concentration range, flushing Ar during an equilibration time of 1 min. The corresponding cyclic voltammogram was then recorded.

4. Results

The current (I, uA) *vs*. concentration (mmol L^{-1}) parameters show a significant linearity (R^2 = 0.998, line equation I = 5,005*C + 0.361, n = 6) with good precision and limits of detection (LOD) and quantitation (LOQ) 0.050 and 0.015 mmol L^{-1}, respectively.The adsorption study shows L-type isotherms from which a gradual saturation of the solid for HA extracted from Collipulli, Frutillar, N. Braunau soils was suggested, showing a defined *plateau*, which reveals the existence of a limited adsorption capacity. This could be related to these HAs possess high Critical Micelle Concentration (CMC), so at this HA concentration no pseudo micellar aggregates would be forming, reducing thus its adsorption capacity. In this work the HA concentration was 1 g L^{-1}, while CMC values ranged from 1.41 to 3.47 g L^{-1}. For Freire and Vilcún HA the plateau was not well defined, consequently it was not possible to establish that it is a solid with limited capacity. Colina, Diguillin, Osorno, Ralún and Temuco HA showed S type isotherms where a cooperative adsorption can be appreciated in which two mechanisms would exist: first, soluble HA would form a complex with cypro, so then the cypro be adsorbed by the HA remaining solid fraction. Type S HAs have low CMC with respect to L type, with the exception of Colina HA that is the one with the highest CMC and is not of volcanic origin. Maximum adsorption concentration range between 9.5 and 17.5 mM g^{-1} for type-L HA isotherms and between 12.7 and 18.8 mM g^{-1} for type-S HA isotherms was found.

5. Conclusion

The electrochemical method exibited good precision. Adsorption between Cyprus and HA, is usually a cooperative process in which firstly a complexation occurs followed by adsorption of the drug on the solid HA. Besides, it can be concluded that working at values close to CMC, the adsorption is favored.

Acknowledge

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P 3.6.41

The fate of carbon from soil amendments in horticultural systems

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1. Introduction: The application of organic soil amendments to soil to improve fertility and augment the soil carbon pool has been of increasing interest in recent years. However, little is known about the fate of carbon in soil amendments after application to horticultural soils.

2. Objectives: This research focuses on soil carbon dynamics, and interactions with soil microbial ecology in a practical horticultural context. Specifically, the effects of the use of soil amendments, which is a common gardening practice. This project is interested in three broad areas: (i) how soil amendments influence soil physico-chemical properties, and therefore yield; (ii) the quantity and composition of soil C under different soil amendments; and, (iii) the impact of soil amendments on the microbial community, and the ability of this community to suppress soil-borne plant pathogens.

3. Materials and Methods: Ten different treatments (8 replicates) have been applied annually, since 2008, in a randomised block arrangement to eighty 3mx3m plots at the Royal Horticultural Society's (RHS) Deers farm at Wisley, Surrey (UK). Organic soil amendments that are commonly used by and/or available for use in the wider horticultural community were selected. These are peat, composted bark, composted horse manure, composted bracken, spent mushroom compost and garden compost (two different application rates). In addition three control treatments are also being applied; a bare plot (no organic amendment, no plants), plants sown (no organic amendment) and plants sown with chemical fertiliser (no organic amendment). Horticultural plants (e.g. *Cosmos bipinnatus*, *Helianthus annuus*) have also been grown on the plots annually. Soil physical and chemical properties (e.g. pH, bulk density, nutrient concentrations etc.), along with plant yield data, are obtained annually.

4. Results: Organic amendment treatments began to have a significant effect on plant yield three years after initial application. However the best performing yield treatment depends on the plant species in question. The quantity and composition of soil organic carbon (SOC) in the plots is being assessed using a combination of physical fractionation techniques and nuclear magnetic resonance (NMR) analysis. Physical fractionation allows soil organic matter (SOM) to be split into: (i) unprotected, or free, SOM; (ii) physically protected SOM, which is occluded in aggregates; or (iii) chemically protected SOM, which involves sorption onto mineral surfaces. Therefore fractionation can help to emphasise the importance of various SOM stabilization mechanisms in the soil system. NMR analysis on the SOM fractions obtained, will indicate whether certain organic components of SOM are affiliated with a particular stabilisation mechanism, or fraction. Preliminary experiments indicate that difference in total C concentration between treatments result from an increase in unprotected particulate organic matter (POM), rather than an increase in SOM being occluded in aggregates or in organo-mineral complexes. Microbial activity this year has been assessed using a method known as the Tea Bag Index (TBI) to determine decomposition rate constants in each of the plots. Initial analysis of decomposition rates in the plots suggest that the differences seen in decomposition rate in the plots is largely determined by the C:N ratio of the amendment, and the presence of plants on the plots that compete with microorganisms for N.

5. Conclusions: This research is of value to any gardeners wishing to gain knowledge on how the materials they select to apply to their gardens can impact on plant yield, disease suppression and soil carbon storage. Preliminary results of this research are suggesting that the soil amendment used influences plant yield, the quantity of soil C, and microbial activity on the experimental plots. Plans for future research, to expand on current findings, will involve: (i) a continuation of physical fractionation and NMR analysis, on soil samples from the plots; (ii) a UK wide crowdsourcing project in the UK gardening community using the Tea Bag Index; and (iii) assessment of the microbial community in the experimental plots using a combination of assays and microbial fingerprinting techniques.

Figure 1

Figure 2

P 3.6.42

C and N mineralization in an eroding agricultural landscape

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Introduction

Quantitative evaluation of soil organic matter (SOM) mineralization in eroding landscapes is an important problem of contemporary investigations of carbon (C) and nitrogen (N) budgets in terrestrial ecosystems. Water erosion results in the breakdown of soil aggregates and redistribution of C and N compounds in landscape elements, consequently, soil organic carbon (SOC) and soil organic nitrogen (SON) mineralization can be decreased or increased.

Objectives

We aimed i) to assess pool size of potentially mineralizable SOC (Cpm) in soils of different positions of agricultural landscape subjected a water erosion depending on temperature and moisture, ii) to perform predictive evaluation of SOC mineralization for the period from May to September using data of a long-term incubation and to compare this value with CO_2 emission from the surfaces of these soils *in situ* during the same period, iii) to evaluate net-mineralization of SON (Nnm) and to estimate an effect of this N pool on winter wheat yield.

Materials & methods

We performed our study on stationary arable runoff plots (Institute of Soil Science and Agricultural Chemistry NAS, Belarus), situated on a convex south facing slope of 5-7° along geomorphic transect. Objects of the study: soddy-podzolic soils formed on coarse loess-like loam. Non-eroded soil (I) is situated on stable position (plateau), moderately eroded (II) and strongly eroded (III) soils are on eroding positions (slope), gley sedimentary soil (IV) is on depositional position (footslope). Samples were taken from topsoil (0-20cm) in spring after snowmelt and renewal of winter wheat vegetation. In soils I, II, III, IV SOC content was 1.44, 1.27, 1.17, 1.43%, SON was 1299, 1207, 1172, 1225 mg kg^{-1}, mineral nitrogen (Nmin) was 36, 26, 22, 26 mg kg^{-1}, correspondingly. Soil samples were incubated for 150 days under 8 and 22°C and water content of 5, 15, 25 and 35 mass %. Cpm and Nnm were determined using data of cumulative C-CO_2 production and Nmin accumulation in soils by biokinetic SOM fractionation technique. To assess influence of change in temperature by 10°C and moisture by 10 mass % on change in Cpm size we calculated temperature (Q_{10}) and moisture (W_{10}) coefficients. We used Q_{10} and W_{10} to predict potential SOC mineralization in the studied soils under average long-term weather conditions. We evaluated CO_2 emission into atmosphere from surfaces of the soils without plants and plant residues using data of *in situ* measuring by chamber technique.

Results

Maximal size of Cpm pool was under temperature of 22°C which is close to the maximal soil temperature measured in field and amounted on average to 5.2, 6.2, 7.2 and 9.6% of SOC in soils I, II, III, IV, correspondingly. Temperature coefficients Q_{10} for Cpm pool size in diapason of 8-22°C were 2.24±0.06, 2.00±0.17, 1.98±0.09, 2.20±0.59 for the respective soils. Moisture coefficients W_{10} for Cpm pool size were 1.17±0.03, 1.16±0.04, 1.22±0.06, 1.41±0.31 for the soils I, II, III, IV. Intensification of SOC mineralization under increase of soil water content is conditioned by the release of easily available to microorganisms water-soluble organic compounds due to soaking of soil aggregates, therefore our results indicate that organic matter of soils subjected a water erosion is protected to a lesser degree in comparison with non-eroded soils. Long-term incubation data were used to perform predictive evaluation of SOC mineralization for the warm period of the year when mineralization occurs most intensively. In non-eroded, moderately eroded, strongly eroded, gley sedimentary soil under average long-term temperature during period from May to September and optimal moisture of 25 mass % SOC mineralization is predicted about 1.16, 1.15, 1.26, 1.76 t C ha^{-1}, correspondingly. Prognostic evaluation of C losses due to mineralization is confirmed by *in situ* measurements. CO_2 emission from surfaces of bare soils I, II, III, IV under field moisture of 22-24 mass % was about 1.54, 1.50, 1.68, 1.76 t C ha^{-1}, correspondingly. C, incoming into soils with roots and stubble of winter wheat compensated SOC mineralization losses.

Mineralization of SON in the studied soils of eroding landscape was not accompanied with yield increase. Nnm in soils I, II, III, IV was 101 155, 143, 158 kg N ha^{-1}, whereas winter wheat grain yield was 8.1, 7.2, 5.9, 7.3 t ha^{-1}, correspondingly.

Conclusion

We conclude that C and N organic compounds mineralization occurs more intensively in soils subjected water erosion than in non-eroded soil. C losses can be compensated by roots and stubble, and N can be lost.

Acknowledgment

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P 3.6.43

Soil Usage in the Construction of Local Building in Old Kuntunkun Communities in Gwagalada Area Council of the Federal Capital Territory, Abuja Nigeria

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In Nigeria, some of soils have been identified. Mainly; the black cotton soils, which occur widely in the north-eastern part of Nigeria and the Sokoto soft clay shale (attalpulgite) in the north-western Nigeria, Ola (1987). Adesunloye (1987).The geotechnical information on typical tropical soils are important, environment changes, are crucial to the sustainable development of human resources and activities, which are also vital to the contribution factors in enhancing the available resources in different localities. A research was conducted in the various usages of tropical and residual soils in Old Kuntunkun Communities in Gwagalada Area Council of the Federal Capital Territory, Abuja Nigeria. Findings is that soil were being used in the construction of buildings, Agricultural practices, surveying of land .Pictures were taken questionnaires were distributed and administer and analysed. This paper presented the over all pictures, suggestion were made to the best usage of the soil, for productive purposes, creation of an inventory that would serve as an information database for International Countries and Nigerians which is very important for the safe design, usages and important aspect of soil.

Keywords: Soil, Gwagalada ,Usage .

P 3.6.44

Increasing soil organic carbon as a foundation of enhanced soil productivity and sustainable crop production in China

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China's economy underwent great changes since 1949, especially since Chinainitiated economic reforms and the open-door policy in the1980's. The growth of agricultural production has been one of the main national accomplishments. By 1999 Chinawas feeding 22 % of the global human population with only 7 % of the world's arable land (Zhang et al., 2011). It has been acknowledged widely that the crop yield increase was accomplished by greater inputs of fertilizers, irrigation, new crop strains, and other technologies of the "Green Revolution" (Tilma et al., 2002; Fan et al., 2012). However, soil productivity improvement in most of the arable land has been base of "Green Revolution" in China(Fan et al., 2013). The unique experience in improvement of inherent soil productivity was combination of engineering-based measurements (e.g. leveling and consolidating soil) and biological approaches (e.g increase input), which led to increase in soil organic carbon (SOC) and macro-nutrients especially for low and moderate yielding soils (Fan et al., 2013; Huang and Sun, 2006).

Looking towards 2030, further increases in crop production on the remaining arable land to meet the demand for grain and to feed a growing population will be more problematical than it has been for the last 50 years for China. The availability of high quality soil remains one of the major limiting factors in China. However, comparison in SOC between soils of high and low productivity of major Chinese cropping systems showed there are quiet potential in increase SOC for almost more than 70% arable land. Thus, we propose the advancement of food security in 21th century inChina will depend on a continuous improvement of soil productivity, which may be accomplished by better management of SOC. However, the benefits of increasing the amount of SOC are bought at a cost (Johnston et al., 2009). This may be enhanced especially when C and nitrogen management is decoupled in arable land. Thus, seeking practices which could maximize crop productivity with SOC enhancement and reducing environmental cost would be major challenges.

This paper summarizes historical trends, current situation and future perspective in SOC and crop productivity inChina. Then, the approach of increasing further SOC of arable land for advancing food security inChinaand for strengthening other ecosystem services in the new century is discussed.

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P 3.6.45

Optimizing the harvesting stage of rye as a green manure to maximize nutrient production and to minimize methane production in mono-rice paddies

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Question

1) Does the organic components of the rye cover crop change greatly across growth stages in a way that can influence nutrient availability in the soil as well as CH_4 production in the flooded paddy soil?

2) When will be the most promising stage for increasing nutrient production and decreasing GHG emissions in temperate mono-rice paddy soils?

Methods

To investigate the effect of rye harvesting stage on nutrient productivity and CH_4 production potential, rye was harvested at different growing stages, from the flowering stage to the maturing stage, for seven weeks. The chemical composition and biomass productivity of rye were investigated. CH_4 production was measured by laboratory incubation, and CH_4 production potential was estimated to determine the real impact on CH_4 dynamics in rice soils.

Results

Rye biomass increased with plant maturation, but nutrient productivities such as N (nitrogen), P_2O_5, and K_2O were maximized at the flowering stage. The contents of cellulose and lignin increased significantly as plants matured, but the total N, labile organic carbon (C), and hot and cold water-extractable organic C clearly decreased. Soils were mixed with 0.3% (*wt* wt^{-1} on dry weight) air-dried biomass and incubated to measure the maximum CH_4 productivity at 30 °C under flooded conditions. Maximum CH_4 productivity was significantly correlated with increasing labile organic C and protein content, but it was negatively correlated with total organic C, cellulose, and lignin content. CH_4 production potentials were significantly increased up to the pre-maturing stage (220 DAS) and remained unchanged thereafter.

Conclusions

As a result, CH_4 production potential per N productivity was the lowest at the late flowering stage (198 - 205 DAS), which could be the best harvesting stage as well as the most promising stage for increasing nutrient production and decreasing GHG emissions in temperate mono-rice paddy soils.

Figure 1

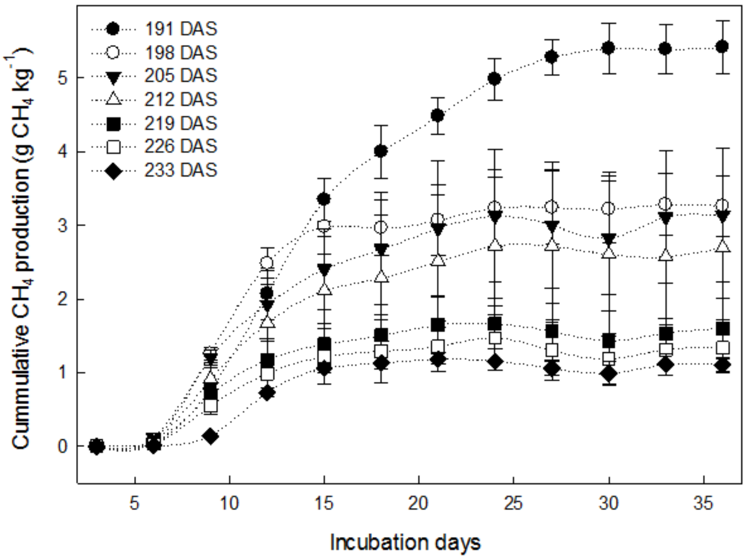

Figure 1. Changes in cumulative CH_4 production with rye incorporated at different harvesting stage. Bars represent standard deviations (*n=3*). DAS means days after seeding of rye in a rice field.

P 3.6.46

The role of cork oak trees on soil organic matter content and quality in Mediterranean agro-silvo-pastoral systems

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Introduction

In agroforestry system the positive effect of trees is usually attributed to their capacity to pump nutrients from deep soil layers (Young 1997) and from areas near by the trunk (Scholes and Archer 1997) and subsequent recycled via leaf litter (Gallardo and Merino 1998). Carbon inputs to the soil from root decay, litter fall, and animal excreta are broken down by macro- and micro-fauna. Most of this C is lost in this process of decay, but some residual C becomes incorporated into the soil, humified, and eventually it ends up in longer term soil C pools (Howlett et al., 2011b).

Objectives

The aim of this study was to evaluate the microscale variation of SOM quality as influenced by isolated cork oak trees (*Quercus suber* L.) in a agro-silvo-pastoral system under Mediterranean semi-arid conditions. We evaluated the role of isolated trees by determining the differences in C and N content of the SOM, water-extractable organic matter (WEOM), particulate organic matter (POM-free and occluded) and mineral associated organic matter (MOM) at increasing distances from individual cork oak trees in a wooded grassland in Sardinia, Italy.

Materials & methods

The study, still ongoing, was carried out in an area representative of Mediterranean agro-forestry systems, located in the N-E Sardinia (Italy) The soil developed from granite and is classified as Typic Dystroxerept (Soil Survey Staff, 2010). In May 2011 six isolated cork oak trees in a wooded pasture were randomly selected and for each of them two transects in opposite orientations (NE-SW) were identified. Along the two transects, measurements were made at five positions following a gradient from underneath to beyond the tree crown projection (from 1 to 5). Soil and floor litter (dry matter kg ha^{-1}) samples were collected at each sampling position. Total organic C (TOC) and total N (TN) were determined using an elemental analyser. The WEOM was determined according to Burford and Bremner (1975). Density fractions of soil were then obtained using the procedure described by John et al. (2005).

Results

The average amount of floor litter significantly differed among the distance from the trunk within the transects (Fig. 1). In the SW transect floor litter was about tenfold higher in the position 1 than in the outer positions (4 and 5). In the NE transect, the position 2 showed +68% higher floor litter than the positions 4 and 5.

TOC and TN decreased sharply from the vicinity of the tree trunk and stabilized in the outer position (Table 1). The C content of all the SOM fractions were not significantly influenced by the transects orientation, whereas significant differences were observed among positions within the transect with decreasing trends from the trunk to outside the crown projection (Table 1). Only the POMo-C had similar values along both transects ranging from 3.2 to 4.2 g kg^{-1}. The C/N ratio in the SOM fractions showed significant differences between the transects only for POMf (Table 1). In POMo the lowest C/N ratio was observed close to the trunk (position 1) for both transects. For MOM, the C/N ratio differed among positions only for the SW transect, with lower values beyond the tree crown than beneath the tree.

Conclusion

Our results highlighted that the presence of trees in Mediterranean wooded pastures is well correlated with a whole range of positive effects. The main impact is the capacity to store and stabilize more C in the soil, thus in the long term these systems can play a fundamental role in the C sequestration and conservation processes.

Data of SOM fractions indicate that the trees influence the quality of SOM and the microscale spatial distribution of these pools. In particular, the labile fractions (WEOM and POMf) have proved to be sensitive indicators of short term changes in the soil C status as they are directly correlated to fresh C inputs.

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Table 1. Analysis of variance and means for contents of TOC, TN, C/N ratio, C and C/N ratio as WEOM,POM f, POM o, MOM g kg^{-1} in the top soil layer (0-20 cm) in relation to the transect and distance from the tree trunk.

Fig. 1. Floor litter dry matter (kg ha^{-1}), in the NE and SW orientations of the transects.

Figure 1

Table 1. Analysis of variance and means for contents of TOC, TN, C/N ratio, C and C/N ratio as WEOM,POM f, POM o, MOM g kg^{-1} in the top soil layer (0-20 cm) in relation to the transect and distance from the tree trunk

Transect	Position	TOC	TN	C/N	WEOM-C	POMf-C	POMo-C	MOM-C	POMf-C/N	POMo-C/N	MOM-C/N
North-East	1	36.9 a	2.5 a	12.1 a	0.3 a	4.5 a	4.0 a	22.8 a	17.6 a	16.7 b	12.5 a
	2	29.7 b	2.0 b	14.9 a	0.2 b	3.2 ab	3.5 a	19.3 ab	18.2 a	18.1 a	12.5 a
	3	26.9 bc	1.8 bc	14.6 a	0.2 bc	1.4 b	2.7 a	20.5 ab	18.3 a	19.0 a	12.7 a
	4	24.5 cd	1.6 c	15.4 a	0.1 cd	1.9 b	3.5 a	16.6 b	18.2 a	18.3 a	12.0 a
	5	22.3 d	1.6 c	14.1 a	0.1 d	2.6 ab	3.1 a	16.3 b	17.4 a	18.4 a	11.6 a
	Mean	28.0 A	1.9 A	14.2 A	0.2 A	2.7 A	3.4 A	19.1 A	17.9 B	18.1 A	12.3 A
South-West	1	42.8 a	2.9 a	15.0 a	0.4 a	6.8 a	3.7 a	25.4 a	17.0 a	15.9 c	13.3 a
	2	34.8 b	2.4 b	11.9 a	0.2 b	4.6 ab	3.4 a	23.0 ab	16.9 a	16.5 bc	13.1 a
	3	29.0 c	1.9 c	14.9 a	0.2 b	2.4 b	2.7 a	22.6 ab	16.9 a	17.5 ab	12.9 a
	4	23.0 d	1.6 c	14.9 a	0.1 c	2.0 b	3.4 a	15.8 b	17.2 a	18.5 a	11.4 b
	5	23.5 d	1.6 c	14.9 a	0.1 c	1.9 b	3.6 a	15.2 b	17.5 a	18.3 a	11.2 b
	Mean	30.6 A	2.1 A	14.3 A	0.2 A	3.6 A	3.3 A	20.4 A	17.1 A	17.3 A	12.4 A
Source of variation	*d.f.*	*P-value*	*P-value*	*P-value*	*P-value*	*P-value*	*P-value*	*P-value*	P-value	P-value	P-value
Transect	1	0.584	0.593	0.531	0.695	0.46	0.884	0.596	0.005	0.261	0.825
Distance (transect)	8	<0.0001	<0.0001	0.732	<0.0001	<0.0001	0.36	0.001	0.919	<0.0001	<0.0001
CV (%)		12.2	15.1	6.8	23.1	57.5	30.5	22.7	7.4	5.3	6.5

Mean values among distances from trunk within transect with different lower-case letters significantly differ for $P \leq 0.05$.
Mean values between transects with different capital letters significantly differ for $P \leq 0.05$

Figure 2

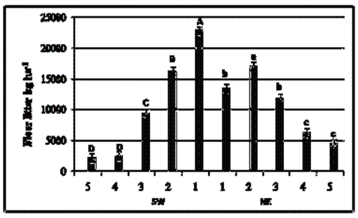

Fig. 1. Floor litter dry matter (kg ha^{-1}), in the NE and SW orientations of the transects. Mean values among different positions within NE transect with different lower-case letters significantly differ for P = 0.05. Mean values among distances from trunk within SW transect with different capital letters significantly differ for P = 0.05.

P 3.6.47

The effect of conservation agriculture on the content of soil organic matter and activity of microorganisms in the rain-fed agriculture in the north-eastern of Syria

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With drought conditions that prevailed in the region in recent years, it has become an urgent need for new approaches in the cultivation of crops and improve soil properties, such as conservation agriculture and which has spread globally to reach 70-80% of the cultivated areas in many countries. carried out during the four seasons starting from 2010-2011 until 2013-2014 in order to test the effect of agriculture clipboard on the soil content of organic matter and activity of microorganisms in the northeast of Syria, At an altitude of 452 m above sea level, at longitude 41.13 ° east and latitude 37.03 ° north. The average annual rainfall rate of about 440 mm. Where clay soil Lomé, where mud ratio ranging from 54% and 24% silt and sand 22%, pH = 7.2 and that the rotation of wheat and vetch at the same site experience from one season to another. Tested 2 treatments the first conservation agriculture (Agriculture directly without cultivation by private seeders believes in the goddess incision and put the seed and covered at the same time) and the second conventional cultivation (after consecutive peasant cultivation by plow disc harrow) repeated 4 once each transaction. Soil samples were taken before planting and after harvest of each growing season to know the content of soil organic matter as well as the diversity of microorganisms from the fungi and bacteria. Analyzes carried out in laboratories in scientific agricultural research center in Al-Qamishly. The results showed that the average proportion of organic matter before planting in the first season 0.7 % in the experiment site and the number of fungal colonies 5×10^2 spore/g. soil. In successive seasons fluctuated soil content of organic matter by experiment transactions to arrive at the end of the 2013-2014 season to 1.7 % in agriculture portfolio transactions, compared with 0.9% in conventional agriculture transactions. The density of fungi and bacteria in the soil as well as varied from one season to another, reaching its density to 7.2×10^4 spore /g. soil in conservation agriculture, compared with 4.3×10^3 spore/g. soil in conventional agriculture. It was the largest number of them to identify the species level and genera the following: *Aspergillus niger, A. flavus, A. candidus, A. clavatus, A. foetidus, A. ochraceius, Aspergillus spp, Fusarium culmorum, F.moniliforme, Fusarium* spp, *Penicillium atramentosum, Penicillium* spp*, Alternaria, Cladosporium* spp*, Stemphylium, Rhizopus* spp, *Mucor* sp, *Bacillus* spp. It was noted that increasing numbers of bacteria and fungi throw more than others in the agriculture portfolio transactions. And the associated increase soil organic matter content of positively with the activity of microorganisms in the soil and reflected positively on the growth of crops and increase their productivity in the agriculture portfolio transactions compared with conventional agriculture

Key words: Al-Qamishly, Conservation agriculture, Fungi, Soil organic matter, Microorganism, Syria

IT 3.7

Soil organic matter formation from litter decomposition: A call for modeling of both DOM and POM pathways

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Soil organic matter (SOM) is the largest terrestrial carbon (C) pool, and depends on the balance between SOM formation from the decomposition of plant inputs and SOM mineralization rates. Knowledge of SOM formation remains limited and most of the current C models are based on the assumption that recalcitrant plant litter contributes to stable SOM. Here, we provide experimental support to the existence of two independent pathways leading to SOM formation from litter decomposition: a *dissolved organic matter (DOM)-microbial path* important during early stages of decomposition when litter loses mostly non-structural soluble compounds, resulting in high microbial incorporation and SOM formation efficiencies; an equally efficient *physical-transfer path* at final stages when brittle litter fragments move into soil. These two pathways contribute to the formation of different SOM fractions. The DOM-microbial path leads to formation of fine mineral—stabilized organic matter, while the physical transfer path generates less stable coarse particulate organic matter.

Experimental support to this hypothesis derives from a study of above-ground litter decomposition to complete mass loss in a tall grass prairie over a period of three years, using isotope tracing. In this study we examined how SOM formation efficiencies varied over time, with changes in litter-derived C incorporation in microbial phospholipid fatty acids and the loss of different litter compounds (e.g., water soluble, celluloses and acid unhydrolyzable fraction). Additionally, through laboratory incubations we determined the sizes of the active and stable litter-derived SOM pools. We also

Thus far we have utilized these experimental results, other literature values, along with a Bayesian Hierarchical framework to design and parameterize a new Litter Decomposition and Leaching Model (LIDEL). The LIDEL model mechanistically represents how non-structural, cellulose and lignin components of litter, as well as the C:N ratio, control the efficiency with which microbes utilize litter C and transform it to CO_2, DOM and particulate organic matter (POM; microbial products and litter residues). The ability to predict DOM leaching from litter to the soil based on litter chemistry and CO_2 efflux greatly enhances our ability to model both C transformations during decomposition and the connection between litter pools and C fluxes to the atmosphere and soil. Future steps include expanding the experimental work to other ecosystems along an Arctic-to-Tropical transect and incorporating the LIDEL model into an ecosystem model, linking the DOM and POM pool produced during decomposition to the formation of fine and coarse SOM fractions.

O 3.7.01

Modelling of soil organic matter from top down and bottom up

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Models of soil organic matter vary in complexity and the amount of process detail they are able to include. Models range from highly-complex, process-based models used to describe organic matter turnover at the experiment / plot scale, to very simple, single-pool models used as part of early couple carbon cycle climate models. In this presentation, I will summarise some of the different approaches to modelling of soil organic matter used at different spatial scales. The choice of model has very significant effects of the projections of change in SOM under future climate change, and some examples will be presented. Early suggestions of a large loss of carbon from mineral soils under future climate change appear to be less likely according to more recent modelling, with most projections now suggesting a net sink in mineral soils under future climate. The evolution of these estimates over time will be presented. I will conclude with a summary of current knowledge and future perspectives in SOM modelling - to allow us to better join our top-down and bottom-up modelling expertise.

O 3.7.02

Interpretation of incubation experiments with fresh organic matter

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Models are widely used to predict SOM dynamics as reaction on management and climate. While "usual" materials like manure can be managed by calibration to long term experiments, the implementation of "new" materials like digestates or roots requires alternative approaches. Incubation experiments about carbon mineralisation are useful to identify the properties of fresh organic matter and extract model parameters that can be used for the prediction of SOM behavior under field conditions. To reach this goal we have to transform the environmental conditions from field to lab scale and apply a coherent system understanding in both cases. Using some examples the presentation will demonstrate the workflow from the time series of lab observations to model application under field conditions including the analysis of uncertainties and the time dependent sensitivity of parameters that may be useful for the further refinement of the experimental design.

O 3.7.03

Evaluation of the ECOSSE model for simulating soil carbon under selected bioenergy crops in Britain

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The UK government committed to reduce GHG emissions by 80% in 2050 compared to 1990 levels; the use of bioenergy could contribute to this target using dedicated 'second generation' crops. Consequently, understanding and predicting the effects of land-use change to bioenergy crops on soil carbon (C) is an important requirement for fully assessing the C mitigation potential.

The ECOSSE model was developed to simulate soil C dynamics and GHG emissions in mineral and organic soils. However, it has not been extensively evaluated under bioenergy crops such as short rotation coppice (SRC), *Miscanthus x Giganteus* (*Miscanthus*) and short rotation forestry (SRF). Nineteen paired transitions to SRC-Willow, twenty paired transitions to *Miscanthus* and twenty-nine paired transitions to SRF were selected in the UK to evaluate the performance of ECOSSE in predicting soil C and soil C change from conventional systems (arable and grassland) to selected bioenergy crops.

The results of the present work revealed a strong correlation between modelled and measured soil C and soil C change after transition to *Miscanthus*, SRC-Willow and SRF plantations, at 0-100 cm soil depth.

The r value of the soil C at both *Miscanthus* (r = 0.95) and SRC-Willow (r = 0.72) sites showed a significant ($p < 0.05$) association between simulated and measured values. The modelled C under SRF also showed a strong correlation with the soil C measurements (r = 0.82). Overall, the change in soil C simulated by the model followed the same direction of the measured soil C changes. The simulated changes in soil C to all selected bioenergy systems were within the 95% confidence intervals of the measured values.

The statistical analysis of the model performance in simulating soil C and soil C changes after land-use change to all bioenergy crops showed no significant error, and no significant bias between modelled and measured values.

The high degrees of association and coincidence with measured soil C under *Miscanthus*, SRF and SRC-willow plantations in UK, provides confidence in using this process-based model for quantitatively predicting the impacts of future land-use on soil C, at site level, as well as at national level.

O 3.7.04

Modelling the dynamics of soil C after land use change to perennial energy crops - using evidence from time series under Miscanthus

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1. Introduction

Climate mitigation through renewable energy has brought particular interest to fast growing grasses and trees due to their dual potential to reduce GHG emissions and to lock up carbon (C) in the soil organic carbon (SOC). Usually experiments focussed on assessing productivity of these new crops, the initial soil carbon status was rarely quantified, nor existed time series to substantiate the rate of change. Recent integration of existing and new evidence showed an almost linear annual increase of 0.8 Mg ha^{-1} Miscanthus derived SOC over almost 20 years [1], however net effects can be very variable due to simultaneous decomposition of old SOC (derived from C3-plants). Two major questions arise, first, is there a lag of SOC build-up due to a lag of establishment and yield dynamics, and second, does the variation of above and belowground residue composition [2] affect the dynamics of SOC.

2. Objectives

The objective of our work was to use two versions of the Rothamsted Carbon model to analyse the effect of different residue properties on the dynamics and compare it to measurements in experiments of different age.

3. Materials & methods

The experiments used were both located on Rothamsted Farm (51.81 N -0.358 E), established (a) in 1997 as part of the European Miscanthus Improvement (EMI) program on a silty clay loam with sandy inclusions (Chromic Luvisol) and (b) in 2009 as part of the BBSRC Sustainable Bioenergy Center (BSBEC). For details of the experiments see [3, 4], respectively. Each of these experiments contained three genotypes of Miscanthus, *M. sinensis*, *M. sacchariflorus* and *M. x giganteus.* Detailed records for annual yields as well as residue and belowground biomass components exist [3, 4]. Soil cores were taken after 4 and 6 years as well as 14, 16 and 18 years after late and earlier establishment, respectively. From these cores root and soil bulk densities as well as bulk SOC, inorganic C and ^{13}C in the decarbonised soil were measured.

The empirical model RothC [5] was used to model the SOC dynamics with and without plant inputs to estimate the accumulation of total SOC stocks (C3+C4) and the decline of old (C3) SOC. A constant input from surface litter plus 10% of root residues were based on the average yield over the whole length of the experiment. Alternatively, residues were separated into major components, leaf litter, rhizomes and roots, assigning specific annual input and turnover rates derived from the literature [2].

4. Results

The simulation with the standard RothC overestimated both, the accumulation of bulk SOC and the decline of old SOC under the long-term (18 Yr) by about 10 and 2 Mg C ha^{-1}, respectively. The net accumulation of 9 Mg SOC ha^{-1} under 14 years of *M x giganteus* could be well modelled using disaggregated inputs but later measurements showed considerable uncertainty of measured and modelled accumulation suggesting a new equilibrium SOC content in the surface horizon. Early phase bulk SOC accumulation was underestimated by the partitioning while old SOC decline was again overestimated pointing to a considerable C input from the weed population. Slightly smaller inputs from Miscanthus were modelled and measured in the young experiment, which increased subsequently.

5. Conclusion

When accounting for the component specific input and turnover rates, the change in bulk SOC and accumulation of newly sequestered SOC were more realistically described by the model than with the standard empirical approach. Results for other genotypes confirm this finding. Postulated lag phases (resilience) in response to the land use change seem to depend on initial SOC and ground cover by weeds during establishment.

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O 3.7.05

Integrating peatlands into the coupled Canadian Land Surface Scheme (CLASS) and the Canadian Terrestrial Ecosystem Model (CTEM)

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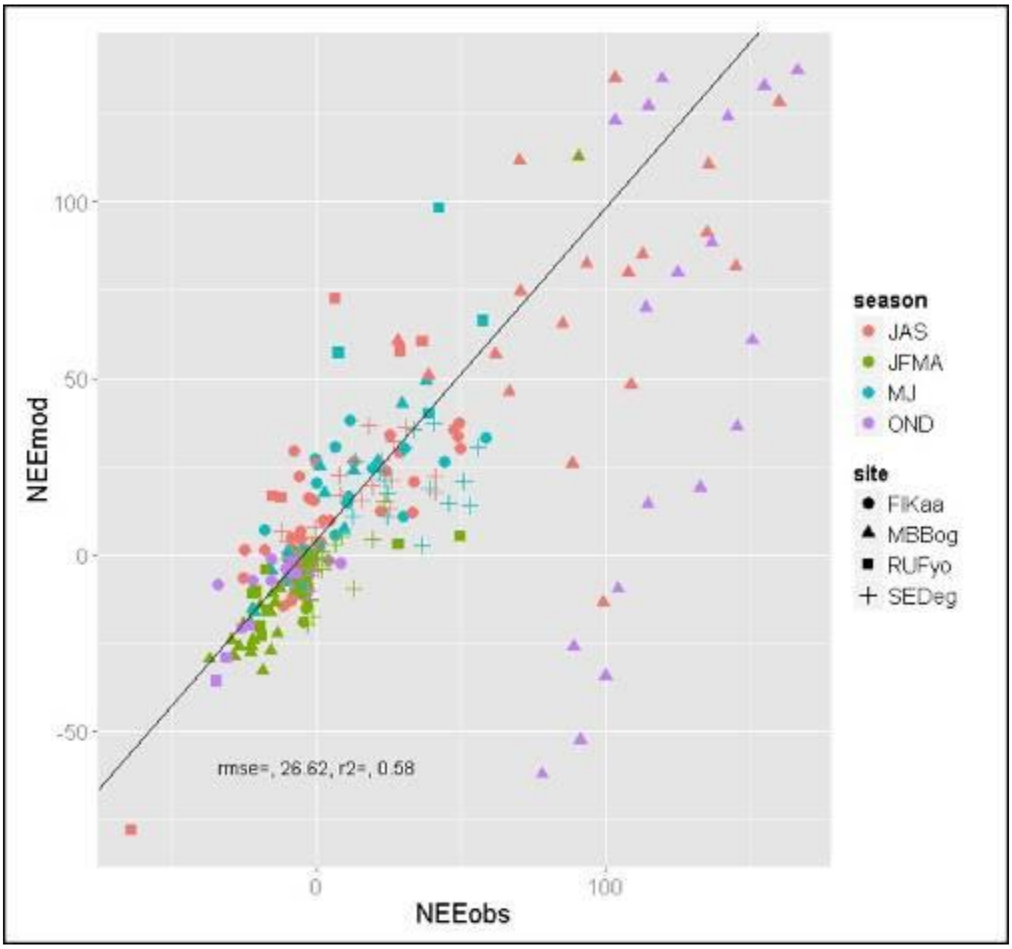
Storing about one third of the global soil carbon (C), peatlands have acted as a long-term regulator of the global C cycle during the Holocene and continue to play a crucial role in the global C budget. However, peatlands are highly sensitive to climate and to nutrient availability. These factors may induce profound change of the C cycle in peatlands, through altering the vegetation dynamics, biogeochemical processes and ecohydrological feedbacks.

The Canadian Land Surface Scheme (CLASS) and the Canadian Terrestrial Ecosystem Model (CTEM) have been coupled to incorporate feedbacks from dynamic vegetation to the energy and vapor exchanges at the land surface. The integrated CLASS-CTEM model has successfully simulated the C fluxes and pools at regional and global scales, yet components are missing from CTEM to account for the extensive soil C storage in peatlands. Since 2014, we have been developing new components for the CLASS-CTEM model to incorporate peatlands for simulations of the regional and global C budget. The new components aim to represent peatland vegetation, the decomposition of permanently saturated soil organic matter and the periodically saturated fresh soil organic matter at the subsurface. The model has been evaluated for both bogs and fens in Canada, Finland, Sweden, Russia and UK with respect to net C exchange and energy and water dynamics. This presentation will give an overview of the modeling approach and the recent simulation results from the model, as well as elaborate on the prospective scaling up of the model to the regional and global level.

Figure 1



O 3.7.06

Microbial turnover and temperature effect on soil organic matter decomposition: model structure as a crucial factor

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Integrating of microbial activity/dormancy function or, in broader terms, microbial ecology in ecosystem models with description of soil organic matter (SOM) became recently a hot topic (Todd-Brown et al., 2012; Wang et al., 2015; Bradford, 2013). Traditional SOM models were compared with models explicitly considering active microbial biomass (Wutzler & Reichstein, 2013; Wieder et al., 2013; Li et al., 2014). It is became clear that the latter models are more flexible and more appropriate for description of dynamical changes caused by batch substrate inputs and variation of environmental factors, such as temperature and moisture. Prediction of SOM balance in future warming world strongly depends on the way how temperature effect is incorporated in conceptual model structure. In the simple case temperature affect only decomposition rates of SOM pool, i.e. microbial death and enzyme production do not depend on temperature. However, temperature can effect microbial carbon use efficiency, and/or microbial turnover/death (Hagerty et al., 2014; Xenakis and Williams, 2014). The selection of parsimonious and biologically sound modeling approach for temperature regulation of SOM turnover is currently under discussion. We compared four possible alternatives of temperature regulation in SOM models with explicit description of microbial biomass dynamics and 2 soil organic matter pools based on MicExplicit model version described in Wutzler and Reichstein (2013) paper. Reaction rate in all cases varied with temperature according to Arrhenius law. The following cases were analyzed in numerical experiment: 1) temperature change affects only decomposition rates of two SOM pools. Other processes, such as microbial turnover or maintenance assumed to be temperature independent; 2) In addition to regulation described in case 1, the microbial turnover, i.e. microbial biomass die-off with opposite flux coming to the stable SOM pool, was included in model scheme; 3) case 1 was amended with temperature regulation of microbial growth efficiency; 4) microbial activity function (Blagodatsky et al., 2010) and temperature regulation of microbial activity were included in the model. In the last case an application of index of microbial physiological state (r) help to describe the adaptive variation of the cell composition and metabolic activity by one variable (Panikov, 1995). We will present the results of sensitivity analysis with 5 different temperature values in the range of 15-35^{o}C with 5 degree interval.

The “one-way” temperature effect in case 1 leads to the change of steady-state levels for S_low (low quality) and S_high (high quality) SOM pools with their decrease at higher temperature or increase at lower temperatures. Microbial biomass is temporarily increasing at higher temperature and later reach the same biomass steady-state at all temperatures. However, steady-states levels for S_low were completely different and unrealistic for high and low temperatures. Long-term effect of temperature on steady-state levels of SOM differs distinctly between case 1 and cases 2-4, i.e. when temperature regulation of microbial turnover or carbon use efficiency is included in the model. In case 2, for example, the steady-state level of S_low decreased very slowly by 3% of initial stock level with increasing temperature. According to our analysis consideration of temperature effect on microbial turnover is necessary in SOM models, but further selection of optimal solution should be done based on experimental validation of proposed model schemes.

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O 3.7.07

Effects of Land Use Change on Soil Carbon Storage and Water Consumption in an Oasis-Desert Ecotone

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Question: Land use and ecosystem services need to be assessed simultaneously to better understand the relevant factors in sustainable land management.

Methods: This paper analyzed land use changes in the middle reach of the arid Heihe River Basin in northwest China over the last two decades and their impacts on water resources and soil organic carbon (SOC) storage. Landscape pattern analysis based on landscape metrics coupled with field sampling and laboratory analysis of soils under different land uses were used to estimate the SOC and water use effects.

Results: The results indicated that from 1986 to 2007: (1) cropland and human settlements expanded by 45.0 and 17.6 %, respectively, at the expense of 70.1, 35.7, and 4.1 % shrinkage on woodland, grassland, and semi-shrubby desert; (2) irrigation water use was dominant and increased (with fluctuations) at an average rate of 8.2 %, while basic human water consumption increased monotonically over a longer period from 1981 to 2011 at a rate of 58 %; and (3) cropland expansion or continuous cultivation led to a significant reduction of SOC, while the land use transition from grassland to semi-shrubby desert and the progressive succession of natural ecosystems such as semi-shrubby desert and grassland, in contrast, can bring about significant carbon sequestration benefits.

Conclusions: The increased water consumption and decreased SOC pool associated with some observed land use changes may induce and aggravate potential ecological risks for both local and downstream ecosystems, including water resource shortages, soil quality declines, and degeneration of natural vegetation. Therefore, it is necessary to balance socioeconomic wellbeing and ecosystem services in land use planning and management for the sustainability of socio-ecological systems across spatiotemporal scales, especially in resource-poor arid environments.

O 3.7.08

Is the soil carbon model Yasso07 suitable for estimating soil carbon stock dynamics of temperate forests at large territorial scales?

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Background and Aims: Modeling and predicting the dynamics of soil carbon (C) stock of forest ecosystems can help us to better evaluate the ecosystem service of forests with regard to the C sequestration for climate change mitigation. The process-based model Yasso07 is considered as one of the most promising tool for this purpose. We aim at examining the prediction accuracy of Yasso07 on soil C dynamics over the whole French territory at a decennial scale.

Methods: The measured forest data for model validation are from the French National Forest Inventories (NFI) that covers most the French temperate forest ecosystems and main species. The data includes measured litterfall (leaves, branches, fruits and miscellaneous) from aboveground part monitored at yearly scales (1994-2008), estimated litterfall from slashes due to either harvest or storms and from roots and soil C stocks measured at an interval of fifteen years (1993-1995 and 2007-2012). Using the published Yasso07 parameters, we simulated both C stock (t ha^{-1}) and stock changes (t ha^{-1} y^{-1}) per plot and then compared with the measured ones.

***Key Results*:** At the national level, both the simulated C stock and stock changes stayed in the same order of magnitude with the measured ones. At the plot level, correlations between predicted and measured data remain weak. Analysis of residuals showed that there was a significant effect of soil type, tree functional group and forest age on the residuals.

Conclusions: We revealed both interest and challenges of applying Yasso07 toward temperate forests. The performance of Yasso07 depends on the biochemistriy, pedoclimate and land-use history. A better refining several biochemical processes in Yasso07 might improve its prediction precision at the plot level.

O 3.7.09

Spectroscopic and thermo-spectroscopic approaches for initialization and parameterization of SOM models

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1. Introduction

While compartmental soil organic matter (SOM) models such as Century or Daisy have been applied in a variety of environments and land uses to simulate measured SOM dynamics, the issue of how to parameterize or initialize the compartments or pools of these models is not straight forward. Measured SOM fractions have been used to parameterize the pool sizes, but particularly slow turnover pools have been difficult to relate to measureable fractions.

2. Objectives

The main objective of this study was to examine the use of size/density fractionation (*SOM fractions*), mid-infrared spectroscopy (*MIRS*) specific peak area, thermally evolved gas analysis (*EGA*), and pyrolysis-MIRS (*Pyro-MIRS*) derived pools to initialize the fast (SOM2) and slow (SOM1) turnover pools of the Daisy model as implemented within the Expert-N modeling framework.

3. Materials and Methods

Initial carbon (C) pool sizes were set via various methods described below and measured soil parameters used for the beginning of the model run. The specific initialization methods were derived from: *SOM fractions*, a combination size/density/chemical oxidation fractionation (Zimmermann et al., 2007), *MIRS*, in the diffuse reflectance mode (DRIFTS), with analysis of specific functional groups, *EGA*, coupled with in situ thermal DRIFTS measurements to elucidate functional group changes during relatively slow heating (68 ºC min^{-1}) to 700 ºC, and *Pyro-MIRS*, rapid heating of 60 ºC ms^{-1} until 700ºC. Modeled results were compared with measured data of long-term experiments in Pforzheim (Kraichgau region, 2009-2013), Nellingen (Swabian Alb region, 2009-2013), and the Extreme Farmyard Manure Experiment Bad Lauchstädt (1983-2008), Germany and the Ultuna Frame trial (1956-2005), Sweden.

4. Results

It was found that the different initialization methods resulted in a wide range of pool allocations, with the *SOM fraction* method generally resulting in the smallest SOM2 pool allocation and the *MIRS* initialization in the largest for the four different sites. Often it was the case that the *MIRS*, *EGA*, and *Pyro-MIRS* gave similar pool allocations, even though they rely on different measurement principals. Especially over long-term periods (>20 years), the size of slow turn-over pools resulted in different final soil organic carbon (SOC) amounts, showing the importance of proper initialization of the intermediate and passive pools for future predictions of SOC.

5. Conclusions

This study demonstrated several approaches and possible implications of using these methods for SOM model pool initialization and the considerations that need to be taken into account in order to allocate these measureable fractions as model pools, and also the strengths and weaknesses of each method. As *MIRS* and *Pyro-MIRS* are less labor intensive than the *SOM fractions* method, these show promise for further research for model pool initialization.

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P 3.7.01

Soil organic carbon accumulation predicted by Roth C model in Andalusian olive groves with three management practices: natural plant cover, olive pruning debris and composted olive mill pomace

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1 Methods

The RothC-26.3 model (Coleman & Jenkinson, 1996) was applied. We chose different levels of the organic inputs based on literature and in our experimental field data: 2 levels of incombing biomass as natural plant cover (PC), 3 levels of olive pruning debris (PD) calculated by considering average values of olive oil production and by transforming them into olive pruning debris production with the equation of Civantos & Olid (1985), and 1 level of composted olive mill pomace (MP).

2 Main results

The largest soil organic carbon (SOC) accumulated at the end of the 100 years was in the scenarios combining PC with PD and PC with MP, 39.9 and 35.98 t C ha^{-1}, respectively (table 1, figure 1b).

Otherwise, in the case of single inputs, the scenarios corresponding to the PC and PD managements accumulated the largest amount of SOC after 100 years, 23.1 and 22.4 t C ha^{-1}, respectively (table 1, figure 1a).

Moreover, we calculated the SOC accumulation rate for the first 10 years (SOC10), 50 years (SOC50) and during the 100 years (SOC100). As expected, SOC 10 rates were the highest. Indeed, rates were between 2 and 2.5 times higher than that of SOC 50 and between 3 and 4 times higher than SOC 100 values (table 1)

Table 1. Total amount of the organic inputs (t C ha^{-1} yr^{-1}), initial and final soil organic carbon (t C ha^{-1}), soil organic carbon accumulation after hundred years (t C ha^{-1}) of treatment application and soil organic carbon accumulation rates after 10, 50 and 100 years (t C ha^{-1} yr^{-1}).

Figure 1. Total soil organic carbon accumulation after 100 years for each management and organic input level (a, single managements; b, combined managements). Bare soil with only olive trees represents the conventional tillage management.

3 Conclusions

Any of the easy-to-implement management which includes inputs of locally available organic matter increased significantly the SOC , particularly when both (natural plant cover plus olive pruning debris or composted olive mill pomace application) management were combined, and specially at the short term.

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Figure 1

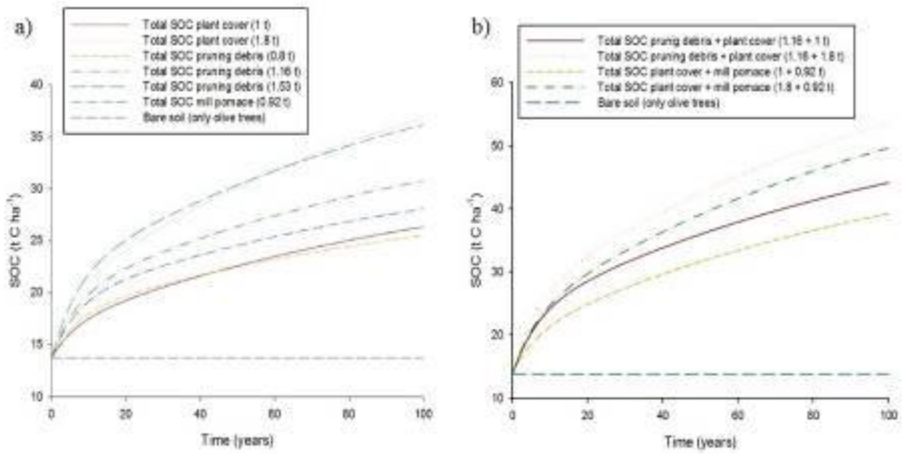

Figure 2

Input	Amount	Initial SOC	Final SOC	SOC accumulation	SOC10	SOC50	SOC100
Plant cover of weeds	1.00	13.70	26.32	12.62	0.38	0.18	0.13
	1.80	13.70	36.79	23.09	0.72	0.33	0.23
	0.80	13.70	25.50	11.80	0.43	0.18	0.12
Olive pruning debris	1.16	13.70	30.75	17.05	0.62	0.25	0.17
	1.53	13.70	36.15	22.45	0.81	0.33	0.22
Composted olive mill pomace	0.92	13.70	28.06	14.36	0.55	0.22	0.14
Plant cover + olive pruning debris	2.16	13.70	44.14	30.44	1.05	0.45	0.30
	2.96	13.70	53.61	39.91	1.31	0.58	0.40
Plant cover + composted olive mill pomace	1.92	13.70	39.21	25.51	0.77	0.36	0.26
	2.72	13.70	49.68	35.98	1.10	0.51	0.36

P 3.7.02

From aggregate-scale microbial community dynamics to prediction of soil profile fluxes with varying hydration conditions - upscaling methodology and applications

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Three dimensional pore networks within soil aggregates provide unique conditions for coexistence of oxic and anoxic microsites that shape (and respond to) aerobic and anaerobic microbial communities and their functioning. Soil hydration dynamics continuously alter the extent of anoxic niches (hotspots) that flicker in time (hot moments) and support anaerobic microbial activity even in unsaturated soil profiles. We constructed artificial soil aggregates comprised of 3-D angular pore networks (preserving salient features of partial saturation and transport), and employed individual based models of motile microbial cells that grow, move, intercept nutrients, and respond to oxygen levels. The model quantifies how hydration conditions affect microbial community size, spatial segregation and activity (e.g., rates of CO2 and N2O production) from single model aggregates. Single aggregate results were generalized to provide input for modeling the functioning of assemblies of soil aggregates of different sizes. The activity within typical soil aggregate size distributions spatially distributed in the soil profile was estimated form the range of boundary conditions (reflecting water, carbon, and oxygen profiles). An upscaling scheme was developed toaccountfor aerobic and anaerobic activity within each aggregate class size and soil depth integrated over the aggregate size distribution in the soil for a range of hydration conditions. Results show that dynamics adjustments in microbial community composition affects CO2 and N2O production rates in good agreement with experimental data. The modeling approach addresses a long-standing challenge of linking hydration conditions to dynamic adjustments of microbial communities within “hotspots” with the emergence of “hot moments” reflecting high rates of denitrification and organic matter decomposition.

P 3.7.03

Unravelling effects of an extreme drought on the components of net ecosystem exchange in a natural peatland by a process model

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Drought spells normally reduces the net carbon uptake in high latitude peatlands. Drought severity or frequency my also increase in the future in certain peatland regions. Reduced net carbon uptake emanates either from decreased photosynthesis or increased ecosystem respiration, or both. An extraordinary low carbon balance in the long time series (12 years) of measured net ecosystem exchange (NEE) has been reported during a dry and warm year at Degerö Stormyr, a Swedish natural mire. The objective of this study was to analyse the various responses on the single factors at the beginning, during and the end of the drought. Therefore the process oriented CoupModel was applied, using a Monte Carlo based uncertainty calibration and multiple criteria to select runs with an acceptable fit to the measurements. The contributions of the different components to NEE and resulting parameter ranges of the accepted runs were analysed.

Preliminary results show that the decrease of NEE during the drought resulted to a large extent from reduced plant assimilation. Large changes also occurred in the soil: Heterotrophic respiration decreased in upper soil layers due to too low moisture content. This was overcompensated by an increase in lower layers, where it used to be constraint by too high water contents. When the first rain arrived, heterotrophic respiration increased again in the upper layers, while it was still ongoing in the lower layers which were not yet saturated. This explains the increased heterotrophic respiration in after the drought period.

This study has shown that process oriented modelling can help to unravel the complex interactions between several processes involved in controlling variations in NEE, occurring at several layers and overlaying each other.

P 3.7.04

Straw export in continuous winter wheat and the ability of catch crops and early sowing to offset soil C and N losses: a simulation study

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The export of winter wheat straw for bioenergy may reduce soil C stocks. Establishing fast-growing catch crops between successive wheat crops could potentially offset some of the C losses. Another option is to sow wheat earlier, increasing biomass production during the autumn. The effects of straw export, catch crop and early sowing on soil C storage, N leaching losses and N_2O emissions were simulated by applying the *Daisy* model to winter wheat grown continuously for a period of 100 years on a sandy loam soil in a Danish climate. The simulations included five levels of initial soil C content (1-3 % C), three levels of straw incorporation (0, 50 and 100 %), +/- catch crop (oil radish) and two sowing dates (1 and 22 September). Exporting the entire straw production reduced initial soil C stocks by 1.2 to 14 % after 100 years, depending on the initial C content. Inclusion of a catch crop could offset this loss by 2-3 percentage points. Earlier sowing of wheat increased straw production by 18 % and reduced loss of soil C by 3-5 percentage points compared to normal sowing time with full straw export. Catch crops and early sowing also reduced N-leaching losses compared to a scenario with full straw export. Early sowing performed better than catch crops in reducing N leaching and N_2O emissions,. However, the enhanced risk of excessive weed competition and pest damage during autumn followed by over-winter crop failure may jeopardise the environmental advantages of early sowing. Sensitivity analyses showed that a wetter climate had little effect on soil C storage, but increased N leaching losses by up to 48 %. Loss of soil C and leaching of N increased when early-sown wheat was subject to winter-kill and when sandy loam soil was replaced by a sand soil. When wheat is grown continuously, losses of C are mainly defined by the initial soil C content (reflecting the management and land-use history of the soil) and by the level of straw export. The use of catch crops and early sowing may offset some of the adverse effects of straw export.

P 3.7.05

Soil organic matter and readily dispersible clay sensing with a mobile sensor platform

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Introduction

Soil organic matter (SOM) is an essential property which has a significant influence on soil fertility and erosion resistance. Particle size fractions strongly affect the physical and chemical properties of the soil. The amount of readily dispersible clay (RDC) in the soil is of importance for agriculture and environment because clay dispersion is a cause of poor soil stability in water. This contributes to soil erodibility, mud flows, and cementation which in turn affect SOM content.

Objectives

To obtain a detailed map of SOM and RDC, many samples are needed. Moreover, SOM and RDC determination are costly and time consuming. The use of a mobile visible and near-infrared (VIS-NIR) platform is proposed here to map those soil properties and obtain detailed map at field level.

Materials and methods

Soil properties prediction was based on a calibration model developed with 10 representative samples selected by a fuzzy logic algorithm. Calibration samples were analysed for soil texture (clay, silt and sand), RDC and SOM using of conventional wet chemistry analysis. Moreover, the VerisÒ mobile sensor platform is also collecting electrical conductivity (EC) data (deep and shallow), and soil temperature. These auxiliary data were combined with VIS-NIR measurement (data fusion) to improve prediction results. EC maps were also produced to facilitate understanding SOM and RDC data. The resulting maps were visually compared with the orthophotography of the field taken at the beginning of the plant growing season. Models were developed with partial least square regression (PLSR) and support vector machine regression (SVMR).

Results

No significant differences were identified between calibration using PLSR and SVMR technics. Nevertheless, the best models were obtained with PLSR and standard normal variate (SNV) pretreatment and the fusion with deep EC data (SOM: RMSECV = 0.16%, R2 = 0.70 RDC: RMSECV = 0.35%, R2 = 0.71; Clay: RMSECV = 0.32%, R2 = 0.73). The best models were used to predict the soil properties from the field spectra collected with the VIS-NIR platform. Maps of soil properties were generated using natural neighbour (NN) interpolation. Calibration results were satisfactory for all soil properties and allowed the generation of detailed maps. All maps are consistent with our knowledge of the field. The spatial variability of SOM and RDC were in accordance with the field orthophotography. Areas of high RDC and low SOM contents were corresponding to areas of bad plant development.

Conclusion

Only 10 calibration samples were needed to obtain a detailed map of a 15 ha field. This study introduces the possibility of using VIS-NIR for predicting readily dispersible clay at the field level. In addition to SOM prediction, the results obtained could be used counterfighting soil erosion.

P 3.7.06

Survey of soil N mineralisation literature to evaluate the performance of process-based crop models in tropical environments

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The prediction of soil organic matter (SOM) turnover is a major challenge for crop model simulations, due to the complex interaction of the processes involved. Process-based simulation models pursue various approaches, resulting in very different SOM decomposition rates, despite identical input information. Improvement of the diverse model routines is impeded by the lack of adequate field or laboratory data on SOM turnover, which generation is time and cost consuming. One of the most critical state variables in crop growth models is the nitrogen (N) mineralisation from soil, as soil-borne N is the primary source of N supply to the crop in many low-input agricultural systems. However, model parameterisation differs strongly between climatic regions and especially the tropics are still lacking sufficient data. We extensively investigated literature data to obtain a range of soil N mineralisation rates for tropical regions. The observed confidence interval (95%) between 59 and 73 kg N ha^{-1} (mean: 66 kg N ha^{-1}) for tropical soils from Brazil, Central Africa and South-East Asia is considerably less compared to that of temperate regions. However, the literature sources provide only little information about land use, SOM content or other important factors which determine SOM turnover, whereby a classification and evaluation of the results is difficult. Nevertheless, it is expected that this analysis will help to ground the assumptions which are inherent to crop models being initially developed for temperate environments, but used in the tropics without prior testing.

P 3.7.07

Modelling Sorption of Munitions Constituents Using Humic and Fulvic Acids as the principal Organic Carbon components in a Wide Range of Soil Characteristics

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The organic matter contained in soil is generally the most important soil constituent responsible for the sorption of organic compounds and this has led to the use of the organic carbon normalized partition coefficient, K_{oc} (L/kg), the octanol-water partition coefficient, K_{ow} (Lwater/L octanol), and fraction of organic carbon in the soil, f_{oc} to describe this phenomena. These simplifications have been successfully employed to model the partitioning of many hydrophobic organic chemicals like PCBs and PAHs, but their application to Munitions Constituents (MC) results in order of magnitude errors. In addition is well known that the soil organic matter (SOM) is not a single material. It is a composite of many materials with differing abilities to sorb organic contaminants. The fraction of SOM that is active in the sorption is likely to vary among soils. For this reason, a refined measurement to provide better predictability of partitioning among soils was investigated. It involved a classical, solubility-based, determination of fulvic and humic acids (FA and HA) to test if these components relates better the partitioning rather than the organic carbon. On the other hand, as literature indicates clay mineral exchange sites influence the adsorption of munitions constituents, so, this research also included the clay content in the model proposed to identify its influence in the partitioning of the MC. We conducted batch experiments near 1:1 soil to solution ratios reflecting field conditions using a mix of HMX, RDX, nitroglycerine (NG), nitroguanidine (NQ), TNT and 2,4-dinitrotoluene as MC. We used 15 soils that varied from 5 to 40% clay content and 0.04 to 18% total organic carbon in an experiment that involved 2 days of adsorption followed by four consecutive desorption steps and final extraction explosives from soil, which was analyzed by HPLC. To determine FA and HA fractions from soils, solid-liquid extractions for separation using HCl and NaOH were made, these supernatants were quantified by UV/Vis. With the data generated, partition coefficients (soil/water) were calculated for each MC, and these data were compared with the estimated multilinear model developed in the research. This model relating the partition coefficients with the fraction of physicochemical properties of the soil including HA and FA multiplied by empirical coefficients of each soil property. The most important observation was that for each explosive, even if they were in a mixture and have different chemical composition, we successfully predicted the fate of the explosives in the environment. In addition it was improved the estimation by a factor of 2 in accuracy compared with the traditional model of normalization carbon. The root mean square error RMSE was near 0.5 for each MC indicating that the differences between estimated and observed values are very low and this model can be used as a tool for prediction of environmental impact in areas potentially contaminated with these compounds.

P 3.7.08

A modeling approach to estimate management effects on soil organic carbon changes in Danish mineral soils

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Soil organic carbon (SOC) is beneficial for soil fertility and soil structure and is in active exchange with the atmosphere. The amount of organic carbon (OC) input into the soil and SOC turnover rate are important for predicting the carbon (C) sequestration potential of soils subject to changes in land-use and climate. The C-TOOL model was developed to simulate the SOC storage on medium- to long-term trends in the whole soil profile. C-TOOL defines three discrete soil carbon pools (Fresh Organic Matter (FOM), Humified Organic Matter, and Resistant Organic Matter (ROM)) that comprise the SOM of mineral soils; and by considering the degradation and transformation between these pools, it simulates the dynamics of SOM in whole soil profile (0-100 cm). In Denmark a national 7 × 7 km grid net was established in 1986 for soil C monitoring down to 100 cm depth, and was sampled 3 times with approximately 10-year intervals in 1986, 1997, and 2009. C-TOOL was parameterized using SOC and radiocarbon data from selected long-term field treatments in North West Europe. Additionally, C-TOOL was verified against measured values from Danish grid monitoring network. Then we used C-TOOL to compare SOC changes under typical Danish farming conditions for two sites in Denmark with the greatest possible temperature differences; Denmark's Northernmost (North Jutland) and Denmark's southernmost (South Zealand) part. For this purpose various agricultural land use and management scenarios were considered. These scenarios included characteristic crop rotations with and without the presence of cover crops. Additionally, the application of organic amendments such as manure or crop residues was considered. Therefore, the objective of current study was to examine SOC dynamics in topsoil and subsoil of typical Danish farms, and to identify management impacts on SOC stocks between 1986 and 2012 using the C-TOOL model. We compared these simulated management effects with management effects estimated from a national SOC monitoring network over the same period of time. Temperature wise, Denmark has a cool temperate climate with only little variation across the country with South Zealand being approximately 1 °C warmer than North Jutland during 1986 to 2012. This temperature difference resulted in slightly smaller SOC at the end of the initialization period for the warmer compared with the cooler site. The results of the C-TOOL simulations demonstrate that application of organic manure (i.e. straw and manure), use of cover crop in rotations, and converting the croplands to grassland have the potential to increase organic matter in both top and sub soils of Denmark. The simulated data also suggested that C-TOOL gives a reasonably good account of changes in soil organic C in these soils when it compared with measured SOC values from Danish national monitoring network. The estimates show rather small potential for increasing SOC in Danish cropping systems, unless there is conversion to rotations with more grasslands or the use of cover crops is increased. Future work will focus on further evaluating effects of different cover crop species on SOC accumulation, improving the estimation of C inputs, particularly root C input from different crops at different soil depth.

P 3.7.09

Testing the suitability of DNDC model for simulating soil organic carbon dynamics in Korean paddy under long-term fertilization

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Soil organic carbon(SOC) is one of the most important constituents of soils due to its capacity in affecting plant growth indirectly and directly. This change in SOC content is associated with organic input with various source in soil. This study was conducted in order to simulate SOC dynamics in paddy soil applied long-term fertilization using DeNirification and DeComposition (DNDC) model. The long-term experiment field located at Department of Southern Area, National Institute of Crop Science, Milyang, southern part of Korea. The plots designed randomized complete block with three replication. The paddy soils were subjected to different fertilization practices: inorganic fertilizers (NPK, N-P-K=120-34.9-66.7 kg ha^{-1} yr^{-1} during 1967-1972 and 150-43.7-83.3 kg ha^{-1} yr^{-1}) from 1973 to 2007), straw based compost(Compost, 10 Mg ha^{-1} yr^{-1}), a combination of inorganic fertilizer and compost(NPK+Compost), and no fertilizer(Control). For simulating SOC dynamics, soil samples selected in the 11th, 16th, 21st, 26th, 30th, 37th, 41st year to determine the changes of SOC contents in plough layer. The fertilization significantly increased the total biomass yield(grain+straw) to 173%, 139 and 194% of the control with NPK, Compost, NPK+Compost fertilization, respectively. Rice grain yield slightly and continuously increased with the rate of 4.57 kg ha^{-1} yr^{-1} from 3.3 Mg ha^{-1} in the control treatment. In comparison, the grain yield significantly increased with the lapse of years in the fertilized treatment. It increased with rate of 30.4 kg ha^{-1} yr^{-1} from 5.3 Mg ha^{-1} in NPK, 63.9 kg ha-1 yr^{-1} from 3.5 Mg ha^{-1} in Compost, and 51.4 kg ha^{-1} yr^{-1} from 5.5 Mg ha^{-1} in NPK+Compost. Continuos compost application increased the SOC concentration in plough layer. In contrast, NPK and Control plots markedly decreased SOC concentration. DNDC model was verified to simulate the change of SOC contents in paddy soil as considering the significantly low RMSE between the observed and simulated data value. However, careful tuning of crop growth parameters should be promoted for better simulation, and detailed information about farm management required for input parameters in often difficult to obtain, especially in long-term experiments. In conclusion, the DNDC model is an effective tool for simulating long-term SOC dynamics in paddy soils.

Key words: Soil organic carbon, Long-term fertilization, DNDC model rice paddy

P 3.7.10

Watersoluble and lignin phenols in lichens: relationship to SOM formation in tundra soils

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Introduction

Phenolic compounds comprise abundant and highly reactive portion of plant-derived organic matter. Oxidation and co-polymerization of phenolics with other prescursors contribute to the formation of humic substances while fast and irreversible sorption of phenolics onto mineral surfaces result in the formation of stable organic-mineral compounds. Overall, phenolic compounds contribute largely to the formation of SOM. Since Devonian appearance of higher plants, lignin and its transformation products can be considered as the main source of phenolic derivatives. Little is known about phenolics input in soils from non-vascular communities which are predecessors of higher plants and occupy large territories in the Northern hemisphere. Lichens are particularly interesting with respect to C sequestration and primary pedogenesis. They accumulate significant amounts of biomass and dominate in extreme habitats on about 6-8% of land surface. Before plants terrestrialization, lichens could be distributed much wider and occupy ordinary habitats (Zavarzina, Zavarzin, 2013). Literature survey reveals that lichen phenolics are poorly studied both quantitatively and qualitatively, except for specific "lichen substances" which are poorly soluble and thus their involvement in environmental processes is limited. We have recently found that lichens possess considerable amounts of watersoluble phenolics (Zagoskina et al., 2013). The aim of the present work was to assess the quantity and composition of watersoluble and "lignin" phenols with respect to their possible involvement in humification. We have also studied lignin phenols in soils under lichens as well as adsorption and oxidation capabilities of water-soluble phenolics.

Patients and Methods

Epigeyic lichens *Cladonia stellaris, Cetraria islandica, Flavocetraria nivalis, Alectoria ochroleuca, Peltigera aphthosa and Solorina crocea were* collected in the Khibiny montains (Kola peninsula). Mosses *Sphagnum fuscum* and *Pleurozium schreberi* were used for comparison. Phenolic compounds were extracted by H_2O (1h, 30C) and quantified by Folin-Denis assay. Qualitative composition were studied by TLC and reversed-phase HPLC before and after acidic and alkaline hydrolysis. 11 "lignin" phenolics (p-hydroxybenzoic, vanillic (V), syringic (S) and coumaryl (C) structures) were quantified by GC-MS after CuO oxidation of lichen tissues.

Results and Discussion

Peltigerous lichens contained 3-4 times higher amounts of water-soluble phenolics, then lecanorous lichens. Soluble phenolics in both systematic groups comprised about 2.5% of soluble organic C. The TLC revealed the presence of 6-8 phenolic compounds, about half was represented by the conjugates of phenolic acids with amino acids and sugars. These conjugates were actively adsorbed by a number of mineral phases, including natural soil, and oxidized in presence of laccase. Reversed-phase HPLC of the hydrolysis products revealed the presence of benzoic, salicylic, p-hydroxybenzoic, vanillic, syringic, p-coumaric (?), gallic, ferulic (?) and cinnamic (?) acids and vanillin. The CuO-oxidation showed that total content of "lignin" derivatives was quite different in the lichens studied (0.09-1.3 mg/g, 0.01-1.8% of organic C). Mosses contained 0.6-2.2 mg/g lignin phenols, however these were almost exclusively represented by p-hydroxybenzoic structures. In lichens, syringic structures dominated over vanillic and p-hydroxybenzoic ones and acids dominated over the aldehydes. On the basis of the very high S/V ratios and low content of coumaryl structures, unusual for the lignin of higher plants, it can be suggested that CuO-oxidation products of lichens contain non-lignin phenols admixtures. In soils under lichens vanillic and p-hydroxybenzoic structures were dominant, suggesting fast decomposition of syringil phenols.

Conclusions

We have found that lichens contain phenolic structures common in higher plants, including “lignin” phenols. Lichen soluble phenolics showed high oxidation potentials as well as adsorption capabilities. This clearly shows importance of lichens as a source of aromatic compounds in soils where lichens are abundant.

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P 3.7.11

Modelling seasonal and inter-annual variations in carbon fluxes of temperate grassland ecosystem: Application of CoupModel

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1. Introduction

Grassland is one of the most widespread terrestrial ecosystem (~40% of the global land surface), containing the largest share (39%) of terrestrial soil carbon (C), and is considered as a potential option for global mitigation. Net ecosystem C flux or net ecosystem exchange (NEE) is controlled by the balance between C uptake by gross primary production (GPP) and C loss through total ecosystem respiration (Reco). Low to high seasonal and inter-annual variations have been reported for different C fluxes in grassland ecosystems. Grassland C fluxes have also been found to be influenced by extreme climatic events, such as drought, heat wave, and wet and dry spells. In last few decades, different process-based soil-plant-atmosphere system models are increasingly being used in simulation of ecosystem C fluxes in different time scales for a variety of purposes. Model performance has been found to decrease with finer time resolution. Seasonal and inter-annual variations in modelling C fluxes are also major issues. Model calibration and uncertainty analysis in seasonal and inter-annual scales are important to improve our understanding about the system, and reduce simulation uncertainty in modelling C fluxes, their annual balances and future climate change studies. In the present study, a Monte Carlo-based calibration and uncertainty assessment was performed in simulation of seasonal and inter-annual variations in GPP, Reco and NEE, simulated by a soil-plant-atmosphere system model (CoupModel).

2. Objectives

The specific objectives of the present study were to (a) calibrate and evaluate the performance of CoupModel in simulation of seasonal and inter-annual variations in GPP, Reco and NEE in a temperate mown grassland ecosystem, (b) analysis of parameter behaviours.

3. Materials & methods

A mown grassland was selected within SOERE-ACBB experiment, Lusignan, France for the present experiment. The mown paddock was equipped with an eddy covariance sensor array measuring CO_2 flux at a 30-minute time-step from 2006-2012. Measured NEE was partitioned into Reco and GPP. CoupModel 5.0 was run from 2005-2012 on a one-hour time step, driven by climate and management practices. A total of 35 parameters were selected for calibration. Uncertainties in parameters were analyzed using the general likelihood uncertainty analysis (GLUE) methodology. A total of 14,000 simulations were implemented using Monte Carlo random uniform sampling of the pre-defined parameter ranges. Coefficient of determination of a linear regression (R^2) and mean error (ME) were used as performance indices. A total of 137 behavioural models were obtained when the prior model simulations were constrained by the accepting criteria of NEE as $R^2 > 0.62$ and ME ±0.55 g C m^{-2} day^{-1}.

4. Results

Overall, good agreements between model and measured values obtained after calibration for GPP, Reco and NEE (R^2~0.65, ME~0.39 g C m^{-2} day^{-1}). Although, only NEE was constrained, model performances were also improved for GPP and Reco. Most of the selected model parameters were constrained with their new improved distributions. Average annual GPP, Reco and NEE were 1633, 1263 and -370 g C m^{-2} yr^{-1}. There was strong seasonal variation in C fluxes. Spring constituted maximum proportion of annual GPP (43%), Reco (36%) and NEE (69%). GPP were equally lowest (14% of annual GPP) in autumn and winter, whereas Reco ranged as low as 14-18% during autumn and winter. However, NEE was lowest in autumn. Inter-annual variability in GPP (1414-1942 g C m^{-2} yr^{-1}), Reco (1017-1425 g C m^{-2} yr^{-1}) and NEE (-588 to -23 g C m^{-2} yr^{-1}) were also higher. The CoupModel successfully captured overall seasonal variation in different C fluxes. However, the model slightly underestimated GPP in winter and spring, whereas slightly underestimated Reco in spring and summer. NEE was minutely underestimated in winter, but overestimated during spring and summer. The model also simulated inter-annual variations in GPP and NEE sufficiently, but model performance was relatively poor in capturing inter-annual variation in Reco.

5. Conclusion

Overall model performance in simulation of C fluxes in mown, temperate grassland ecosystem was satisfactory. Model calibration helped in parameter conditioning and improving simulation efficiency for all the three C fluxes. The CoupModel sufficiently simulated overall seasonal variations in different C fluxes. The model also successfully captured inter-annual variations in GPP and NEE, but performed poorly for Reco. Future model improvement is necessary for simulating inter-annual variation in Reco more efficiently in managed, temperate grassland ecosystem.

P 3.7.12

Predicting soil organic carbon stocks by coupling soil profile data and soil maps - Results from Lower Saxony and perspectives for Germany

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With about 1.500 Gt soils are worldwide the third biggest carbon storage. Soil organic carbon content is supposed to be at equilibrium by input and output, which depend on several environmental factors. The main factors determining the long term carbon content in soil are pedogenesis, land use, climate (soil wetness/dryness) and soil depth. By changing these factors soils can serve as a carbon sink or source. Thus, evaluating exact soil organic carbon values is important for climate models and soil protection issues. However, based on deficient soil data and the lack in understanding the complex mechanisms determining the soil organic carbon content, its prediction in soils of Germany is still challenging. The aim of this study is therefore to evaluate the current state of Germany wide soil organic carbon content and stocks, based on an adapted soil carbon model developed by Möller and Kennepohl (2014) for Lower Saxony. Founded on the differentiation criteria, soil type, horizon symbol and depth, land use (agricultural land and pasture), texture and climate analytical soil profile data were assigned to the standardized profiles of the soil map of Lower Saxony (BÜK 50), followed by statistical evaluations. For Lower Saxony the model showed high prediction accuracy. The evaluations for the low lands of northern Germany confirmed that pedogenesis and land use are important factors determining the soil organic carbon content. The difference between agricultural land and pasture cannot be explained by the different land use alone, but is more a result that pasture is usually found on marginal land, which cannot be used for agriculture, e.g. because of its wetness. Less important influence on soil organic carbon contends and stocks had climate and soil texture. The results indicate that factors regulating the time period of organic matter decomposition like soil wetness, but also soil dryness may have a strong influence on the soil organic carbon content in soils. For the determination of soil organic carbon contends in soils of Germany these and other factors will be further assessed and soil profile data of the soil information system FisBO BGR will be joined with the standardized profiles of the soil map of Germany (BÜK 200).

Literature:

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P 3.7.13

Oscillatory dynamics in soil organic matter decomposition

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Linear compartment (pool) models of soil organic matter decomposition have been criticized for not explicitly including organo-mineral interactions and microbial dynamics at the level of enzyme production and substrate degradation. New approaches to represent soil organic matter decomposition account for enzyme limitation rather than carbon limitation in soils, and introduce realistic mechanisms that seem to improve model predictions at different scales. However, these models have also been criticized for introducing unexpected oscillatory behavior in the stocks and fluxes of carbon over time. Here, we present an analysis of soil organic matter decomposition models determining under what circumstances oscillations occur. We used a standard mathematical technique that consists in calculating eigenvalues in the system of equations that represent the decomposition model. When the eigenvalues contain a complex part, the system of equations shows oscillations, but the frequency and amplitude of these oscillations are reduced over time at different degrees according to the real part of the eigenvalues. We found that linear compartment models can show complex eigenvalues, but the oscillations are strongly attenuated due to a dominance of the real versus the complex part of the eigenvalues. In contrast, in microbial models with Michaelis-Menten terms these oscillations may take longer to reduce the oscillation amplitudes, depending on the carbon use efficiency of the microorganisms in decomposing substrates. With this contribution we expect to discuss potential experiments that may contribute to identify the likelihood and mechanisms involved in the oscillatory behavior of the process of organic matter decomposition.

P 3.7.14

Coupling midDRIFT spectroscopy with geostatistics for regional scale mapping of soil organic matter in croplands of south-west Germany

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1. Introduction

Lack of accurate, high resolution soil data from local to global scale has been acknowledged as the main limitation in landscape monitoring and evaluation for sustainable land use planning. This lack of data hampers the efforts towards food and water security, especially under changing climatic conditions. Therefore, monitoring of agricultural soils requires techniques to address spatial variability for high resolution soil property mapping. Diffuse reflectance infrared Fourier transform mid-infrared spectroscopy (midDRIFTS) linked to partial least square regression (PLSR) analysis was shown to quantify a broad range of physico-chemical soil properties as a compliment to conventional soil analyses.

2. Objectives

The main objectives of this study were i) to evaluate the robustness of midDRIFTS-PLSR calibrated models to predict soil organic matter (SOM) using only the soil spectra, ii) to map the spatial distribution of SOM based on midDRIFTS-PLSR derived predicted values, and iii) to compare the accuracy of the newly created maps to the currently existing lower resolution maps.

3. Materials and Methods

A midDIFTS-PLSR model was developed to predict total organic carbon (TOC) of 126 soil samples across two contrasting regions, Kraichgau (K) and Swabian Alb (SA), in Southwest Germany. Thereafter, a probability-based sampling design (e.g. simple randomized and regular grid sampling) was used resulting in a total of 1170 potential sampling points. All bulk soil samples analyzed by midDRIFTS and predicted for their TOC using midDRIFTS-PLSR model. TOC values were first converted to SOM by multiplying by a factor of 1.724 according to Jackson (1958). The midDRIFTS-based values of SOM were further applied in geostatistics to assess its spatial variability and create kriged_SOM map. The kriged_SOM maps were compared to the currently existing maps of SOM developed at International Soil Reference and Information Centre (ISRIC_ SOM; 1×1 km resolution) and the State Office for Geology, Resources and Mining (Landesamt für Geologie, Rohstoffe und Bergbau) Baden-Württemberg (LGRB_ SOM; 1:200000). Overall, similarity between the existing and new maps was estimated using the two-map comparison approach.

4. Results

MidDRIFTS-PLSR models accurately predicted, after spectral and concentration outlier removal, 558 and 572 samples for K and SA, respectively. SOM contents ranged from 0.4-6.2% in K, while the values for SA were 1.4-9.4%. Spatial analysis in the K revealed moderately weak spatial dependency (Nugget-to-sill ratios > 50%) with ranges of 22 km respectively. SOM in the SA showed moderately strong spatial dependencies, with a 14.3 km range. There was a trend of decreasing SOM contents from west to east in kriged_SOM map in both regions. In K region, the kriged_SOM map showed considerable differences when compared to existing 1 km^2 maps (ISRIC_SOM) while it corresponded very well with LGRB_SOM map. The main difference was the SOM content class 1 to 2% which increased in area from the ISRIC_SOM to the LGRB_SOM to the kriged_SOM. Likewise, the kriged_SOM map for SA matched well with the LGRB_SOM map with an overlap of 69%. Both maps were dominated by 2-5% SOM content.

5. Conclusions

The results demonstrated potential use for midDRIFTS-PLSR as a rapid-throughput approach to provide data for geostatistics to create high resolution maps. The spatial distribution of SOM revealed some dissimilarity in compared to existing maps, which was attributed to the data resolution and the mapping methods. This leads to substantial differences in TOC stocks, which for regional dynamic modeling applications will affect SOM turnover, plant growth, and carbon fluxes to the atmosphere.

Due to the high accuracy of kriged_SOM, the technique can be used for further research to update soil property maps and to facilitate appropriate regional land use planning and as inputs for modeling SOM dynamics. However, upscaling of the technique requires verification of midDRIFTS-PLSR model accuracy and an appropriate sampling strategy to properly capture regional soil heterogeneity.

P 3.7.15

Depth trends of ^{14}C ages: Can we explain between-site differences with a SOC model?

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1. Introduction

SOC models are not very successful at simulating SOC and $\Delta^{14}C$ profiles without resorting to passive or inert pools or a slow-down of decomposition rates with soil depth. With the COMISSION model, we have shown for a single profile that these ad-hoc fixes are unnecessary when we implement a combination of different stabilization processes. In the COMISSION model, these processes comprise microbial depolymerization limitation, sorptive stabilization and microbial recycling.

2. Objectives

At 2 coniferous, 3 deciduous and 3 grassland sites in Europe we want to use the COMISSION model (Fig. 1) to disentangle the contributions of different model processes to observed depth trends of ^{14}C ages:

- advective transport of DOC with the water flux
- the shape of the root biomass distribution
- differences in soil texture and mineralogy
- differences in soil temperature and aeration
- litter quality

For this purpose, we want to refine the COMISSION model by introducing

- stabilization of microbial residues on mineral surfaces,
- a texture-dependent sorption capacity,
- moisture-dependent microbial depolymerization and uptake rates,
- a split between the lignified litter and the assimilable DOC pool based on litter quality.

3. Material & methods

In the COMISSION model we assume that the depth-distribution of root litter inputs is following the root biomass distribution (Fig. 1). Most commonly, an exponential function is used to describe the shape of the root biomass profile. At our study sites, however, this function performed very poorly at reproducing the observed root biomass profile for the grassland and coniferous soils. At these sites a Weibull-like distribution of root biomass reproduced the root biomass profile significantly better.

The new moisture dependency of microbial depolymerization and DOC uptake rates is based on the Dual Arrhenius and Michaelis-Menten approach. Michaelis-Menten terms are used to describe the concentrations of extracellular enzymes, DOC and oxygen, which are modelled with diffusivity functions based on soil water content. The Michaelis-Menten terms potentially limit the oxidative degradation of litter and aerobic microbial respiration.

4. Results

First results indicate that we can reproduce between-site differences in depth-trends of ^{14}C ages with our mechanistic SOC turnover and transport model. Here, we present a first analysis on the role of advective DOC transport and the shape of the root profile for ^{14}C age depth trends: The average pore water velocity, which drives the DOC transport in COMISSION, varies by a factor of 10 between the different sites. Most sites with a lower pore water velocity show a stronger increase of modelled ^{14}C ages with soil depth than sites where the pore water velocity is high.

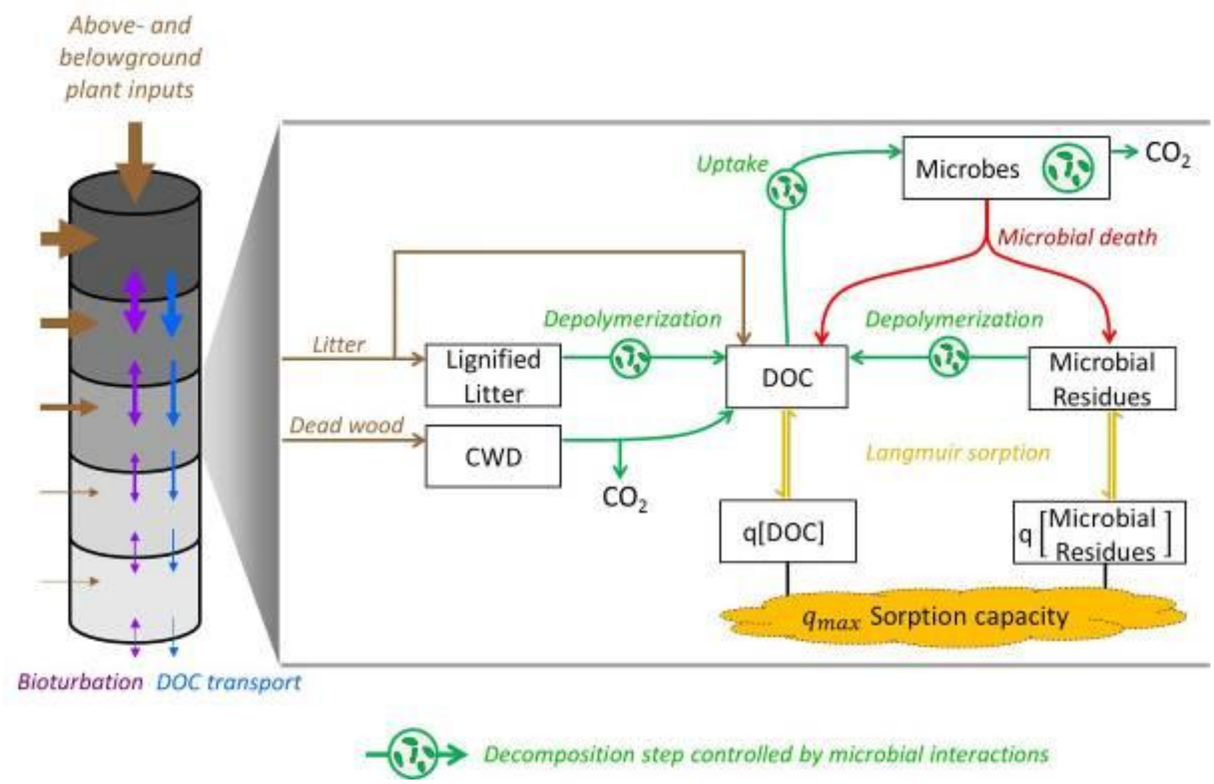
We found the shape of the root distribution to be essential for explaining the ^{14}C profile. At sites where the root biomass distribution is rather shallow, the modelled depth trends of ^{14}C ages are stronger than in profiles with a higher relative input to deeper horizons.

5. Conclusion

To be able to represent SOC profiles and especially ^{14}C depth trends, it is vital to consider a combination of different processes. Our first analysis already showed that both the magnitude of water fluxes and the root distribution contribute to between site-differences of ^{14}C age depth trends. Our future research will include the role of soil temperature and aeration, litter quality and soil minerals. A suite of model-experiments will be needed to disentangle the relative contributions of the different processes and to quantify the interactions between them.

Figure 1: Overview of the refined COMISSION model. Left: Carbon from aboveground plant inputs is added on top of the profile. Belowground plant inputs are allocated to soil layers according to the root biomass profile. Bioturbation and water transport translocate carbon between the soil layers. Right: The readily leachable and soluble fraction of litter inputs enters a dissolved organic carbon pool (DOC), while the rest enters the lignified litter pool. Microbes depolymerize the lignified litter pool to DOC. DOC is the substrate for microbial growth and maintenance. The insoluble part of dead microbes enters the microbial residue pool, while the rest enters the DOC pool. Both the DOC pool and the microbial residue pool can sorb to mineral surfaces according to Langmuir kinetics. Just like the lignified litter pool, microbial remains can be depolymerized to DOC by the microbial pool. Dead wood enters a coarse woody debris (CWD) pool that is decomposed independently of SOM. A small fraction of the CWD pool enters the SOM cycle via DOC leaching.

Figure 1



P 3.7.16

Assessment of soil carbon stock and heterotrophic soil respiration in forests on permafrost in Russia

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INTRODUCTION

The most part of Russian forest is allocated in the area of cold soils that are more than six months a year frozen and developed under significant influence of cryogenic processes. These processes cause special conditions for soil organic matter formation, accumulation and mineralization.

OBJECTIVES

The objective of this research was assessing of organic carbon stock and turnover in the permafrost soils under forests in forest-tundra and northern taiga zones of Russia.

MATERIALS & METHODS

We have used a soil map of Russian Federation at the scale of 1:2.5 million and reference soil profile database to estimate the soil organic carbon (SOC) stock. In order to accounting zonal/regional features as well as vegetation and land-use impact on SOC distribution we collected a database of soil carbon measurements (1068 records) from published papers. The SOC pool was calculated separately for the topsoil organic O horizon (FAO, 2006) and for the first 1m of soil below. The method of assessment of the SOC pool is described in details in Schepaschenko et al. (2013).

To estimate heterotrophic soil respiration (R_S) flux, we collected the majority of studies on R_S *in situ* measurements that were reported in peer-reviewed scientific literature and organized them into a database. A substantial part of the data was obtained from the global database by Bond-Lamberty and Thomson (2010) that accounted for 3379 records from 818 studies. Data from another 291 sources were collected by us on the same basis especially focusing on Russia. To assess the influence of climatic drivers on the respiration flux from soils that are presented in the permafrost zone we have used 259 records on soil respiration.

RESULTS

Our estimates of carbon content of soils in forest-tundra, northern taiga zones of Russia is 34.1 Pg C, and 95% of this amount is allocated in the 1 m soil layer while 5% is stored on the organic surface horizons - the soil organic carbon pool with a fast turnover rate.

The average SOC density is high in the forest tundra (up to 28 kg C m^{-2}). The main reason for such a large stock is low temperature in the north that inhibits the microbial activity in soil. These results also fit to the average Rs data, calculated by individual soil groups. According to the collected records, Cryosols, dominating tundra and forest-tundra ecosystems, had the lowest heterotrophic soil respiration rates.

Organic carbon pool of forested permafrost soil stores about 30% of total carbon stock of Russian forest soil (Mukhortova et al., 2015).

Average heterotrophic soil respiration flux from these soils is estimated as 699 g C m^{-2} $year^{-1}$ or 270.2 Tg C $year^{-1}$ for the entire territory of forest-tundra and northern taiga. This amount is only 16% of the total soil heterotrophic respiration flux from forest soils of Russia.

It was found that respiration flux from Cryosols, one of the major soil of cold permafrost region, is mostly driven by amount of precipitations and the length of periods with temperature above 0 and 5°C. Particularly the positive correlation with duration of the frost free period can be explained by heat deficiency in the regions.

Negative correlation with precipitation during the frost free period and positive - with period with temperature above 5°C can be a consequence of that abundant precipitation during a cool period between 0 and 5°C can increase overwetting of the soils with permafrost as a waterproof stratum and this overwetting can slow down microbial processes in the soil, while the precipitation during the warmer period with temperature above 5°C can positively influence on the microbial activity especially in the case if summer is very warm and soil is able to lose its moisture.

Heterotrophic respiration of Podbur soils (another wide spread soils that formed on sandy or sandy-loamy sediments in well-drained conditions) is positively correlated with amount of precipitations during the warmest period of a year (daily mean temperature over 10°C) and negatively correlated with precipitation during the frost free period. While these soils developed in the forest-tundra and taiga zones they do not show water deficiency except the warmest period especially if the summer is very hot.

CONCLUSION

Thus, the regression equations that were received have reasonable explanation and can reflect deficiency or redundancy of the climatic factors in separate periods of the year. Based on the model results for soil carbon stock and heterotrophic soil respiration, the mean residence time of soil organic matter in permafrost soils was estimated as 119-130 years for forest tundra and northern taiga zones.

ACKNOWLEDGEMENTS

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P 3.7.17

Long-term Effect of Rice Straw Incorporation on Soil Organic Carbon Content in Korean Paddy Soil Simulated by DNDC Model

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Question: Soil organic carbon (SOC) contents in paddy soil are affected by climate, crop type, soil condition, and field management practices such as tillage, irrigation, fertilization, and organic matter incorporation (i.e. manure or rice straw). Rice cultivation either decreases or increases SOC contents which affect rice yields as well as soil fertility. The changes in SOC contents are associated with input and output of carbon (C) such as rice straw incorporation, decomposition, or removing rice biomass out of soil. This study was conducted in order to estimate SOC contents affected by long-term application (35 years) of rice straw using denitrification and decomposition (DNDC) model in Korean paddy soil.

Methods: For the evaluation of long-term effects, data were collected at the long-term plots at the experimental field of National Institute of Crop Science, where three different treatments of organic materials (none; Control, rice straw; RS, and rice straw compost; RSC) as main-factor and three levels of chemical nitrogen (N) fertilizer at 0, 150, and 200 kg N ha^{-1} as sub-factors were allocated by split plot design.

Results: The study showed that mean grain yields under RS and RSC were higher than Control as 9% and 11%, respectively, regardless of N levels. The RS and RSC application increased SOC contents significantly ($P<0.05$) compared with Control. However, N fertilizer application showed no effect on changes in SOC contents regardless of its levels. DNDC model was verified to simulate the long-term change of SOC contents well enough as considering the sufficiently low RMSE between the observed and simulated data values (Fig. 1). The result showed that RS and RSC tended to increase SOC contents while Control decreased it.

Conclusion: The rice straw incorporation increased the SOC contents and rice production as well. Therefore, results of this study recommended that SOC might be crucial for sustainable rice productivity. However, we need to consider a confliction between gain of rice production and greenhouse gas emissions derived by organic material incorporation.

Figure 1. Changes in SOC contents during 35 years (legends: Control, Rice straw incorportaion, and Rice straw compost incorporation)

Figure 1

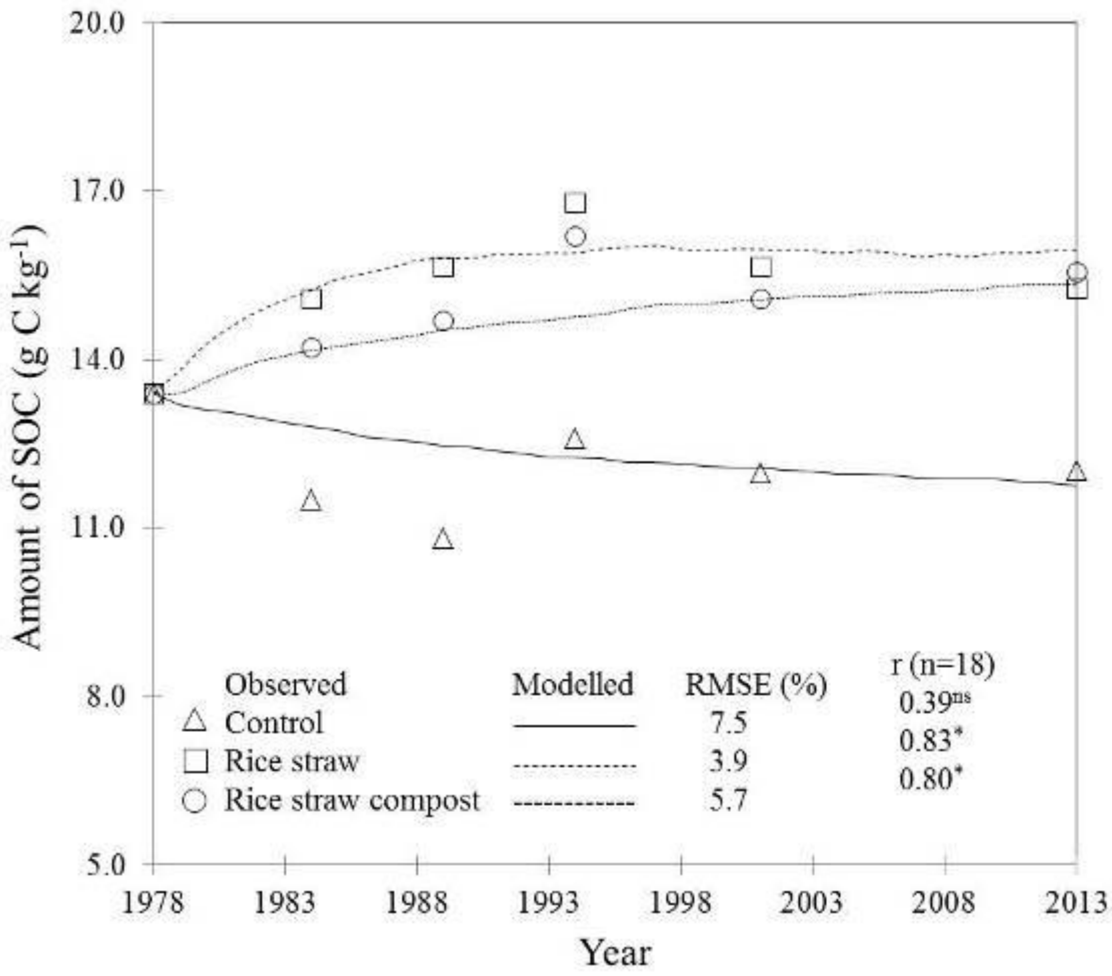

Figure 1. Changes in SOC contents during 35 years

P 3.7.18

Total C, N, and S, and C/N-ratios in European agricultural soils (GEMAS project)

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EuroGeoSurveys published a new and extensive database on the geochemistry of European agricultural soils (Ap horizon) and grassland in 2014 (GEMAS project). We have reanalyzed the 2108 Ap samples for total C, N, and S concentrations. While the previous total carbon and organic carbon concentrations could be confirmed, this is the first presentation of Europe-wide nitrogen values. The sulphur concentrations deserve attention, too, since the previous dataset presented more than 50% of the values below the lower limit of determination. We could quantify all samples with a very tight quality control and present the respective pedochemical soil maps.

Total carbon, nitrogen, and sulphur have been analyzed quantitatively after milling to <63 µm at TUBAF with an Elementar Vario EL Cube instrument. The technique is based on a purge and trap chromatography (C, N) with IR detection (S), following high temperature incineration (1800 °C) and constant temperatures above 1150°C for the sample with a catalyst (WO_3). The Geochemical Laboratories have more than 20 years of experience with this technique.

The results deviate considerably from previously published results (partly based on modelling), basically inviting a more in-depth discussion about appropriate ways to assess larger-scale pedogeochemical element distribution. Given the practical relevance not only of element concentrations but also of element ratios such as the C/N-ratio, the remaining text shall focus on nitrogen and the C/N-ratio.

Four “belts” of oscillating total nitrogen concentrations cover Europe, stretching roughly in parallel from West to East. Most of Scandinavia with Estonia and Latvia show significantly elevated values, while further south a belt from northern Germany through Poland and northern Ukraine yields much lower concentrations. The third belt start in Ireland and the United Kingdom and stretches through Belgium and the Netherlands, partly France, the central and southern parts of Germany, Switzerland and Austria, Northern Italy, Czech and Slovak Republics and most of former Yugoslavia and Bulgaria into the southern half of Ukraine with higher concentrations. To their south, the fourth belt prevails with low nitrogen values.

This general image is overprinted by several anomalies. Positive anomalies with N-concentrations above 0.33 wt.% (Q90) emerge largely at locations with above average annual precipitation, e.g., in northwestern Spain and the Central Pyrenees, Ireland and western United Kingdom, West coast of Norway, in the Alps and the Dinarides. While not all of these locations are at the same time mountainous, their precipitation yield will be largely influenced by nearby higher elevation terrain to their East. This becomes apparent at locations with lesser annual precipitation but significantly higher altitudes, such as at the interface of northern Mazedonia with western Bulgaria and southern Serbia. Two anomalies, in the western Netherlands and in northwestern Germany do not fall into this pattern. Here, intensive agriculture with pig farming may explain the anomaly. Unusual positive anomalies also occur in various parts of Sweden and Finland. While some may be related to agriculture, too (southern Sweden), most of them are represented by organic (peaty) soils, which clearly can explain the anomalies.

The negative anomalies are not as prominent, yet usually seem to reflect soil conditions. Plutonic felsic and quartz-rich soils prevail with high permeability, partly low organic content and thus low retention capacity for nitrogen (Scandinavia).

The C/N-ratios show a rather different signal, and a three-"belt" constellation. Northern Europe and the extent of the Quaternary glaciations dominantly show above average C/N-ratios. Further south and into the Mediterranean realm, the lowest ratios occur, albeit more erratic and partly interrupted by larger areas with higher C/N-ratios. Higher ratios dominate again in Iberian Peninsula, southern Italy, and partly Greece (the latter merging with the low ratio belt.

Again, various processes seem to dominate the spatial distribution. Rainfed systems in western Ireland and the west coast of Scotland emerge as much as the strong signal in organic-rich soils of Finland (and partly Norway and Sweden). Positive anomalies in northwestern Germany, in parts of France, in Spain, southern Italy and Greece are more likely related to agricultural practice.

While this analysis is by no means all-encompassing, the new data clearly deserve attention and a more in-depth discussion of nutrient behaviour in soils.

Figure 1

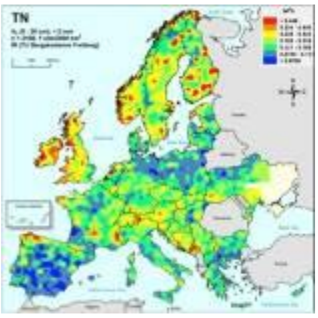
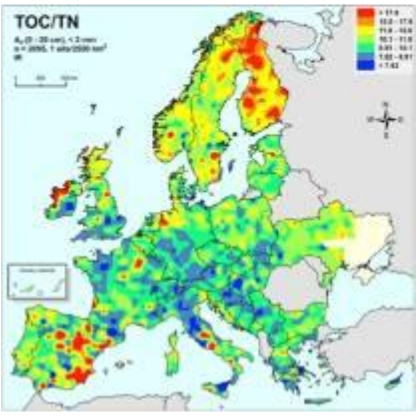


Figure 2



P 3.7.19

Moisture-Microbial-Mineral Interactions in Process-Based Simulations of Soil C Dynamics

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Soil carbon models developed over the last couple of decades have shown a limited capacity to accurately predict the magnitudes and temporal variations in observed carbon fluxes and stocks. New process-based models are now emerging that attempt to address the shortcomings of the previous more simple, empirical models. While a spectrum of ideas and hypothetical mechanisms are finding their way into these new models, the addition of only a few processes that are known to significantly affect soil carbon (e.g. enzymatic decomposition, adsorption, Michaelis-Menten kinetics) has shown the potential to resolve a large number of previous model-data discrepancies. In addition, these processes provide new insights and hypotheses of what soil carbon pools are and how they respond to external drivers.

This study presents a model of soil carbon dynamics that combines these key processes (already found in many recent enzyme-driven models) with moister interactions. The model simulates carbon in particulate, soluble and adsorbed states, as well as enzyme and microbial components. Similar to other new-generation models, key processes that limit carbon decomposition are mechanistically described. While more complex in terms of the number of parameters and diversity of carbon pool, this model is significantly more realistic than traditional models (Century, Roth-C) and allows exploring several mechanisms that can explain observed variations in fluxes and pools.

Since water is the medium where all main reactions take place, moisture becomes a central element en every aspect of soil C dynamics. This study explores a number of approaches integrating moisture into other processes. As such, it does not use any empirical moisture scaling factors. The immediate aim is to simulate observed dynamics such as re-wetting pulses, priming effects and other feed-backs and non-linearities. This study starts from a theoretical basis and aims to test against data to finally obtain a predictive model. In contrast to other enzyme-driven models, the addition of moisture allows for a direct comparison with field data.