Soil Organic Matter
IN A STRESSED WORLD

SYMPOSIUM POSTER ABSTRACTS

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The methodology for farm-scale modelling for spatio-temporal prediction of soil carbon sequestration under climate change

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A methodology for region-specific adaptation of existing soil carbon (C) models was developed by integrating location-specific automated data with local farm-based knowledge. The aim was to optimise the balance between scientific accuracy and farm-scale practicality of C modelling tools to identify the most influential location-specific variables. The methodology identified region-superfluous inputs (through automation and region-insensitive data omission), incorporation of additional inputs to improve region-specific accuracy, tuning the regional model, and development of a Tool that could be used on-farm. The methodology was evaluated in south-western Australia using the RothC soil C turnover model. Automation and rainfall-based tuning of the RothC model were used to produce the south-western Australian RothC modelling (SWARM) Tool. The criticality of rainfall within the region provided both tuning direction and additional inputs for improving the accuracy of the automated "monthly rainfall" impact, through location-specific rainfall utilisation (e.g. accounting for water repellence) and compounded rainfall impacts (e.g. plant growth, soil cover, erosion). Integration of manual adjustments for high sensitivity inputs for this region with additional considerations of field-scale rainfall utilisation characteristics provided a soil C content potential relative to the location-specific tuned base case. The SWARM Tool delivers soil C modelling to the farm gate, facilitating estimation and education under the challenging future of agriculture-based incomes. The methodology presented in the creation of the SWARM Tool provides a template for adaption to any region across the globe for the provision of an accessible, practical and appropriately accurate information on the potential impact of climate change.

Organic amendments combined with chemical fertilizers improves soil organic matter and crop yields under rice-based intensive cropping systems

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Simultaneous increase in crop yield and improvement of soil health are key challenges of cropping intensification under rice–based cropping systems. A long-term experiment was commenced in 2007 at Gazipur, Bangladesh to determine nutrient management strategies that sustain soil fertility, increase cropping system productivity and overcome agronomic and soil constraints for successful crop production in rice-based triple cropping system on a Grey Terrace soil. Combinations of organic amendments (cowdung(CD) and poultry manure PM)) with chemical fertilizers were contrasted with native soil nutrients and with only inorganic nutrients to evaluate the changes in soil properties and yield of component crops over the years. Treatments were native fertility(control), chemical fertilizers with 5 tonne ha-1 CD to obtain medium yield goal(MYG*), only chemical fertilizer to obtain high yield goal (HYG*), chemical fertilizer with 5 tonne ha-1 CD to obtain HYG, chemical fertilizer with 3 tonne ha-1 PM to obtain HYG and chemical fertilizers to obtain MYG. Only mungbean residues were incorporated. Poultry manure applied at the rate of 3 t ha-1 together with the IPNS dose consistently produced the highest yield of all component crops of the maize-mungbean-rice cropping system (e.g. maize grain yield was 11.2 t ha-1 in 2017-2018, mungbean grain 1.1 t ha-1 and rice 5.1 t ha-1 in 2017). After 11 years of cropping under organic amended nutrient application, the soil organic matter (SOM) stocks (0-15 cm) increased by 6.3 tonnes ha-1 compared to initial SOM stock, while the control soil and the soils treated with only chemical fertilizers had decreased SOM (by 1.6 and 1.1 tonne ha-1, respectively). Most of the chemical properties of post-harvest soil were improved due to incorporation of organic manures through IPNS. The highest yield of crops and improved soil properties was associated with increased soil organic matter content in soils under the treatment.
* IPNS means amount of nutrients estimated to mineralize from cowdung and poultry manure were subtracted from STB chemical fertilizers.
*HYG and MYG were determined according to Fertilizer Recommendation Guide, BARC Bangladesh-2012 version

Unravelling the climate-soil-management interaction to explore SOM in the Brigalow Belt bioregion, Queensland, Australia

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In this poster presentation, we provide a case study examining Soil and land management within the Brigalow Belt bioregion of Queensland, Australia. Occupying less than 10% of its former approximately 7.5 million hectare distribution, recovery of this ecological community is a focus for biodiversity planning assessments (State of Queensland, 2018), although the interactions between soil and variation in land management across the large area are complex.

With an SOM cycling focus, we present a 'snapshot' of measured data from 45 sites representing remnant uncleared native brigalow forest, native brigalow forest cleared then maintained as pasture for >10 years, and regrowing native brigalow forest ranging from 10 to 58 years. We consider SOM properties including C and N dynamics (stocks, fractions and natural abundance signatures) and associated soil physical, biological and chemical properties. We illustrate two common approaches to statistical modelling – regression trees and linear mixed models – to SOM data, including explanatory variables relating to climate, soil and past land management, the interactions between them. We visualise the data in the form of regression trees linked to linear mixed models, explicitly accounting for spatial autocorrelation and enabling the presentation of realistic uncertainties alongside the models' predictions.

Finally, we explore 'where next' for SOM understanding in this ecological community, in the context of emerging policy areas of land restoration and environmental accounts.

Soil microbial activity and nutrient dynamics with soil depth, under mixed tree species environmental plantings in NSW, Australia

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The impacts of mixed tree species environmental plantings on soil biology is an emerging topic. A pilot study was conducted to determine the variability of microbial activity, total soil organic carbon (C), nitrogen (N) and available phosphorus (P) under Eucalyptus camaldulensis and Acacia pendula used for mixed tree species environmental plantings in NSW. A 13 year old tree planting was selected from a chronosequence of established environmental plantings near Gunnedah, NSW. Soil samples were taken from both inside and outside the tree canopy at depths of: 0–5 cm, 5–10 cm, 10-20 cm, 20-30 cm and 30-50 cm. The soil was tested for heterotrophic respiration (MicroRespTM), total C and N (LECO), and available P (Colwell).
For both tree species, greater microbial activity was observed at: 0-5 and 5-10 cm soil depths compared with the deeper soil layers (20-50 cm). Further, both basal and substrate induced (glucose) respiration rates were higher under the tree canopy compared with outside the tree canopy by 3% and 12%, respectively. Basal respiration rate was significantly higher under E. camaldulensis canopy compared to A. pendula canopy at the 5-10 cm soil depth, however, at 30-50 cm, this result was reversed for the two tree species. For both tree species, C, N and P significantly decreased with depth up to 20 cm. However, no significant difference were detected between 20-30 cm and 30-50 cm. Further, C, N and P contents were lower under the E. camaldulensis canopy than outside whereas, those were not different under and outside of A. Pendula canopy. Under A. pendula the C, N and P were higher than under E. camaldulensis, however, the differences were significant only for total N. Furthermore, microbial respiration was positively correlated with C, N and P. These results suggest trees in environmental plantings do have positive impacts on soil microbial activity and enhance soil nutrient status.

Key Words: Available Phosphorous, Environmental plantings, Microbial respiration, Soil organic carbon, Total nitrogen

Influence of organic amendment, tillage method and crop system on soil organic matter and soil microbial properties in newly organic corn cultivation field

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Maintenance of soil organic matter is important for the productivity of agroecosystems. It has beneficial effects on soil biological, chemical and physical properties, which influence the productive capacity of agricultural soils. This study was conducted to investigate the effects of organic farmland soil and nutrient management on soil properties depending on organic resources (animal manure compost and green manure [hairy vetch]), tillage systems (tillage and no tillage), and crop rotations (corn-wheat, corn-hairy vetch). It was found that the application of organic matters such as animal manure compost and hairy vetch, increased the soil organic matter content, the soil microbial density and microbial biomass C content as compared with the chemical fertilizer treatment. It was also confirmed that the functional diversity of soil microbial community was increased. As a result of the comparison with the crop rotations and single cropping, the soil chemistry showed no significant difference between the treatments, but the corn-wheat and corn-hairy vetch rotation treatments tended to have higher microbial biomass C content and shannon's diversity index than the single cropping. Soil chemical properties of tillage and no-tillage treatment showed no significant difference between treatments. There was no statistically significant difference in substrate utilization of soil microbial community between tillage and no-tillage treatment. Correlation analysis between soil chemical properties and soil microbial activity revealed that soil organic matter content and exchangeable potassium content were positively correlated, with statistical significance, with substrate utilization, and substrate richness. To conclude, organic fertilization had positive effects on the short-term improvement of soil chemical properties and diversity of microbial communities.

The response of soil carbon to no-till depends on climate.

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Adopting no-tillage (NT) in agro-ecosystems is a recommended measure to enhance C accumulation in soils. However, estimates of potential soil organic C (SOC) storage rates under NT compared to conventional tillage (CT) vary widely, and the reasons for this variability are still unclear. Using a meta-analysis based on global data, we related mean annual precipitation (MAP) and mean annual temperature (MAT) to the potential of NT to accumulate SOC relative to CT. A total of 76 studies were included in the analysis from 5 continents. In all cases, there was a positive effect of NT on SOC in the 0-5 cm soil layer. In non-clayey soils only (<37% clay), SOC accumulation under NT was dependent on MAP and MAT. The relative increase in SOC under NT was best fitted using a hyperbolic curve for MAP and a linear relationship for MAT. SOC accumulation under NT at dry sites (MAP < 600 mm) is likely associated with crop residue accumulation at the soil surface which decomposition is slowed down compared to wetter conditions. At MAP around 700–900 mm, the relative SOC accumulation under NT was close to zero. The greatest effect of NT on SOC was observed at high precipitation and temperature probably due to high productivity (and C input) and accumulation of C at depth under NT. We conclude that at the global scale the response of SOC to NT is partly dependent on climate but in ways that are still largely unclear.

LIFE Nadapta: Considering soils vulnerability and resilience in a regional adaptation strategy of agriculture to the effects of climate change.

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Because of the high vulnerability of agriculture, which is highly climate-dependent, farmers need crops and agricultural systems that consider the climate change effects. The IPCC defines the risk of climate-related impacts as the results of the interaction of climate-related hazards with the vulnerability and exposure of systems, and also explain how the adaptation of a system can modulate this vulnerability, and also reduce exposure to different hazards. In this context, the LIFE Nadapta project includes, among a number of strategies for improving the adaption of the region (Navarre, SPAIN) to climate change, an adaptation strategy intended to increase the resilience of agrosystems, especially in relation to one of the most important production factors: the agricultural soil.

Considering the diversity of this region and the variety of agricultural practices spread throughout it, the work was conducted at three levels: First, a vulnerability study of agricultural soils was conducted at the regional level after zoning out the region into 12 homogeneous areas, identifying critical soil characteristics in each of them. Second, a network of up to 150 control plots was created, in which a number of indicators related to vulnerability and resilience were analyzed, encompassing the diversity of both soil types and management systems. Finally, threshold and target values of each indicator will be set for each area and monitored along the 8 years of the project.

The proposed set of indicators, defined according to climatic drivers and the chains of impact they generate, is classified into two levels. Those related to the intrinsic characteristics of the soil, vulnerability indicators, and those potentially modifiable by management, dynamic indicators, which allow monitoring the evolution of this vulnerability. SOC is one of the main indicator proposed for long-term monitoring of the agrosystems vulnerability, as well as water retention capacity, bulk density and structural stability.

Strategies to improve the prediction of organic carbon in bulk soil and fractions from a target region using an existing national mid-IR library

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Currently, the measurement of organic carbon concentration in soil is completed using techniques that can be expensive, slow or generate toxic residue. Mid-infrared spectroscopy (MIR), when combined with chemometric analyses, can provide a fast and clean approach but proper model calibration is required for achieving reliable predictions of OC concentration. This study aimed to evaluate different strategies to calibrate the application of MIR to predicting OC concentration in the soil in order to improve the accuracy and cost-effectiveness values predicted for bulk soils and fractions of target samples. For this purpose, we used regional soils from Brazil (target samples – BRreL) and an existing Australian national library (AUnaL). In total, nine different model calibration strategies were tested for OC prediction in the target samples. Partial least square regression (PLSR) using only BRreL for calibration provided the highest accuracy for OC prediction in bulk soils and fractions. When only the AUnaL was used for PLSR calibration, the accuracy decreased, and OC predictions were acceptable for bulk soils but not for soil fractions. Alternative algorithms (e.g., cubist and spectrum-based learning - SBL) applied on the AUnaL, in general, did not improve OC predictions. The most promising results were found when the calibration of the model was performed by adding 20 BRreL samples in with the AUnaL samples. Through this spiking technique, regardless of the algorithm used (e.g., PLSR, cubist or SBL), the OC predictions were improved, making it very accurate for both bulk soils and fractions. In addition, this technique was more cost-effective since only a small number of samples from the target location had to be analysed in the laboratory to derive the analytical data required for model calibration. This makes the MIR technique a valuable resource for accurate, fast and cheap predictions of OC in bulk soils and fractions.

Nanoscale chemical imaging of organo-mineral fractions of an andosol (La Martinique, France)

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Organo-mineral associations are a main process driving organic matter (OM) stabilization in soils, but mechanisms of their dynamics are still not fully known. Basile-Doelsch et al. suggested that mineral alteration generating amorphous phases on minerals's surfaces was a driver of OM stabilization. Coprecipitation synthesis led to a new model of organo-mineral associations at nanoscale, combining nanosized Co-precipitates of inorganic oLIgomers with organiCs molecules (nanoCLICs, Tamrat et al.). In the present study, we investigated nanoCLICs in soils using TEM (FEI Tecnai Osiris 200kV) coupled with 4 EDX detectors and EELS to semi-quantify C, N and major elements. We analyzed an andosol (15-20 cm) from La Martinique (French West Indies). OM-short-range-order and mineral associations were collected in the supernatant after sonication and a 48h-decantation. Areas analyzed ranged from 5 µm to 300 nm with pixel resolutions from 500 to 3 nm. Amorphous mineral phases were dominant. Fe, Si, Al and O were the main component and were homogeneous at nanoscale. Even down to 50 nm they were systematically associated to C and N. Proportions varied about 60% of Si, 30% of Al and 10% of Fe. No imogolites or allophanes were observed, mineral phases must be less polymerized (Levard et al.). Images acquired are similar to those obtained by coprecipitation on synthetic samples (Cam et al.). The nanoCLICs model (Tamrat et al.) seems to be valid in andosols. By focusing on a mg-vermiculite surrounded by amorphous material, chemical profiles showed an increasing C content from the center of the vermiculite to the amorphous material (over 150 nm). Although the amorphous phase may be bonded on mineral surface by sample preparation, these first results suggest a continuous alteration of minerals resulting in an amorphous phase progressively associated to OM molecules, as proposed by Basile-Doelsch et al.

Methodology to predict nitrogen mineralisation in agricultural soils in New Zealand

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Improved fertiliser management is critical to lifting the economic and environmental sustainability of agricultural production systems. Forecasting fertiliser N requirements depends on predicting the supply of plant-available N from soil and the demand for that N by crops/pastures during their growth. The nitrogen released by mineralisation of soil organic matter can contribute a large (but variable) amount of plant-available N. Accurately predicting the supply of N from mineralisation remains a key limitation to properly forecasting the amount and timing of fertiliser N additions. Predicting the supply of plant-available N under field conditions requires knowledge of the soil's N mineralization potential (i.e. N released under "optimal" conditions of temperature and soil moisture) as well as capability to predict how much of that N will actually be mineralised under varying environmental conditions (e.g. soil temperature and moisture). Soil type and management history affect the quality and quantity of soil organic matter that determines the amount of potentially mineralisable N (PMN). PMN is best measured using a longer-term aerobic incubation, but the procedure is laborious and time-consuming. A reliable, "laboratory-friendly" test for soil N mineralization potential is not available; this remains a major barrier to implementation of best management practices for N on farm. This paper will describes recent advances in measuring PMN based on analysis of hot water extractable organic matter from a wide range of soils and land uses across New Zealand. We also describe preliminary results from field validation trials that shows how PMN may be used to predict the supply of plant available N under field conditions.

Dynamics of Soil Carbon Sequestration in Tropical and Temperate Agricultural systems (DSCATT)

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The DSCATT project proposes to explore the potential for sequestering C in cultivated soils, taking into account the sustainability of agricultural practices in the context of global changes. It operates at 4 sites (in Senegal, Zimbabwe, Kenya, and France). The project addresses 3 interrelated scales, i.e field, farm and territory or village scale.

At field level, research focuses on how biomass production and soil C sequestration relate, in different soil and climate conditions. Two approaches complement each other. One studies at the soil-plant interface the processes regulating the forms and residence time of C in soils. It includes the analysis of interactions between nutrients and C storage, the role of deep roots and in soils with contrasting storage potentials. The other approach determines the C balances under different practices. Farms will be characterized in order to propose practices likely to improve complementarities amongst the activities of rural households. At this scale, DSCATT research will focus on farmers' practices (for crops, livestock, forestry…) and assess the impacts of farmers' practices on their objectives (income, food security…), taking into account their main constraints (cash, labour…). At the territory (or farmers' network) level, the different compartments of agroecosystems and the organic matter flows will be studied. The project will analyze the role of the socio-economic and biophysical contexts and will test several possible changes and their impacts on soil C sequestration dynamics, economic performance of farms and food security. This scientific knowledge and the viewpoints of the farmers involved will be shared and used for a transdisciplinary assessment of several C sequestration strategies in agricultural soils. Considering changes and uncertainties, a multi-criteria and prospective evaluation approach is proposed. It will allow iterations between evaluation and redefinition of strategies to cope with global changes in agriculture.

Does soil organic matter stoichiometry varied with agricultural practices on the long-term?

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Carbon (C), nitrogen (N) and phosphorus (P) cycles are intimately linked in ecosystems through key processes such as primary production and litter decomposition. Ecological stoichiometry has become a common approach for exploring relationships between biogeochemical cycles and ecosystems functions in ecological science. In agronomy, the concept of stoichiometry is far less utilized, probably because the addition of fertilizer reduced biotic interactions between the C, N and P cycles. Surprisingly, little is known about the long-term impact of agricultural practices on soil stoichiometry. Within the context of agro-ecology, however, alternative agricultural practices aim to increase nutrient recycling from plant residues, soil organic matter and inorganic reserves (e.g. legacy P), while reducing tillage or mineral fertilizer input. The success of such practices relies on the increase of soil biotic interactions and may impact C storage in soils on the long term, if soil organic matter stoichiometry is constrained.

We aimed at determining the long-term impacts of alternative agricultural practices on soil stoichiometry. To do so, we compiled and completed a dataset of long-term (8-49 yr) field experiments in France in which P or N fertilization rates or tillage intensity was strongly reduced.

The agricultural soils studied presented C:N and C:P ratios ranging from 8 to 14.5 and from 15 to 28 respectively, and N:P ratios ranging from 1.5 to 2.8 (total P). The site effect was significant on the soil CNP contents and ratios (one-way ANOVA, $P < 0.05$). Interestingly, whereas the soil C:N ratios were constrained and not influenced by the different agricultural practices, the C:P and N:P were more flexible. The C, N and P balance were calculated at each site and related to the soil stoichiometry.

Long-term effects of straw removal on soil carbon dynamics in sugarcane cropping systems in south-central Brazil

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Brazil is the major producer of sugarcane (Saccharum spp.) with a production of 615-million-ton from a cultivated area of 9 million hectares, accounting for 40% of global sugarcane production. Large-scale energy demand has triggered new approaches to sugarcane straw as a promising solution to increase bioenergy production (bioelectricity and cellulosic ethanol) in Brazil. However, the maintenance of straw in the fields ensures the continued provision of ecosystem services such as soil organic carbon (SOC) accumulation, which plays a critical role to maintaining soil quality and increasing the resilience of agroecosystems to extreme climatic events. The approach taken in this work was to simulate the temporal dynamics of SOC to a 0.3-m depth, validating the DayCent model through field experiment data, and finally to make predictions of the effects of straw removal scenarios (TR–total removal; MR–moderate removal; and NR–no removal) on long-term SOC changes in sugarcane areas under contrasting edaphoclimatic conditions in south-central Brazil. The DayCent model estimates were consistent (r = 0,99; P < 0.05) with the field-observed SOC changes in clayey and sandy soils. The DayCent simulations from 2014 to 2050 showed that TR depleted SOC at a rate of -0.39 and -0.21 Mg ha-1 year-1 in clayey and sandy soils, respectively. While MR did not modify SOC at any soil types, the long-term data indicated that NR resulted in SOC accretion of 0.35 and 0.29 Mg ha-1 year-1 in clayey and sandy soils, respectively. By 2050, SOC stocks under TR and MR in clayey soil were predicted to be 70% and 85% of those observed in NR, while in sandy soil TR and MR were 48% and 72% relative to NR. This study provides new insights to stakeholders for developing improved straw management strategies towards greater sustainability for bioenergy production in Brazil.

Aluminium-DOM precipitation: A high resolution mass spectrometry (LC-QTOF-MS) study

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The interaction of metal cations – iron and aluminium – with dissolved organic matter (DOM) derived from leaf litter leads to the formation of the dark coloured and resistant Bh horizons in podzols. The characteristics of these Bh horizons – especially the effect on water permeability – partly inspired the innovative SoSEAL project (Soil Sealing by Enhanced Aluminium and DOM Leaching). SoSEAL aims at making dykes more stable by reducing water permeability through the dyke body by enhancing metal-DOM precipitation. In order to use metal-DOM interaction for engineering purposes, it is important to identify the molecular characteristics of DOM involved in metal-DOM interaction. This allows us to select suitable DOM sources and be able to better control the formation of metal-DOM flocs. Molecular characterisation of DOM was done with a new non-target screening method using liquid chromatography (LC) coupled to high resolution quadrupole time-of-flight mass spectrometry (QTOF-MS). DOM solutions were prepared from coniferous, deciduous and mixed leaf litter and from HUMIN-P 775, a commercially available leonardite material which dissolves completely in water and has a high number of carboxylic groups. We measured the molecular characteristics of the DOM solutions before and after the addition of aluminium. The amount of precipitation was quantified by measuring aluminium and dissolved organic carbon content. Results show that humin-DOM precipitation is up to twice as high as that of leaf litter DOM. Preliminary results suggest that there is preferential precipitation of larger/heavier compounds and of aromatic compounds. However, we did not observe preferential precipitation of specific compound groups (such as lignin and tannin) and also not of nitrogen poor compounds. These findings mean that we can increase the formation of aluminium-DOM precipitates by selecting a source of DOM with a DOM composition that is more suitable for aluminium-DOM precipitation.

Forest conversion effects on SOM composition: Disentangling effects of parent material and litter input chemistry

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Increasing forest carbon stocks through forest conversion is being considered in Western-Europe as potential climate change mitigation measure. Edaphic factors, such as soil pH, as well as tree species affect forest carbon cycles, but are difficult to disentangle. We studied how conversion of deciduous stands to mono-culture spruce plantations affected the soil organic matter (SOM) composition along a lithological gradient in the Mullerthal (Luxembourg) and Gaume (south-east Belgium) regions. Parent materials in these regions range from decalcified sands to calcareous marls. We used a twin plot setup of adjacent deciduous and coniferous stands on the same parent material to evaluate the effect of edaphic factors versus litter input chemistry on SOM composition and soil organic carbon (SOC) stocks. Lignin and cutin/suberin molecular proxies were identified with thermally assisted hydrolysis and methylation (THM), to distinguish litter sources (coniferous vs. deciduous and leaf litter vs. roots) in the studied stands. In this study, SOC stocks were influenced more by parent material than by forest type. Lignin yield, composition and degradation state were influenced both by litter input chemistry as by the edaphic context. Moreover, there appear to be important interaction effects between the two, as the relative importance of parent material and litter quality was site specific. These conclusions seem also valid for cutin yield, as tree type effects were absent from the Mullerthal loamy plots with more favourable pH values. We suggest that models used to estimate carbon stocks should always combine data on vegetation history and edaphic context. For forest management this study shows that if forest conversion is applied to increase forest SOM stocks, as climate change mitigation measure, this can only be a success when substrate differences are taken into account, including relatively minor substrate-directed differences in soil properties such as pH and texture.

Biochar activation by co-application with manure into the soil

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Plain, non-activated biochar applied in the soil affects microorganisms generally negligibly. If it does, biochar changes mostly the community of gram-negative bacteria and actinomycetes. Fungi and gram-positive bacteria are less affected. On the contrary, amendment of manure combined with inorganic fertilizer in the soil significantly increases abundance of all soil microbiota, both bacteria and fungi and among other groups also ammonia oxidizing bacteria (AOB).

We hypothesize that the co-application of inactivated biochar and manure in the soil could enhance positive effects of both amendments on the soil microbial community and other soil parameters.

Therefore, the effect of following variants of biochar, manure and inorganic fertilizer was tested in the pots experiment in greenhouse: 1) control - NPK only, 2) biochar + NPK (15 tons per hectar), 3) manure + NPK (50 tons per hectar), 4) biochar + manure + NPK (15 + 50 tons per hectar). Additional NPK fertilizer - 1) - 4) – was applied according to annual crop nutrient normative. The experiment was carried out on the soil from the topsoil (0-30 cm), collected from Rapotín locality in the Czech Republic, on soil type fluvisol at an altitude of about 345 m a. s. l. The soil in the pots was sown with wheat. The experiment was conducted in 2018.

Application of combined variant manure + biochar + NPK increased abundance of three microbial groups – bacteria, fungi, and AOB – significantly more as compared to both biochar + NPK and manure + NPK. The results showed that activation of biochar by co-application with manure is rather synergic and it exceeds additive effect of sole biochar and sole manure amendments.

Mineral regulations on microbial necromass accumulation efficiency in soils

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Soil microbes are known to play a key role in transforming labile organic carbon (OC) into relatively stable soil carbon in the form of microbial necromass. However, the efficiency of microbial necromass accumulation relative to labile OC mineralization remains under-investigated, which has vital implications for soil carbon sequestration. Here we construct artificial soils based on fructose, a common microbial inoculum and inorganic matrices with varying contents of clay and mineralogy to examine mineral regulations on microbial necromass accrual versus mineralization. By measuring microbial biomass and necromass (indicated by amino sugars) relative to respiration, we compare microbial carbon use efficiency (CUE) and amino sugar accumulation efficiency (AAE) throughout the 116-day incubation. We find that while clay promotes microbial consumption of labile OC (fructose), it enhances the rate as well as efficiency of microbial necromass accumulation without affecting CUE. On the contrary, ferrihydrite decreases CUE and AAE and promotes fructose preservation via inhibiting microbial growth. Hence, microbial necromass accrual is more efficient in clay-rich soils while labile OC is better preserved in soils containing ferrihydrite. Collectively, our findings suggest that the accrual efficiency of microbial carbon heavily depends on its preservation other than growth efficiency and is mediated by soil mineral content as well as composition. Parameters depicting microbial carbon preservation such as AAE warrant further study for modelling and managing the formation of microbial derived stable soil OC.

The role of Ectomycorrhizal fungi mediating soil organic matter mineralisation: Impacts of N availability and CO2 conditions

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The role of ectomycorrhizal (EM) fungi on soil C cycling is receiving increasing attention and they are suspected to alter soil C decomposition. However, direct measurements of their impact are not available and , information on how this ,function might change with ,elevated CO2 ,(eCO2) is ,scarce. These symbiotic fungi provide nutrients to the plants in exchange for C. With eCO2 plant productivity and thus, nutrient demand, are expected to increase. Higher C allocation belowground may promote EM colonisation and nutrient mining from soil organic matter (SOM) to meet plants demands, with potential impacts on soil C. Therefore it could be expected that the impacts of EM fungi on SOM with eCO2 might dependon nutrient availability. Research so far on this matter is scarce, showing conflicting results and facing methodological constraints.

We aimed to understand the impact of two different isolates of EM fungi on soil C cycling under eCO2 and nitrogen (N) availability conditions (high/low). We used a whole plant-soil system with Eucalyptus plants in chambers with a continuous 13C- input that allowed us to differentiate between plant and SOM-derived fractions of different C pools.Above and belowground biomass responses along with EM colonisation rates were also studied. EM fungi responses to eCO2 and N varied between the isolates, although hartig nets were generally deeper at low N and shallower with eCO2. eCO2 and high N increased plant biomass, while EM presence reduced shoot biomass. EM fungi did not have a significant effect on SOM-derived respired C. Our direct and high resolution assessment of SOM mineralisation indicate that in this ecosystem EM fungi may not have a substantial role enhancing soil C cycling under eCO2 as generally expected.

Relationships between SOM and nitrogen availability

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Soil organic matter (SOM) is intrinsically linked to nitrogen (N) availability, not only harbouring the majority of soil N as solid organic matter, but also mediating its release and processing by the soil microbial community. Given the recent advances in our understanding of both SOM and N processing over the past 20 years, gaps still exist in our understanding of the role of SOM in N release. Our objective was to build a better understanding of the diversity of N pools and processes in relation to SOM across a broad range of Australian soils of different types and land uses, and to relate this to plant N uptake. A total of 358 topsoil (0-10 cm) samples were collected from 89 sites in Australia, consisting of 13 different land uses. These were measured for pools of N (bulk DON, free amino acid N (FAA-N), nitrate and ammonium) and rates of mineral N and plant available DON production quantified. A subset of 100 soils were selected for a pot experiment to observe plant N uptake. Investigating the different variables measured from the pot experiment showed that the strongest relationship to plant N concentrations was microbial biomass N ($r=0.634$, $P<0.001$, $n=97$). Other factors that played an important role were found to be pH, C:N ratio, FAA-N and DON. When examining relationships between soil C content and the various N pools and rates, surprisingly little direct correspondence was observed ($r=0.1771$) between total soil C and proteolysis, the main rate limiting step of N production. The relationship between total C and plant N uptake was not much stronger ($r=0.2560$). These findings indicate that across this diverse range of soils, SOM content has only a small direct influence on plant N availability, and it is likely that other multi-step processes are involved.

Leaf litter decomposition of adjacent natural broadleaf and Japanese cedar forests in the mid-elevation mountain area, Xitou, Taiwan

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Native vegetation has been mostly replaced by Japanese cedar in the montane area of central Taiwan since the 1950s. Soil carbon content is known to decline once natural forests replaced by the plantations. Therefore, to understand the litter decomposition rate of the adjacent natural broadleaf and the Japanese cedar (Cryptomeria japonica) forests is helpful for estimating carbon and nutrients cycling after the natural broadleaf forest replaced by Japanese. Litter bag method was used to evaluate the litter decomposition rate. Forty-two litter bags filled with 3.0 g leaf litter were placed in each study stand (three study plots for each stand) since March 2016. Six litter bags were retrieved at 7 time intervals (1, 2, 3, 6, 10, 16, 25 months) from March 2016 to April 2018. Litter samples were oven dried (60 ℃, 72 h) and the remaining mass of litter was measured, and C, N, P, K, Ca, and Mg contents of litter were also analyzed. The results indicated that the decomposition rate of the litter under natural broadleaf forest was more rapid than that under Japanese cedar forest. After over 2-year insitu incubation, the litter remaining weight was 0.40 g (12.78 %) for natural broadleaf forest and 1.1 g (35.28 %) for Japanese cedar forest. C/N ratio of both two forests decreased with the incubation time, and the litter under natural broadleaf forest displayed the lower C/N ratio than Japanese cedar at all time intervals. The higher lignin concentration of Japanese cedar pine litter, which is more biodegradation resistant, was considered to contribute to the higher remaining weight and C/N ration. Since the analysis of P, K, Ca, and Mg contents of litter haven't finished, more results for estimating the nutrient contribution to forest soil will be presented in the future.

Spatial and temporal evolution of detritusphere hotspots at different soil moistures

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Soils are spatially heterogeneous environments at different scales and this heterogeneity still very little taken-into-account in the study and prediction of soil organic matter dynamics. The incorporation of plant residues in soils leads to hot spots of microbial activity and biogeochemical cycling at the fine scale.
The objectives of this study were to determine: (i) the spatio-temporal evolution of microorganisms and their activity after the incorporation of fresh plant residues in soils, and (ii) how this evolution was affected by soil moisture, given the importance of soil moisture in regulating decomposition and (iii) what were the specific contributions of bacteria and fungi.
The experimental set-up was based on incubated soil microcosms with addition of a central layer of 13C labelled maize residues at different soil moistures (pF 1.5, 2.5 and 3.5). Total and residue derived 13C mineralization were monitored; the microcosms were destructively sampled at four dates, fractionated into soil layers with increasing distance from the residue layer and we quantified residue-derived carbon in these layers and determined microbial community abundance, structure and contribution to the biodegradation of residues with PLFA and SIP-PLFA.
We observed that the mineralization of the residues decreased with soil moisture but that the extent of the detritusphere (defined the zone in which residue derived C was present and microorganisms had been stimulated) increased with soil moisture. Soil moisture also affected the microbial community structure, and in particular the fungal and bacterial contributions to decomposition.

Organic carbon decomposition rates with depth under an agroforestry system in a calcareous soil

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Soil inorganic carbon (SIC) in the form of carbonates is found in a large part of soils, especially in arid and semi-arid environments. Despite their important distribution at the global scale, the organic carbon dynamic has been poorly investigated in these soils due to the complexity of measurement and of the processes involved. It requires the removal of carbonates by acid dissolution or the use of natural isotopes to discriminate the carbon originating from the soil organic carbon (SOC) than the one from the carbonates. We incubated soil samples, coming from an 18-year-old agroforestry system (both tree row and alley) and an adjacent agricultural plot established in the South of France, during 44 days. Soil samples were taken at four different depths: 0-10, 10-30, 70-100 and 160-180 cm. Total CO_2 emissions, the isotopic composition ($\delta 13C$, ‰) of the CO_2 and microbial biomass were measured. The contribution of SIC-derived CO_2 represented about 20% in the topsoil and 60% in the subsoil of the total soil CO_2 emissions. The SOC-derived CO_2, or heterotrophic soil respiration, was higher in the topsoil, but the decomposition rates (day-1) remained stable with depth, suggesting that only the size of the labile carbon pool was modified with depth. Subsoil organic carbon seems to be as prone to decomposition as surface organic carbon. No difference in CO_2 emissions was found between the agroforestry and the control plot, except in the tree row at 0-10 cm where the carbon content and microbial biomass were higher, but the decomposition remained lower. Our results suggest that the measurement of soil respiration in calcareous soils could be overestimated if the isotopic signature of the CO_2 is not taken into account. It also advocates more in-depth studies on dissolution-precipitation processes and their impact on CO_2 emissions in these soils.

Spatial variation of earthworm communities and soil organic carbon in temperate agroforestry

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The aim of this study was to assess how soil organic C (SOC) stocks and earthworm communities were modified in agroforestry systems compared to treeless control plots, and within the agroforestry plots (tree rows vs alleys). We used a network of 13 silvoarable agroforestry sites in France along a North/South gradient. Total earthworm abundance and biomass were significantly higher in the tree rows than in the control plots, but were not modified in the alleys compared to the control plots. Earthworm species richness, Shannon index, and species evenness were significantly higher in the tree rows than in the alleys. Total abundance of epigeic, epi-anecic, strict anecic and endogeic was higher in the tree rows. Surprisingly, earthworm individual weight was significantly lower in the tree rows than in the alleys and in the control plots. SOC stocks were significantly higher in the tree rows compared to the control plots across all sites. Despite higher SOC stocks in the tree rows, the amount of available C per earthworm individual was lower compared to the control. The absence of disturbance (no tillage, no fertilizers, no pesticides) in the tree rows rather than increased SOC stocks therefore seems to be the main factor explaining the increased total abundance, biomass, and diversity of earthworms. The observed differences in earthworm communities between tree rows and alleys may lead to modified and spatially structured SOC dynamics within agroforestry plots.

Influence of no-tilled organic farming system with cover crops on soil organic matter and weed control

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In the last decade, interest in no-tillage systems has increased in Korea. The no-tillage system has provided economic benefits and environmental advantage especially when associated with organic farming. The study evaluated the effects of no-tilled organic farming system with cover crops on the soil organic matter and weed control. The field experiment was conducted from 2014 to 2019 at the National Institute of Agricultural Science, Wanju, Korea. Two cover crops rye (Secale cerale L.) and Hairy vetch (Vicia villosa Roth.), were cultivated in winter season under momo-culture and mixed culture. The cover crops were sown in October from 2014 to 2018, mowed and left as a surface mulch in May of the following year. The statistical design was completely randomized with four replecations. The field was cultivated in 2014 season, but seeding was done after 2015 on no-tilled bed, and covered with plant residues and compost to improve seedling rate. In summer, soybean (Glycine max L.) was cultivated from 2015 to 2017, and with hot pepper (Capsicum annum L.) under mixed cultures in 2018 and 2019. Soil characteristics including soil penetration resistance were investigated before cover crop and summer crop cultivation. In order to compare weed control effects of cover crops, weed weights were measured at 30 day intervals after transplanting. The results showed that four years of no-tillage increased soil organic matter contents from 15.9g/kg to 29.4g/kg and was significantly different with that of conventional tillage. The weed suppression rates of cover crops application for rye and mixture (rye+hairy vetch) treatment during 60 days after transplanting were 80% and 30%, respectively. However, weed suppression rate of hairy vetch treatment was not significantly different as compared to weedy control plots. In summary, th no-tillage cultivation using cover crops was effective in increasing organic matter content and soil improvement.

Soil carbon and nutrient dynamics in high and low fertility pasture soils following cultivation

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Soil organic matter (SOM) can be lost from the soil following cultivation which may affect agricultural productivity. It has previously been shown that supplementary nutrients (nitrogen (N), phosphorus (P) and sulphur (S)) alongside incorporation of carbon (C) rich wheat residue increased SOM after 5 years of cultivation compared to a control without supplementary nutrients. However, SOM-nutrient interactions have mainly been investigated on annually cropped soils. A key point at which SOM is lost from the soil is during the cultivated transition from a pasture to a crop. It is not clear how initial soil fertility or supplementary nutrient addition may affect SOM dynamics during this transition. We investigated the impact of initial soil fertility on the mineralization of soil C and associated changes in soil nutrients in pasture soils following cultivation of a long-term pasture soil with and without lime. The pasture was managed with 20 years of P fertilization compared to a non-P fertilized control. The high P treatment with greater system productivity was shown to have an increase of 12 Mg C ha^{-1} soil C to 60 cm depth. Three treatments were applied during the transition from pasture to crop: a cultivated control, cultivated with lime, and cultivated with lime and along with supplementary nutrient addition. Soil C was assessed in both whole soil and in the more stable <0.4 mm soil fraction. Following the cultivated transition to a crop, loss of C from the <0.4 mm fraction was increased in the limed low fertility soils (12.3% loss) and reduced in the limed high fertility soils (9.6% loss). Addition of nutrients to the limed low fertility soils reduced the loss of C (7.0% loss). Addition of nutrients with lime during pasture to crop transitions can reduce SOM loss in low fertility soils which has implications for management of SOM in cropping systems.

The effect of lignite and modified coal on nitrogen loss from broiler litter

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Poultry meat production generates large amounts of organic waste. Poultry litter, which consists of manure, bedding material (e.g. wood shavings), feathers and spilt feed, is a valuable source of organic matter and nutrients that may be used as a fertiliser or soil amendment to improve soil chemical and biological properties. Nitrogen (N) has the greatest economic value of the nutrients found in poultry litter and the amount and stability of this N is critical to ensure the successful reuse of this waste product. However, large amounts of N may be lost from poultry litter via ammonia (NH_3) volatilisation thereby reducing the quality of the waste product, its value and the potential for reuse after leaving the broiler house. Birds do not produce urine but rather excrete N in faeces in the form of uric acid ($C_5H_4N_4O_3$), which is rapidly hydrolysed to urea (CH_4N_2O) and subsequently NH_3 following manure deposition onto litter. The rate at which NH_3 is volatilised and lost to the environment is highly dependent on broiler house conditions, such as litter pH and temperature. Lignite has been shown to be highly effective at reducing N loss in beef cattle feedlots due to its low pH and high cation exchange capacity (CEC). However, its effectiveness in poultry systems has not been established. Other novel litter amendments such as modified black coal may also prove effective. Oxidisation of black coal can change its surface chemistry, generating high concentrations of acidic oxygen-containing functional groups, thus reducing pH and increasing CEC. The availability and low cost of these amendments warrants further investigation of their efficacy. This research aims to investigate innovative methods to reduce N loss from poultry litter in broiler houses, improve the nutrient value of the waste material and facilitate increased reuse of this important source of nutrients and soil organic matter.

Climate and soil type effects on crop residue decomposition

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Crop residues are an important resource for arable farmers as they add organic matter to the soil and recycle plant nutrients. Decay of plant residues is linked to many ecosystem functions, affecting atmospheric $CO2$, nutrient release, microbial diversity, and soil organic matter quality. The rate of decay, in turn, is governed by soil type, management, and environmental variables, some of which may be changing in coming decades. Our objective in this study was to evaluate effects of soil type, climate, residue placement, and their interaction on the decomposition and retention of residue-derived C. We applied 13C-labelled barley straw (13C = 10.2 atom%; C = 37.9%; N = 0.95%; C:N = 40) at a rate equivalent to 2 Mg C/ha at five locations representing different soil types and climates. Four of the sites were in Canada: Ottawa, Ontario; Swift Current, Saskatchewan; Lethbridge, Alberta; and Breton, Alberta. Mean annual temperature (MAT) at the Canadian sites ranged from 2.1oC (Breton) to 6.0oC (Ottawa) while mean annual precipitation (MAP) ranged from 356 mm (Swift Current) to 869 mm (Ottawa). A fifth site was in New Zealand (Lincoln), where MAT was 11.5oC and MAP was 640 mm. The labelled residues were either surface applied or mixed into the top 10 cm of soil. Samples were collected periodically (up to 8 years after application) for determination of the remaining 13C. Data on the recovery and kinetics of decomposition will be discussed.

Soil organic and inorganic carbon distribution in soil as influenced by land uses in degraded saline land of Northwest India

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Land use change is the second important factor contributing significantly to climate change after fossil fuel burning. Globally considerable area is saline land hampering normal crop growth. We studied eight land-uses namely forest trees including Frass (Tamarix articulata) and Eucalytus (Eucalyptus tereticornis); agroforestry systems involving Prosopis alba-mustard (Brassica juncea) system; and fruit tree such as Kaith (Feronia limonia) plantation; and fruit tree-based agroforestry systems such as Karonda (Carrisa carandas)-barley (initial two years)/mustard (later on)-cluster bean (Cyamopsis tetragonoloba) system, Aonla (Emblica officinalis) –barley/mustard-cluster bean system, Bael (Aegle marmelos) - barley/mustard-cluster bean system, and Grassland (composed of Cenchris ciliaris, C. setigerus, Brachiaria reptans, Dactyloctenium aegyptium, D. sindicum, Panicum miliare, Cynodon dactylon, etc. established naturally after protection) systems located at the Bir Reserved forest, Hisar (latitude 29° 10' N, longitude 75° 44'E, altitude 220m msl), in Haryana State, India to evaluate changes in oxidizable organic carbon (SOC) and inorganic carbon (SIC) content in the soil profile. Results showed that highest SOC stock in the soil profile was observed under Frass (77.7 Mg C ha-1) followed by Eucalyptus (69.2 Mg C ha-1), and Aonla (61.2 Mg C ha-1). Soil profiles of Bael (32.9 Mg C ha-1) and grassland (50.2 Mg C ha-1) stored lowest SOC stock among the land uses studied. Similar amount of higher SIC stock was observed in the soil profiles of Kainth (263 Mg C ha-1), Bael (247 Mg C ha-1) and Prosopis-mustard system (231 Mg C ha-1). Lowest SIC was observed in grassland (65 Mg ha-1) followed by Frass (88 Mg ha-1) whereas Eucalyptus (115 Mg ha-1), Aonla (131 Mg ha-1) and Karonda-mustard (121 Mg ha-1) recorded similar amounts of inorganic carbon stock in the soil profiles. Types of land use significantly influence SOC and SIC contents and need to be considered while formulating their reclamation management strategies.

Combined biomarker analysis and inversed modelling for the environmental reconstruction of the Beerberg peatland sequence (Thuringia, Germany)

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Biomarkers are commonly used to reconstruct paleoenvironments in terrestrial archives, including peat sequences. Various biomarkers were thus analyzed to trace environmental changes along a 3.5 meter core collected from the Beerbergmoor sequence (Thuringia, Germany), covering the last ca. 6000 years. Whereas inputs of various origins (roots, Sphagnum moss and aboveground biomass) are observed below 250 cm, predominantly Sphagnum-derived biomass is suspected between 250 cm and 100 cm depth from elemental analysis and further supported by alkane and fatty acid composition. Polycyclic aromatic hydrocarbons argue for more natural burning below 250 cm, most likely during the phase of neolithic settlements in that area, whereas above 100 cm, their structures suggest more intense burning probably during the middle age and since the industrial revolution. Reconstructed temperatures based on glycerol dialkyl glycerol tetraethers are in good agreement with other climate reconstructions over the covered period. For the first time, an inversed model was applied to assess quantitative shifts in vegetation composition, based on the quantification of biomarkers from locally collected recent plants and roots. It revealed variations in root abundance along the sequence, with a minimum between 100 and 250 cm depth where Calluna vulgaris and Sphagnum capellifolium showed the closest match to the peat material, and a maximum within the uppermost 100 cm. Although this inversed modeling exercise still requires more fine-tuning, the first attempts already showed the strengths of this attempt to better quantify the contribution of different biomass sources to the bulk organic matter than by just looking at different molecular proxies like average chain length, carbon preference index and others, individually. Inversed modeling thus appears as a promising tool to improve our paleoenvironmental understanding, not only in peat sequences, but also in other soil and sedimentary settings.

Biochar produced from water hyacinth in different pyrolysis temperatures as potential P fertlizer

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Water Hyacinth (WH) is a plague that occurs frequently in rivers and estuaries along the Brazilian Coast, hampering port activities and navigation. WH may contain a significant phosphorus (P) concentration, and that makes it a potential soil P fertilizer. Our work aimed to determine chemical and molecular composition of WH biochars (WHBC) produced in different temperatures in order to identify adequate conditions for soil conditioners production. WH samples from Sergipe (BR) were air-dried and submitted to pyrolysis (5 L N2 min-1) at 400 (WHB4), 500 (WHB5) and 600°C (WHB6). Contents of C and N were determined and bulk chemical composition was investigated by FTIR, 13C and 31P NMR CP/MAS spectroscopies. Extractable P forms were quantified by exchange resin method (Pexc) and by liquid 31P NMR spectroscopy after extraction with NaOH + EDTA solution. C content ranged from 37 to 40 %, while that of N decreased steadily up to 600°C, indicating a continuous N loss with temperature. C/N ratio ranged from 13 to 18, and these values are relatively low in comparison BC's from other sources. With increasing temperature, proportion of O/N-alkyl C groups decreased from 15.8 to 6.4 % while that of aromatic C gradually increased reaching 66% in WHBC600. Up to 500°C, alkyl C increased from 31 to 38% and decreased to 20% at 600°C. It seems that heating up to 500°C, carbohydrates are consumed preferentially with a relative enrichment of alkyl and aromatic structures. Further temperature rise concentrates aromatic C at the expenses of alkyl C consume. Increasing pyrolysis temperature also caused a gradual change from P-mono/diester groups towards phosphate in the bulk sample and a decrease of Pexc (60 to 10 mg P kg-1). Our results show that 400ºC is the most suitable temperature to produce WHB to be used as soil P fertilizer.

Does grazing intensity affects organic matter of a Subtropical Oxisol under integrated crop-livestock system?

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The objective of this work was to investigate the influence of grazing intensity on the SOM composition and C stocks in a Brazilian subtropical soil under Integrated Crop-livestock System (ICLS) after 15 years The experiment was conducted in a typical Red Oxisol in randomized blocks (three replications) with different grazing intensities according to pasture height: 10 (P10), 20 (P20) and 40 cm (P40) cm). Litter and soil samples were collected within 1 m depth from treatments and from a forest area. C and N contents and isotopic signature δ^{13}C were determined. Chemical composition was investigated by ^{13}C NMR CP/MAS spectroscopy and n-alkane distribution was determined by GC-MS. Grazing intensity did not affect C stocks and greater values were observed in forest soil. δ^{13}C values were around -22 ‰ at 0-5 cm for forest and P40 soils and increased from -17 to -14 ‰ along the profile. We concluded that the contribution of native pasture that consisted mainly of Paspalum notatum (C3) to the SOM composition below 5 cm was not affected by soil use even after 40 years. Residues of secondary forest and cultivated pasture (C4 plants) contributed to SOM composition only in the first 5 cm. Chemical composition of SOM did not differ relevantly among the treatments and, in average, it was made up by 16.7 to 19.8 % alkyl C, 52.3 to 54.7 O-alkyl C, 15.4 to 17 % aromatic C and 11.6 to 12.5 % Carboxylic C. In all analyzed environments, average chain length of n-alkanes decreased with depth indicating an increase of microorganism derived alkane. The ratio Rs/l increased with depth as expected but it was greater under P40 when compared to P10. It seems that lower intensity grazing promotes enrichment of microorganism derived compounds.

Optimum input of Vermifilter system in swine wastewater treatment under tropical condition

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The latest innovation in waste management, Vermifiltration technology, which uses epigeic earthworms as an environmentally friendly and economical wastewater treatment technique, was almost unknown in developing countries, particularly in South East Asia. Viet Nam has a rapidly growing pig farming industry. However, the majority of the country's pig raising (75-80%) is done in small farms, which lack the appropriate swine wastewater management to control the level of pathogen, odor and loss of nutrients in nutrient flows. This study aims to (i) optimize the parameters for the effectiveness of local organic flow vermifilter (wood-chip, sand, biohar and graviety) in removing swine effluents ; (ii)to manipulate the understanding of hydraulic retention time to minimize the clogging of organic loads and maximize the earthworm population's ability to transform them.

The experiment used 15 mesocosms of around 50 L, which were inoculated by the 50 adults.mesocosm-1 from mixed earthworm species (Adrei Eseinia and Pyrnovax Excavatus). It also used wastewater from swine house which was diluted by 20 times. Over the course of one month, this diluted wastewater was hand-irrigated to the mesocosms in a cycle of five different volumes as the 5 treatments: 3, 5, 7, 9, and 11 liters. day-1. This cycle was repeated three times throughout this month. The results showed, that the wastewater with high chemical properties (pH: 7.3., TSS, COD, BOD5, Pb, As: 162077, 178, 65 and 9 mg.l-1 ; Total contents of N,P,K: 348, 20 and 0.8 %; Coliform bacteria: 533 MNP.100ml-1, respectively) was reached a removal efficiency of around 88-99% for TSS, total N,P, Pb and coliform bacteria; 28-62% for COD and total K ; 11-27% of As and 4-10% of pH for all level volumes. Mature vermicast with a C: N ratio of 19-25 was obtained when irrigated 5, 7litters.day-1. The application of these volumes of wastewaters on a vermifilter bed, with a 24-minute hydraulic retention time, led to an increase in the number of live and functioning earthworms. This experiment indicates that the Vermifilter system has potential to fundamentally change chemico-biological approaches towards water quality and earthworm development

Key words: Vermifilter system, Earthworm, Swine wastewater, Water chemical properties, Tropical condition

Influence of compost and biochar amendments on soil properties and maize yield under tropical conditions

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Organic amendments may improve the quality of sandy and acidic tropical agricultural soils in Southeast Asia . We investigated the effect of biochar, compost and their combination on maize yield, soil physical, biological and chemical properties at harvesting time at four sites in Thailand, Vietnam and Laos. Maize irrigated crops were planted in two seasons. The soils were amended with chemical fertilizers or with 10 t.ha-1 of cow manure compost and 7 t.ha-1 of Bamboo biochar and their combination. Soils were analyzed for elemental contents and N, P and K availability. We also characterized soil macrofauna composition and water infiltration. Few changes were found for biological and physical parameters. Maize yields and chemical soil parameters showed contrasting, site specific results. Compost and biochar amendments tended to increased soil carbon, NO3- and PO4- availability but not K+ availability especially for sandy soils in Thailand. The combination of both amendments decreased P availability and tended to decrease NO3- and K+ availability at all sites. We conclude that compost and biochar amendments have little short-term effects on physical and biological parameters of tropical soils but change to some extent chemical parameters and maize yields.

Key words: compost, biochar, macrofauna, soil health

Wheat-derived SOC accumulates more than its maize counterpart in nutrients supplied wheat-maize cropping system

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Fertilization is the most common way to supply nutrients to the soil and to maintain crop productivity in the agricultural ecosystem, which may further influence soil organic carbon (SOC) accumulation rate. In this study, we set up a long-term fertilization field experiment in the winter wheat-summer maize cropping system. The treatments include no fertilization (Ct), nitrogen (N, 104.5 kg ha-1 N), phosphorous (P, 104.5 kg ha-1 P2O5) and N combined with P (NP, 104.5 kg ha-1 N combined with 104.5 kg ha-1 P2O5) fertilizer application with or without potassium (K, 104.5 kg ha-1 K2O); totally 8 treatments. After 21 years of fertilization, N application did not increase soil total N content, but P application significantly increased soil total P contents by 33.9%. The single application of N or P did not significantly affect SOC content, while the NP combination significantly increased SOC contents by 22.1% and 29.6% compared to Ct in the no K and K treatments, respectively, The natural 13C abundance approach and the SOC contents suggested that the NP combination increased wheat-derived SOC by 37.5% and 49.8% in the no K and K treatments; however, fertilization had no impact on maize-derived SOC content. Wheat-derived SOC was positively correlated to the wheat yield, while maize-derived SOC was not correlated to the maize yield, which indicated that wheat-derived SOC accumulated more than maize-derived SOC in the wheat-maize cropping system. Our results indicate that N combined with P application is more beneficial than N or P alone to enlarge SOC sequestration, especially for the wheat-derived SOC.

Biochar effects on native soil carbon stocks five years after application

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An understanding of the influence of biochar on soil organic carbon (SOC) formed from different carbon (C) sources, other than biochar, at field scale is required to accurately assess and predict the C sequestration potential following application of biochar. For this study, we set up a field experiment in 2009, including four treatments (i.e. B0, B30, B60, and B90, where the biochar application rates were 0, 30, 60, and 90 t ha-1, respectively). We then assessed the impact of biochar on native SOC derived from different plants (C3 and C4) and different SOC fractions, and biochar effect on SIC compositions. After five years, the content of native SOC derived from crop residues increased by 81% (from 4.32 to 7.84 g kg-1) in the B0 treatment, while the increases of native SOC were relatively lower in the B30 (61%), B60 (43%), and B90 (26%) treatments. Thus biochar decreased the content of native SOC compared to the B0. Additionally, biochar decreased "labile pool I" (first-step, weak acid hydrolysable) of native SOC by 11.2–47.7%, compared to the B0, but did not influence "labile pool II" (second-step, strong acid hydolysable) and "recalcitrant pool" (acid non-hydolysable). Using the natural abundance 13C, our results showed that 62–74% of the native SOC was derived from wheat across all the treatments. Biochar application decreased the contribution of wheat-derived C to native SOC by 14.7, 29.0, and 41.5% in the B30, B60, and B90 treatments, respectively, while the content of maize-derived native SOC did not change, relative to the B0. In addition, as biochar application rate increased, δ13C of native soil inorganic C (SIC) decreased, which indicated that pedogenic inorganic C was formed. Biochar application rates were positively related to the pedogenic inorganic C content; however, it did not influence the lithogenic inorganic C content. In summary, the results showed that the long-term (five years) biochar application can improve SIC content, while decreasing native SOC content.

Transformation of corn stalk residue to humus like substances during solid state fermentation with Trichoderma reesei

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Cellulase production from straw waste by Trichoderma reesei has been widely applied, yet the conversion of fermentation residues into humic substances is less reported. The objectives of this study are to evaluate the impacts of Trichoderma reesei on the degradation of corn stalk residue under solid-state fermentation from quantitative and structural aspects. The results show that the highest decomposition rate of corn stalk and the highest activity of cellulase, xylanase and β-glucosidase were got at the 4th day. The cumulative degradation rate was 40.78% after 8 days fermentation. Humus like substance including humic acid-like (HAL), fulvic acid-like (FAL) and humin-like material (HML), is a major transformation product of corn stalk residues. FAL and HML significantly decreased during fermentation, whereas HAL and PQ value (the ratio of HAL / [HAL + FAL]) appeared to be increased. Moreover, HAL degrees of condensation, oxidation, aromatization as well as HAL thermal stability were all enhanced. The data in this study suggest that the fermentation of corn stalk amended with Trichoderma reesei is not only beneficial to the degradation of stalks, but also promotes the transformation of corn stalk to humus, which provide available use of Trichoderma reesei in agricultural soil amelioration.
Key Word: Corn stalk; Trichoderma reesei; Solid state fermentation; Humic substance; Degradation

The effects of long term no-tillage on the chemical composition of soil organic matter

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No-tillage is considered as a potential measure to improve soil organic matter (SOM). In this study, we focused on the impact of different tillage practices on the chemical composition of SOM at molecular level based on a 17-year no-tillage field experiment in the North China. Soil samples were collected from 0-10 cm soil layer under three tillage treatments, including conventional tillage with straw incorporation (CT), rotary tillage with straw application (RT) and no-tillage with straw mulching (NT). Then, solvent extraction and CuO oxidation were used to characterize free compounds and lignin-derived phenols. The results showed that the concentrations of total n-alkanols were increased by 40.7% under NT and 15.5% under RT compared with CT, and the n-alkanols under NT was higher by 21.8% than that of RT. As for the total carbohydrates, NT increased by 66.9% but RT decreased by 58.6% relative to CT, whereas NT had 3.04 times higher carbohydrates than RT. In contrast, the short-chain n-alkanoic acids (<C20) concentrations under NT were lower by 15.1% than that of CT, while the long-chain n-alkanoic acids (≥C20) concentrations under RT were higher by 13.2% than that of CT. Overall, NT significantly decreased the n-alkanoic acids by 25.0% compared with RT. Moreover, the concentrations of lignin monomers under NT and RT were increased by 55.7% and 32.1% than that of CT, while NT had 17.9% higher lignin monomers concentrations than RT in the 0-10 cm soil layer. The lignin degradation was reflected by elevated ratios of syringic acid to syringaldehyde ((Ad/Al)s) and vanillic acid to vanillin ((Ad/Al)v). The (Ad/Al)s under NT was lower than that of CT and RT, while no significant changes in (Ad/Al)v were observed between treatments . We concluded that shifting from conventional tillage to no-tillage changed the chemical composition of SOM under the experimental condition.

Keywords: no-tillage, soil organic matter, biomarker, chemical composition, degradation

Humus build-up in Frisian agricultural soils, towards a certificate trading scheme

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Soil is the most important resource for agriculture. A healthy soil with a sufficient supply of organic matter is of great importance for the agricultural sector. In recent decades, soil quality in Friesland is under pressure and poses a threat to the production capacity of the Frisian agricultural sector.

Therefore, in 2018 Friesland, a province in the Netherlands, decided to implement a certificate-trading scheme, based on the 'Kaindorf model' in Austria. Companies, institutions and individuals who want to compensate for their (non-avoidable) CO_2 because they want to become climate neutral can purchase certificates. The revenues are used to pay farmers a fee for capturing CO_2 in their plots for increased humus. Compensating for their additional costs.

25 farmers joined in 2019 the project and started working actively to increase their SOM content of their soils. Friesland differs from the Kaindorf region with regard to:
soil type, management options, availability and quality of biomass and national legislation.

We present the Frisian case:
- Frisian situation
- research approach
- first results (soil samples participating farmers)

The Frisian approach will be compared to the Kaindorf model with regard to soil parameters: increase in SOM (time, quality), water retention, structure biological activity, and visual observations.

Carbon Connects: A European project on changing traditional high GHG emitting peatland management practices to sustainable low carbon alternatives

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Agriculture is mostly ignored when countering climate change, even though it causes one third of global C02 emissions (UN-Env). 3% of the world's land surface is covered by Peatlands, which are large concentrations of organic matter having accumulated over centuries. They store 2x as much carbon as all of Earth's standing forests. Europe contains 265,000 km2 of various peatland types and if dried out, will go from being a carbon sink to a massive, unstoppable carbon emitter. In the project Carbon Connects (CConnnects) an European consortium will reduce C02 emissions by 50% in agricultural peatlands where traditional practices have unnecessary high emissions (20-40ton C02/ha/y). The land practices drain and strip peatland for energy use, crop production, and animal husbandry. CConnnects will promote alternative practices of wet agriculture land use that reduces carbon by raising water levels, introducing new crops (eg. Cattail, reed), and isolating carbon in land outputs (biomass, building material). CConnnects develops financially viable business models by developing value chains & use blue and C-credit schemes to enable widespread implementation and scaling-up without public subsidies. CConnnects has 8 pilots of 3-10ha in NL, FR, BE, UK, IE, jointly representing all peatland types in NWE. Solutions are scalable in NWE to 4,500,000ha peatlands (Larger than NL). CConnnects has the potential to reduce 90-180M ton emissions in NWE, equivalent to removing 40-80 million cars. CConnnects' transnational Farmer-2-Farmer learning programme allows land users to directly share and scale experiences, while actively targeting new adopters with a transnational toolbox of state of art land use and farming practices. Partners of CConnects are from universities, government, business, research and landowner groups. We will present the CConnect-project and its first results.

Circular use of local biomass for soil fertility in the municipality of Ooststellingwerf

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In the Netherlands conventional agriculture leads to a number of problems such as: soil compaction, a disturbed mineral balance, insufficient soil life, an increase in soil diseases and a falling humus content. It is known that organic matter has a positive effect on this.

However, in the Netherlands biomass is collected and processed at professional biowaste processing facilities. Biomass is processed into valuable biobased products such as organic amendments (compost, biochar and bokashi). Collecting, transporting and processing of the biomass at dedicated sites come with increased transport and loss of local biomass to increase organic matter locally.

The municipality of Ooststellingwerf and it farmers have the ambition to process local produced biowaste into soil amendments locally on site. This gives opportunity to produced custom made compost on site with a potential lower impact.
Therefore, a study was executed that included
-        An inventory on local available biomass (quality and quantity) for composting and what compost quality could be produced from the available biomass;
-        An assessment of soil quality on 5 farms which are representative for the region, their specific soil related problem and if increased SOM could reduce these problems;
-        A LCA to compare CO_2 costs of locally produced compost with the current composting system as well as a costs assessment;
-        An assessment on legislation;
-        An assessment of the pro's and con's of different on farm composting techniques

Results show that the available biomass in the municipality, are largely high in nitrogen and low in carbon. Increased SOM could solve soil problems only partly. Local produced compost has a lower environmental impact and costs than the current system.

Soil organic matter distribution in a floodplain forest

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Soil organic matter is recognised as being central for healthy soil and broader ecosystem functionality, yet its variability and factors that dive this at the landscape scale are less well understood. This is particularly the case in floodplain forest systems where there is significant local and landscape-scale variation in relation to vegetation type and inundation patters and history, along with underlying geomorphology. Here we report the findings of research carried out in Koondrook-Perricoota State Forest in the NSW Riverina, situated between Barham in the north-west and Moama in the south-east, bordering the River Murray. The forest is very low-lying, with a height gradient of approximately 10 m across its whole length, and thus floodwaters are generally slow-moving following mostly subtle local-scale topographic gradients. We established a series of 10 toposequences throughout the forest capturing local scale variation, and collected soils from the 0-30 cm layer in order to understand how inundation history and seasonality affect multiple soil health indicators, including SOM. Preliminary analyses reveal a 3-4 fold difference in soil organic carbon (SOC) concentration between the highest (3.04%) and lowest (0.89%) concentrations, and a 2-3 fold difference (0.06 – 0.17%) in total nitrogen concentrations, resulting in an average C:N ratio of 11.1 across the 40 sites. These results along with data from ongoing analyses will be discussed.

Effect of detritus input change on microorganisms in forest soils

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We examined the effects of litter input on soil dynamic processes in an oak forest in Hungary, at Síkfőkút DIRT site. The goal of the project is to assess how rates and sources of plant litter inputs control the dynamics of organic matter and nutrients in forest soils over decadal time scales. Six treatments were applied in the experimental site. Beside the control (C), two detritus addition (DL and DW) and three detritus removal (NL, NR and NI) treatments were applied in which aboveground and belowground detritus quantities were manipulated. In our detritus manipulation experiment we studied the 0-5 cm soil layer of 18 DIRT plots. We tested the numbers of fungi and bacteria (MPM method) and fungal biomass (ergosterol determination). These parameters of the treatments were compared by ANOVA and these were completed with Tukey's HSD test. These studies showed a significantly higher bacteria number in the case of detritus addition and control treatments than in detritus withdrawal treatments, while in DL and DW showed significantly higher values for fungi number and fungal biomass. More than 3.5 times higher values for litter doubling treatment, and fungal biomass also showed almost triple difference (0.87 and 0.3 mg fungi/g soil were measured in these treatments). THM-GC-MS studies showed that the amount of microbial lipids in the average of doubling and control treatments (5779 mg/kg) was 78% higher than in NL (3241 mg/kg). According to our investigations, the lack of both leaf litter and live roots significantly reduces the amount of soil microorganisms. However, doubling of leaf litter did not cause a significant increase in amount of bacteria or fungi compared to the control.

Changes in chemical and thermal indices of soil organic matter stability with time– method validation using a controlled incubation study.

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Soil organic matter stability is thought to be influenced by a combination of physical and chemical constraints. We have seen relationships between thermal analysis and the carbon mineralization potential of a microbial community1,2,3. In addition, chemical information obtained using spectroscopic methods (synchrotron-based XANES) can also be used to learn how C is stabilized in soils. This study shows results of a controlled incubation study4 to track, over time, the changes in thermal stability using Rock-eval pyrolysis and XANES measurements of a soil incubated for the equivalent of 21 months of accumulated crop heat units in the Ottawa area.

Appraisal of legume cover crops for conservation agriculture in Tigray, northern Ethiopian highlands

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Ethiopian highland agriculture is dominated by crop production on small holder farms. Farmers in Tigray are abandoning cereal-legume crop rotation due to very low legumes' yield. Continuing use of mineral fertilizers often fail to sustain cereal crops' yield due to declining soil productivity and drought. A field experiment was conducted since 2014 to appraise legumes for green manure, and to evaluate wheat productivity for continuous 3 years (2015-2017) after one-time incorporation of green manure on degraded soil. Six leguminous species (Vicia faba, with recorded dry matter yield of 19.7t/ha and Vicia villosa, 12t/ha; Dolicos lablab, 10t/ha and Vigna unguiculata, 6.7t/ha; Lupinus angustifolius, 8.3t/ha and Lupinus albus, 6.7t/ha) were incorporated in 2014. There was no mineral fertilizer use and no crop residue left after each harvest. The results indicated wheat yield on average increased from 0.74t/ha on absolute control to 3.2t/ha in 2015 and 2016 but declined to 1t/ha in 2017 on Vicia species incorporated plots. Wheat yield increased to 2.7t/ha in 2015, 3.1t/ha in 2016 but declined to 1.4t/ha in 2017 on Dolicos lablab and Vigna unguiculata incorporated plots. Wheat yield increased to 1.6t/ha in 2015, 3.1t/ha and then declined to 1.3t/ha in 2017 on Lupinus species incorporated plots. It was observed that Vicia faba (also food crop), Vicia villosa, Dolicos lablab and Lupinus angustifolius in that order are good candidate green manure legumes for conservation agriculture. Wheat grown on Vicia species incorporated plots responded faster than on plots incorporated with Vigna unguiculata, Dolicos lablab and Lupinus species. On average, wheat yield significantly increased more than two-fold over the absolute control for three consecutive years once legume green manure is incorporated. Leguminous green manure obviates mineral fertilizer use in farming systems, sustains crop productivity leading to improved rural livelihoods in the Ethiopian and sub-Sahara African highlands.
Keywords: Wheat production, leguminous species, crop rotation, green manure, Ethiopia

Integrating promising legume cover crop in conservation agriculture practices significantly improve wheat and soil productivity in Tigray, Ethiopian highlands

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Ethiopia has been implementing climate resilient green economy strategy and conservation-based agriculture to reverse impacts of overcultivation, overgrazing and deforestation. Long term experiment has been conducted since 2017 to evaluate the roles of conservation agriculture practices for sustainable production in Tigray, Ethiopia. With split plot design, two tillage depths; (shallow and deep); two tillage frequencies (2- and 3-times); vetch cover (incorporation and mulching), wheat residue maintenance (2/3 and 1/3 residue left) were tested. The soil on the site was hard (e.g. penetrometer test 49kg/cm2 at 15cm depth), low in organic C (0.9%) and total N (0.08). The first year results showed deep-3 times plowing produced higher vetch dry matter (2.8t/ha), wheat dry matter (2.4t/ha) and wheat grain (0.97t/ha) than other treatments. Deep-2times plowing on vetch cover resulted in higher available water (AW, 4mm) and exchangeable K (3.4g/kg). Shallow-3times plowing on wheat enhanced AW (3mm), and K (3.9g/kg). Shallow-2times plowing improved available P (4.5mg/kg on vetch, 3.5mg/kg on wheat plots). Second year, zero tillage was practiced when plots were planted to wheat. Wheat yield increased to 3.4t/ha on vetch incorporation, and to 2.4t/ha on vetch mulching over control (1.6t/ha). Wheat residue maintenance, 1/3 and 2/3 left, produced 1.68t/ha and 1.39t/ha. Vetch cover crop improved soil quality: soil hardness halved (22kg/cm2 at 15cm), AW (10mm) five-fold, organic C (2.1%) and total N (0.24%) contents tripled, and available P (7.76mg/kg) and K (13g/kg) at least four-fold. Decreasing plowing depth and frequency improved P availability. Vetch cover crop enhanced fast soil restoration. Yield benefits after legume cover crops can offset yield penalty of no continuous cereal cropping. Integrating legume cover crops and cereal crop residue management in conservation agriculture strategies can restore soil and crop productivity leading to increased agricultural output for a stable economy in Ethiopia and beyond.
Keywords: Zero tillage, cover crop, soil restoration, crop yield, green economy, Ethiopia

Dynamics of residue 13C and 15N at various depths in diverse soils

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Plant litter decay and the persistence of its carbon (C) and nitrogen(N) crucially affect soil health and can impact soil carbon sequestration. We conducted a long-term experiment that asks: does the depth in soil profiles influence the processes and extent of residue turnover? Barley residue, highly enriched with 13C and 15N, was placed in mesh bags and buried at three depths in the soil profile (5-10 cm, 20-25 cm, 40-45 cm) at three sites with different climate and soil properties (Lincoln, New Zealand; Ottawa and Lethbridge Canada). The mesh bags were periodically retrieved over about a decade, and analyzed for 13C and 15N to determine recovery and also distribution in microbial phospholipid fatty acids (PLFA). At all sites and treatments, decay followed typical 1st-order kinetics, with high initial rates gradually diminishing over time. Decomposition was slower in the cold site (Lethbridge) than at other sites (Ottawa, Lincoln). Depth in soil profiles had no consistent effect on recovery of 13C, even though the residue was processed by different microbial communities, as determined by PLFA analysis. Dynamics of 15N showed patterns similar to those of 13C, although recovery was usually higher, indicating recycling of the N. The absence of a strong depth effect on litter turnover raises intriguing questions about opportunities for sequestering C in soil profiles, and invites further study of how microbes at depth process C and N inputs.

Utilising organic nitrogen: Can plants produce protease enzymes from their roots?

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Nitrogen (N) is an important macronutrient for plant life. Plants can uptake N in the form of ammonium, nitrate, amino acids and oligopeptides. However, plants do not have direct access to the 40% of total soil N represented by proteins. To utilise proteins they first must be broken down into small peptides and amino acids by protease enzymes. The majority of soil proteases are produced by soil microorganisms to obtain their own carbon and N nutrition. Therefore, the ability of plants to secrete proteases to hydrolyse proteins into small peptides and amino acids would increase the availability of N to plants. In agricultural systems, a decrease in the reliance on inorganic N forms by plants would reduce the use of environmentally detrimental inorganic N fertilisers.

In a laboratory experiment, we investigated whether plant roots release protease enzymes. We also investigated whether protease released from roots were up- or down-regulated by the presence of inorganic N. Seedlings (Zea mays L. and Triticum aestivum L.) were grown in sterile, hydroponic conditions in an inorganic N nutrient solution or a zero N nutrient solution. Each week for one month, the nutrient solutions were analysed for proteolytic activity using a fluorescence aminopeptidase assay. At the end of the experiment, the root tip was excised and its in situ protease activity measured to determine whether root proteases are surface bound. We hypothesise that plants roots will not release exoprotease enzymes but instead remain plasma membrane bound with higher concentrations under the zero N treatment. Consequently, proteases present on the root surface allow the plant to utilise the protein fraction of soil without losing essential nutrients into the soil matrix.

Upcycling domestic food waste: Optimising success for the home composter

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Microbial decomposition of organic matter is the underlying mechanism that enables us to reduce the volume of our domestic food waste and transform it into valuable compost. This upcycled product can enhance the physical, chemical and biological properties of soil, enabling us to grow healthier plants and tastier food in our urban environment. There is widespread scientific understanding of the conditions conducive to microbial decomposition of organic matter. Internal factors (physical and chemical composition of the food waste; size, activity and composition of the microbial community) and external factors (temperature, water content, aeration, additives) all play a role. This research explores which factors are the most important to the specific application of home composting in urban Australia. The project seeks to develop recommendations for the home gardener as to how these factors can be optimized to produce compost faster. The approach is grounded in the needs and realities of the industry serving the home compost market, with a combination of laboratory and full-scale field trials. Communication and interpretation of results in formats that engage and inform a general public audience are an integral part of this research collaboration between RMIT University and Maze Distribution.

Subsoil management in agricultural soil: Visualizing the impacts on soil organic carbon stocks and distribution by hyperspectral imaging and machine learning algorithms

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Significant amounts of water and nutrients are stored in deep soil horizons and subsoil management is being considered as an option to sustain high demand in crop productivity. At the same time, subsoils contain a large proportion of total soil organic carbon (SOC) and the dynamics of SOC in subsoils are now receiving more attention, especially given the link of SOC with climate processes. However, subsoils are highly heterogeneous, subsoil SOC contents are low and have longer turnover times, so that detecting SOC changes in subsoils is difficult using classic soil analyses based on sample homogenisation by depth increments.

We analysed soil cores from a field experiment with deep ploughing treatments, with and without compost incorporation, using hyperspectral Vis-NIR imaging spectroscopy. The C distribution within the soil was modelled at a very high spatial resolution (53×53 µm) using random forest and artificial neural network algorithms. The SOC mapping revealed an increase in SOC stocks resulting from deep ploughing (12% relative increase). We hypothesize that, in addition to the added SOC, an increase in rooting densities resulting from lowered bulk density and enhanced nutrient availability in the subsoil are the driving factors for this C accumulation.

Hyperspectral imaging of soil cores is a promising tool for the quantification of SOC stocks and changes in deeper horizons, and allows visualisation of the spatial heterogeneity of soil organic carbon.

Does animal manure application improve soil aggregation? Insights from nine long-term fertilization experiments

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Manure application is widely recognized as a method of improving soil structure and soil fertility due to additional organic matter and nutrient inputs. However, the salinity of animal manure may have a detrimental effect on soil aggregation. The objective of this study was to determine the effects of long-term animal manure application on soil aggregation, binding agents (soil organic carbon, SOC and glomalin-related soil protein, GRSP), and dispersing agents (e.g., Na^+) and their relationships based on nine long-term fertilization experiments (12 to 39 yr) across China. The two red soil experiments (Qiyang, QY and Jinxian , JX) and one paddy soil experiment in Jinxian (JX-P) were conducted in southern China (precipitation above 1200 mm yr-1), whereas the other six experiments were established in semi-humid or arid regions in China with precipitation in the range of 500-900 mm yr-1. Each experiment included three treatments as follows: no fertilization (Control), inorganic fertilizer (NP or NPK), and a combination of inorganic fertilizer and animal manure (NPM or NPKM). Long-term animal manure application not only significantly increased the biological binding agents (i.e., SOC and GRSP) in the nine experiments but also considerably increased the dispersing agents (i.e., exchangeable Na^+) ($P < 0.05$), except for the paddy soil experiment. Consequently, soil aggregate stability increased after animal manure application in three experimental sites in southern China but not in the experimental sites in northern China. Aggregate stability had a positive relationship with SOC and GRSP in the experimental sites in southern China ($P < 0.01$) but a negative relationship with exchangeable Na^+ in the experimental sites in northern China ($P < 0.05$). The Na^+ accumulation in soils was negatively related to mean annual precipitation ($P < 0.001$). Our study demonstrates that the long-term application of animal manure may degrade soil structure via the Na^+ accumulation.

Biological factors controlling soil carbon sequestration after organic amendments in agricultural soils in Zambia (Africa)

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This study aimed to investigate effects of organic amendment on soil biological (soil fauna and microbes) community and soil carbon (C) dynamics under different soil types in Zambia (sub-Saharan Africa). Soil organisms are strongly correlated to decomposition and soil C stock when applied C sources into soils such as organic amendments in agriculture. Although the use of organic amendments is common agricultural practice, it remains unknown the effectiveness of materials of different quality and soil types on the biological activity in southern African soils.

Thus, we conducted field experiments at two locations in Zambia (Lusaka and Kabwe). Lusaka and Kabwe had sandy loam soils and loamy sand soils. Lusaka had higher soil C concentration than Kabwe. A split-plot design was used with crop type (cassava, maize, soybean and control (bare)) as the main plot and soil amendment (chemical fertilizer, cattle manure, poultry manure, maize residue, and control) as the subplot factors. Soil fauna was collected by pitfall traps every 2 weeks during crop growing season (from Dec 2017 to Apr 2018). CO_2 emissions and soil moisture were measured at the same timing. Bacterial community (16S rRNA gene) was also analyzed from extracted DNA from those sampled soils (Ion PGM). The total number of soil fauna in each site was totally different; we found around 1000/200 individuals at Lusaka/Kabwe. On the other hand, CO_2 emissions and microbial diversity at Kabwe significantly increased due to organic amendments.

In conclusion, organic amendments might have indirectly (soil fauna) influenced soil carbon dynamics in IITA, while directly influenced in Kabwe due to lack of carbon sources. More data is required to explain the phenomenal differences between C dynamic and soil types in Zambia.

Pattern of organic residue decomposition in saline soils of Bangladesh

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A pot experiment was conducted to investigate the decomposition of incorporated organic residues in saline soil at the Laboratory of Soil Science Division, Bangladesh Institute of Nuclear Agriculture (BINA), Mymensingh. The experiment was arranged in completely randomized design (CRD) with three replications involving four levels of salinity , S0 = non saline water (0.7 dS m-1), S1 = 5 dS m-1 saline water, S2 =10 dS m-1 saline water and S3 = 20 dS m-1 saline water and three treatments of organic crop residues (C0 = no incorporation of crop residue, C1 = incorporation of rice residue @ 10 t ha-1 and C2 = incorporation of groundnut residue @ 10 t ha-1). Decomposition rate of organic crop residues were decreased with the increase of salinity level irrespective of crop residues. The decomposition rate of crop residues varied between 0.63 and 0.71 % per day. The highest decomposition rate (0.71% per day) was observed in non saline soil (0.7 dS m-1 salinity level) and the lowest decomposition rate (0.63% per day) was observed at 20 dS m-1 salinity level. The decomposition rate of groundnut residue (0.72% per day) was higher compared to rice residue (0.64% per day). Approximately, 58.02% rice and 64.68% groundnut residues were decomposed within 90 days of incubation. The overall results suggest that organic residue decomposition was inversely correlated to the extent of soil salinity.

The effects of long-term nitrogen addition on the composition and sequestration of SOM in a boreal forest

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Boreal forests are responsible for large terrestrial carbon (C) stores. They are typically nitrogen (N)-limited, such that the intense use of fertilisers for forest management in this biome has drawn great attention to the long-term impacts of N additions on biogeochemical processes, especially, decomposition and sequestration of SOMs. We investigated the impacts of N addition on SOMs both qualitatively and quantitatively in a mature Scots pine forest located in Northern Sweden. Two experimental plots were established: reference and fertilised plots. The latter has received the total amount of 950 kg N/ha over the past 13 years (c. 50-100 kg N/ha/yr), resulting in an N gradient in the soil adjacent to this plot. We established soil sampling transects along the gradient and assessed the relationships between the N level and SOMs.

Soils were collected from the litter and humus layers and assessed for 1) the composition of C compounds using solid-state carbon-13 nuclear magnetic resonance (NMR) spectroscopy and pyrolysis-GC/MS and 2) total C mass. NMR demonstrated decreases in O-alkyl relative to N-alkyl/methoxyl C with the N levels. These compounds were derived from carbohydrate and lignin components, respectively. This shift in C compounds was consistent with pyrolysis-GC/MS showing that carbohydrate:lignin ratios were negatively correlated with N. The total C mass was 2.09±0.43 and 1.7±0.30 kg C/m2 (Mea±95% confidence interval) in the fertilised and reference plots, respectively. This treatment difference corresponded to C sequestration of 30 g C/m2/yr. Furthermore, C mass in humus was positively related to the N level. Thus, our study suggests that an N addition in this pine forest alters the composition of C compounds by decreasing carbohydrate-derived compounds relative to lignin and also may increase C sequestration in the organic layer. Our results may help us to disentangle the potential mechanisms of C decomposition/sequestration in N-limited boreal forests.

22-years long-term fertilizations increase soil organic carbon and alter its chemical composition in three wheat/maize cropping sites across central to south China

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As a quantifiable component of soil organic matter, soil organic carbon (SOC) is at the core of soil fertility and the C sequestration in SOC is a pathway to mitigate climate change by reducing atmospheric CO2. Studies have shown that fertilization strategies can alter SOC sequestrations and stocks, but information about fertilization effects on SOC chemical composition is limited. Using the solid-state ^{13}C nuclear magnetic resonance (NMR) spectroscopy, we examined changes in the SOC chemical composition of three soils (0–20 cm depth) from an annual maize/wheat double-cropping system across central to south China. These soils had been subjected to 22-years (1990–2012) long-term fertilization. Compared with unfertilized control, SOC stocks were significantly increased under chemical nitrogen, phosphorus and potassium fertilization (NPK), NPK plus straw (wheat straw, NPKS), and NPK plus manure (varied horse, pig and cattle manure, NPKM). The O-alkyl C (labile C), not the alkyl C (persistent C), was consistently increased across the three fertilized treatments. Additionally, all fertilized treatments decreased the ratio of alkyl-C/O-alkyl-C (SOC decomposition index) or aliphatic-C/aromatic-C (SOC complexity index), indicating that the SOC decomposition was delayed, or SOC was converted into a more complicated structure. The soil C of NMR-determined functional groups (alkyl C, O-alkyl C, aromatic C, and carbonyl C) was positively correlated with the cumulative C input (P < 0.05). The conversion rate of functional groups was highest in O-alkyl C, indicating a largest contribution to the increase of SOC accumulation. Soil pH, C/N ratio and clay were the major factors affecting the functional-group conversion rates, whereas annual precipitation, temperature, and accumulated temperature (>10 °C) played little roles. In conclusion, these results can be applied to the improvement of agricultural soil C sequestration or restoration capacity through changing SOC chemical structure under long-term fertilizer managements.

Warming depleted the δ13CO2 values of soil respiration and accelerated the loss of the light fraction of SOC

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The carbon storage of soil organic matter is about three times as much as the atmosphere or terrestrial vegetation. The pool of soil organic carbon (SOC) is sensitive to climate change, but the response of different components (light fraction and heavy fraction) of SOC to climate change is still not well understood. In order to study the effect of global warming on SOC dynamics, infrared radiation heater was installed in 2008 to simulate global warming and increased the soil temperature of 5cm depth by about 2℃ in Luancheng Agroecosystems Experimental Station, Chinese Academy of Sciences, in the North China Plain. There are four treatments: no nitrogen and no warming (N0T0), no nitrogen and warming (N0T1), nitrogen and no warming (N1T0) and nitrogen and warming (N1T1) in the field expeirment. During 2016 to 2017, we studied the impacts of experimental warming on the SOC decomposition in wheat field by measuring the SOC contents, CO_2 fluxes (soil respiration), $\delta^{13}C$ abundance of SOC and $\delta^{13}CO_2$. The results show that warming increased CO_2 emissions and decreased $\delta^{13}CO_2$ values of soil respiration, especially in winter. Warming increased the $\delta^{13}C$ value of SOC, decreased SOC contents and accelerated the loss of the light fraction of SOC.

Vegetation and precipitation shifts interact with soil depth to change dryland carbon and nitrogen storage

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Dryland ecosystems are experiencing shifts in precipitation and plant community composition, which alter the cycling and storage of soil carbon (C) and nitrogen (N). We measured profile soil organic C (SOC), total N (TN), and associated stable isotopes following 20 years manipulating 1) plant community (native shrub vs. exotic bunchgrass), 2) water availability [ambient, or doubling of annual rainfall in the dormant (DORM) or growing (GROW) season], and 3) soil depth (deep 2 m or shallow 0.5 m soils). Under both native shrubs and exotic bunchgrass, GROW increased profile SOC pools ~70% vs. ambient controls. DORM decreased SOC pools slightly under native shrubs and increased SOC for bunchgrass, primarily in the topsoil. Regardless of vegetation treatment, GROW increased SOC pools for interplant microsites. Contrasting soil depth treatments, profile SOC and TN pools were 1.56 and 1.23× greater, respectively, in shallow compared to deep soil treatments, with significant interactions between soil thickness × vegetation. Profile $\delta13C$ values, which integrate the long-term soil moisture status, were enriched in deep vs. shallow treatments and show greater water stress in deep soils. Similarly, profile $\delta15N$ values in shallow treatments were enriched vs. deep and show greater water availability in shallow treatments leading to enhanced N loss. Our study shows precipitation seasonality can interact with changes in plant community composition to alter soil biogeochemical processes in drylands. We provide evidence that soil thickness as a control volume has an important influence on the surface soil biogeochemical response to changes in climate and vegetation. Our findings could improve adaptive management decisions and help identify landscape control points that regulate ecosystem resilience.

Carbon and nitrogen mineralization dynamics of lignite amended manure during incubation with soil

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Lignite (brown coal), due to its low pH, high cation exchange capacity, pH buffer capacity, labile carbon (C) and humic acid contents, has been shown to suppress the volatilization of ammonia when used as a manure amendment. Though the retention of nitrogen (N) by the lignite enhances the value of the manure as soil amendment, the fates of the retained N and the added lignite C in the amended manure when applied to soil are not well understood. In this ongoing 40-day laboratory soil incubation study, the C and N mineralization rates of cattle manure amended with two different lignite materials are being assessed by determining changes in mineral N (ammonium-N and nitrate-N) concentrations as well as changes in carbon dioxide, methane and nitrous oxide concentrations in the headspace of the incubated soil. We hypothesized that the lignite amended manure would have higher mineralization rates than the unamended manure due to the increased labile C fraction in the former.

Soil organic carbon fractions under smallholder farmer conservation agriculture in Eastern and Southern Africa

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Soil organic carbon (SOC) is a measurable component of soil organic matter and is used as an important indicator for soil health and fertility. This is due to its function through microbial mineralisation processes to assist plant nutrition, improve soil structure, enhance water infiltration and retention, and build resilience against soil erosion. The use of conservation agriculture (CA) has been promoted via zero tillage, residue retention, and crop rotation as a means to raise and retain SOC levels above that of conventional agricultural practices (CP) in the Americas, Europe and Australia. However, it is disputed that CA can provide similar benefits to smallholder farmers in Eastern and Southern Africa. This is due to the limited availability of crop residues for retention in such low productivity systems, and the capacity to accurately measure changes in SOC and its constituent physical fractions. We investigated SOC content via fractionation on soil from three depths in the uppermost 0.3 m under establishment phase CA (zero tillage and residue retention for 4 years) and compared this with CP in continuous maize subsistence agriculture at paired sites across an agro-ecological gradient in Eastern and Southern Africa. We used Dumas method after a series of chemical and physical size fractionation processes to assess SOC content of the various fractions in conjunction with the use of Australian MIR spectral calibrations to fractionate SOC. Strong agreement between measured and predicted values gives confidence in the ability of MIR spectral calibrations from Australia to be used to assess SOC fractions of soils from Eastern and Southern Africa. We found significant increases in particulate (POC) and humic (HOC) organic carbon concentrations in shallow soil (0-0.05 m) from CA treatments with high residues when compared with CP although variable presence of resistant charcoal carbon (ROC) confounded predictions.

Plant biomass inputs and soil organic carbon dynamics in woodlands and pastures of central Queensland

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Above and below ground plant biomass inputs to soil and their effect on soil organic carbon (SOC) dynamics within single and mixed species woodland and pasture areas of Central Queensland was investigated. The major pathway by which carbon is naturally sequestered in soil is through the delivery and decomposition of plant derived inputs. Uncertainty remains about the source and turnover of plant biomass inputs to soil from woodland and pasture vegetation types found in Central Queensland. This study reports on the quantification of above and below ground plant biomass inputs (excluding coarse woody debris), its decomposition over 48 weeks, and its subsequent influence on SOC and constituent fractions within single and mixed species woodland and pasture systems common to scrublands and rangelands of Central Queensland. In situ decomposition of plant components (leaves, sticks/twigs/stems, bark-flowers and fruits, and roots) was followed by SOC analysis for carbon fractions. Site specific field measurements were used to improve existing default parameter settings to calibrate the FullCAM model for predicting change in carbon stocks from different types of plant inputs into soil over time using long-term weather records. Results indicate there is greater SOC content in mixed woodland in comparison to single species woodland, and in single species pasture in comparison to mixed species pasture, although the difference was not statistically significant (p>0.05). SOC decreased, particularly in the ratio of particulate organic carbon (POC) to humus organic carbon (HOC), over the duration of litter decomposition. This study improves the understanding of how different forms, quantities, and quality of plant biomass inputs relate to increases and decreases in SOC at a site specific scale. Comparison of 45-year (1970 to 2015) FullCAM model simulations with measured field study values showed encouraging carbon estimation in woodland but large disparity with quantified pasture values.

Microalgae and phototrophic purple bacteria for nutrient recovery from agri-industrial effluents; influences on plant growth, rhizosphere bacteria, and putative C & N cycling genes.

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Microalgae (MA) and purple phototrophic bacteria (PPB) have the ability to remove and recover nutrients from digestate (anaerobic digestion effluent) and pre-settled pig manure that can be utilized as a bio-fertilizer. The objective of this study was to compare the effect of biologically recovered nutrients from MA and PPB in relation to plant growth and soil biological processes involved in nitrogen & carbon cycling. A glasshouse experiment was conducted with MA and PPB as biofertilizers for growing a common pasture ryegrass (Lolium rigidum Gaudin.) with two destructive harvests (45 and 60 days after emergence). To evaluate the rhizosphere bacterial community we used barcoded PCR-amplified bacterial 16S rRNA genes, for paired end sequencing on the Illumina Mi-Seq. Additionally, we used Phylogenetic Investigation of Communities by Reconstruction of Unobserved States (PICRUSt) analysis for the detection of putative functional genes associated with nitrogen (N) cycling and soil carbon (C) cycling.

There was a significant enhancement of plant growth when applying PPB to soil, which was comparable with the effects of chemical fertilizers. Comparison of rhizosphere bacteria between two harvests revealed an increase in the relative abundance of most gram-negative bacteria. There was also an increase in nitrogen cycling (nitrogen fixation, nitrification and denitrification) and carbon (starch, hemicellulose, cellulose, chitin and lignin) degrading genes in the rhizosphere of microalgae treatments during the second harvest.

These data indicate that biologically recovered nutrients from waste resources can be used effectively as a fertilizer resulting in enhanced C and N cycling capacities in the rhizosphere.

Change in physical properties of forest soils in a long-term experiment of detritus input and removal treatment

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Climate change affects both the productions of detritus and soil moisture and temperature as well. These parameters alter the physical, chemical and biological properties of soils. We modeled the change in the amount of the detritus caused by climate change in a long-term experiment in a temperate-zone Quercetum petraeae-cerris community of Hungary. Six treatments were established in three replicates on Luvisol (clay loam): Double Litter (DL), Double Wood (DW), Control (C), No Litter (NL), No Roots (NR), No Inputs (NI). We examined on each plots how to change the soil physical parameters after 13 years. The bulk density (BD) and water holding capacity (WHC) were measured at 0-10 cm depths. The variance analysis (Tukey's range test) shows that the BD of NL, NR and NI (average BD varies between 1.09 and 1.11 g cm-3) treatments are significantly ($p < 0.05$) higher than in the control, DL and DW treatments (mean BD: 0.95-1.01 g cm-3). There was no significant difference between the control and detritus input treatments. The WHC of the control, DW and DL plots (mean WHC: 48.74-49.62 V/V%) were higher than in the NL, NR and NI treatments (mean WHC: 46.15-46.80 V/V%) but the difference was no significant ($p < 0.05$). In contrast with the detritus inputs and significant higher soil organic carbon (mean OC: 5.66-6.28%), there was no change in soil physical properties compared to the control. However, the detritus removal treatments (OC: 3.57-4.10%) have significant effect on the BD and WHC. As a result of the drying of the climate and forest degradation, the porosity of the soils and their water capacity will probably decrease, which further deteriorates the hydrological condition of the area.

Soil amino acids on association converted to peptide-polypeptide and protein part of humic molecules during humification process.

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The aim of this study were to find out the fate of amino acid on humification processes in soil. For this study humic acid were extracted from jalpaiguri forest soil and treated with eleven different amino acids with or without clay. It was observed that cation exchange capacity and electric potential decreases with time whereas N content, molecular weight and % aromiticity of humic molecule increase with time. Infrared and C13 nuclear magnetic resonance spectra established that various groups of amino acids react with each other converted to peptide ,poly-peptide and finally protein part in humic molecule. Carbon % , N % and protein content of humic molecules increase from 55.4 - 57.1, 3.5 - 4 and 13.575 - 24.725 mgg-1respectively within one year reaction . From this study it is clear that amino acids in soil on association converted to peptide –polypeptide and protein and that became a part of humic molecules during humification process.

Changes in soil organic carbon over 24 years depending on plant cover and weather conditions

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The effect of barley and different perennial fodder crops such as grasses and clover-grass mixture on soil organic carbon (SOC) concentration and stock was studied during 1990-2014. Soil samples (depth of 0-20 cm) were collected from ongoing long-term experiment established in 1964 near Tartu, Estonia (58°22'04.09"N, 26°39'41.47"E). Treatments with perennial crop were renewed after every seven years. Every year the yield of aboveground biomass and SOC concentration after every two years were measured and SOC stock were calculated. Crop-specific C allocation coefficients (Bolinder et al. 2007) based on aboveground biomass yields were used to calculate C inputs. The precipitations and temperatures were monitored using the weather station situated next to the experiment.

During 24 year there were no remarkable changes in average year temperature but there was slight trend of decrease of average annual precipitation. At the same time average temperature from April to end of October tended to increase during study period. There was a negative relationship between temperature and precipitation. Yield of aboveground biomass, C input and SOC stock were positively related and all of them tended to increase during study period. The highest SOC stock change was in treatment with clover-grass mixture (0.43 t ha-1 year-1) and lowest in barley (0.22 t ha-1 year-1) and in grasses (0.21 t ha-1 year-1) treatments. The increase of yield of aboveground biomass and C input was highest in clover-grasses and lower in barley treatment.

The results of this experiment indicate that average annual temperature and precipitation in given region didn't change remarkably during 24 year and didn't describe the changes in yield of aboveground biomass and in SOC stock. The changes could be related to temperature rise during the growing season and a small reduction in precipitation is not limiting. The effect also depended on plant cover.

Measurement and modelling-induced discrepancies in the long-term contribution of root and added biomass to carbon sequestration in a permanent grassland soil

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International efforts focused on environmentally-friendly agricultural production often place a particular emphasis on soil organic carbon (SOC) as it contributes to improved soil health and sustainable development goals. The direct quantification of SOC remains a complicated challenge due to large spatial and temporal variability, as well as sampling-associated errors. Modelling approach can minimize the large-scale variability of SOC and identify whether an ecosystem is either a source or sink of atmospheric CO_2 and its potential to offset greenhouse gas emissions. For a temperate grassland soil, managed with inorganic fertilizer and animal slurry, the SOC density (ρ) and its annual change ($\Delta SOC\rho$) over 45 years simulations using the Denitrification-Decomposition (DNDC95) model were compared with measured values. The measured data for $SOC\rho$ at 0-15 cm depth for unfertilized and urea-fertilized fields (73-77 t-C-ha-1) were significantly higher, relating to a larger contribution from plant roots, than the simulated values (54-55). Despite some variations, $SOC\rho$ was greater with cattle amendments (88-99 vs. 66-116 t-C-ha-1) than with pig slurry (75-78 vs. 55-69). The simulated values correlated significantly well with the measured values (R^2=0.66). The model-estimates revealed increased C sequestration with increasing added-C. Regardless of treatments, the measured and simulated sequestration rate was 0.46±0.06 and 0.37±0.01 t-C-ha-1-yr-1, respectively. The variations in simulated-$SOC\rho$ could be explained by differences in added-C (62%), rainfall (15%) and air temperature (11%). Sensitivity tests demonstrated that $SOC\rho$ increased with increasing bulk density, inherent SOC concentration and clay fraction (R^2 = 0.77-0.99). The $\Delta SOC\rho$ decreased with bulk density and SOC (R^2 = -0.99) and increased with clay fraction and pH (R^2 = 0.89-0.97). These findings imply that a new SOC-equilibrium had not been reached in over 45 years. The DNDC95 could provide an accurate representation of the key drivers but predict smaller contribution of roots to SOC build-up.

Changes of soil organic carbon in paddy soils from sixty-five years fertilization experiments

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Soil organic carbon(SOC) are important for production and quality of rice in paddy soils. Objectives of this study were to assess the changes of soil organic carbon contents during a long-term fertilization experiment on which to base a proper use of fertilizer and soil amendment for a sustainable agriculture in rice production. The changes of organic carbon (SOC) contents in paddy soils (sandy loam) were assessed from data of the 65 years fertilization plots in which the continuous rice cropping experiment started in 1954 at the National Academy of Agricultural Science, Suwon, Korea. The treatments were no fertilization(No fert.), inorganic fertilization (NPK), inorganic fertilizer plus rice straw compost (NPK+C) and inorganic fertilizer plus rice straw compost and silicate fertilizer (NPK+CS). After 33~35 years, SOC content in NPK+C treatment in surface soils (0-15cm) reached at the highest (19 g kg-1), followed by maintaining a plateau level for 8 years. This level was about 1.9 times higher than that (9 g kg-1) of the first 4 years ('54-'57). The SOC content in No fert. and NPK treatments increased steadily to 13 g kg-1, respectively, which were about 1.3 and 1.4 times higher than those of the first 4 years. After 50 years, however, SOC contents in all treatments tended to decrease and reached in 2018 at 10 g kg-1 in no fert., 12 g kg-1 in NPK and 16 g kg-1 in NPK+C and NPK+CS treatments. Continuous application of rice straw compost and silicate fertilizer affected significantly on the levels of SOC in surface soils. The combined applications of inorganic fertilizers with organic compost and silicate are recommended as the best fertilization practice for fertilizer use efficiency and enhancement of soil fertility status in the continuous rice cropping system in Korea.

Relationship between soil microbial diversity and its carbon use efficiency under different land-use in Tanzania

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Microbial carbon use efficiency (CUE) is an important factor to predict the carbon dynamics and future climate change, but its controlling factors are not fully understood. Although soil microbial diversity is considered to affect CUE, there are only a few studies evaluating the relationship between the microbial diversity and CUE. Thus, the objective of this study was to test the hypothesis that "the higher soil microbial diversity, the higher CUE". We collected the surface soils from cropland and forest (F1) with neutral soil pH (6.6-6.8), and also from grassland and forest (F2) with relatively low soil pH (5.7-6.1) in the dry tropical Tanzania, with five replications. We measured soil physico-chemical properties, microbial biomass, and fungi to bacteria ratio (F/B ratio), and conducted the amplicon sequence analysis to know bacterial composition and α-diversity (Shannon index). To evaluate the CUE, we measured hourly microbial respiration rate for 12 hours after glucose application. The microbial biomass was significantly high in F1 and F2, while F/B ratio was not different among the treatments. The bacterial compositions of grassland and F2 were clearly different from that of cropland and F1, and soil pH mainly contributed its difference. The Shannon index of F1 (6.37), F2 (6.32) and grassland (6.33) were significantly higher than that of cropland (5.98). For cropland and F1, the bacterial composition and soil pH were similar, while the bacterial diversity was different. Thus, we compared CUE only for cropland and F1, and CUE was clearly higher in F1 than in cropland, supporting our hypothesis. These results indicate that there was a close relationship between the soil microbial diversity and its CUE in Tanzania.

TeaComposition: Effect of organic matter manipulation on a tea leaf litter decomposition experiment in a deciduous forest

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In June 2016 started an international initiative, the "TeaComposition" experiment, encompassing various ecosystems, covers 570 research areas in nine mainland regions. The aim of the initiative is to investigate the degradation and change of SOM in different climatic conditions using a single protocol and standard leaf-litter (tea leaves). The research area of the Síkfőkút Project also joined the research, taking advantage of the opportunities provided by the DIRT project for the manipulation of organic matter. Two types of tea commodity were used, a green tea (Camellia sinensis) and a roibos shrub (Aspalanthus linearis) leaf filter. The first one is assumes a faster rate of decomposition with high cellulose content, while the second one has a higher lignin content and it is assumes slower decomposition rate. During our investigations, tea filters were placed in the plots of various longtime litter manipulation experiments. According to Tukey test, our results, in the case of the nearly 20-year-old litter manipulation experiments, Double Litter and Control treatments showed significantly higher decomposition rates for both tea types than No Litter. In the more rapidly decomposing tea (green tea), No Roots was also significantly different from No Litter treatments. According to the results of 2016, the average degradation of green tea was 70.26%, while Rooibos tea was 21.56%. One year leaf tea decomposition data showed no significant difference, but the degradation of rooibos tea (27.27%) was stronger than green tea (71.44%).
For soils with balanced moisture and temperature, faster decomposition can be explained by higher activity of the persistent microbial community in contrast to withdrawal treatments where the soil surface is exposed, moisture and temperature conditions change under more extreme conditions.

Dynamics of soil humus formation under different agricultural systems

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Long-term field experiments were conducted at Joniskelis Experimental Station of the Lithuanian Research Centre for Agriculture and Forestry in 2006–2017 on clay loam Endocalcary-Endohypogleyic Cambisol. Organic and mineral fertilisers were applied with the aim to identify the effects of sustainable (S) and organic (O) agricultural systems on humus stability and its composition in soils with low (LH) and moderate humus (MH) content. Investigations were carried out in crop rotation: spring barley (Hordeum vulgare L.) with undercropped red clover (Trifolium pretense L.), red clover, winter wheat (Triticum aestivum L.) with catch crops, and field peas (Pisum sativum L.). Green-manure catch crops were grown during the winter wheat post-harvest period.

During the studies, after the 1st crop rotation, it was established that alternative systems of agriculture, fertilisation and catch crops had a positive influence on humus content in soils with low and medium humus levels. Further research in the 2nd crop rotation revealed a decrease in humus content compared to both the initial data (from 0.01 to 0.15 percentage points) and the humus content after the 1st crop rotation (from 0.05 to 0.27 percentage points). After the 3rd crop rotation, the positive effect of the applied agro-means was revealed, especially that of manure. The mineral fertilisers used in sustainable system of agriculture II were not effective, but the soil was distinguished by a higher organic carbon content in the first and second humic acid fractions compared to organic system I. Statistically significant negative correlations (from r=-0.654 to r=-0.812) were found between soil humus content and hydrothermal coefficient in all agricultural systems in soils with low and moderate humus levels, except LH OI.

Key words: green manure, organic and sustainable agriculture, humus, humic-fulvic acids.

Introducing analytical results database (ARDB): Intuitive database management, data visualisation and quality control

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Analytical Results Database (ArDB) is an intuitive software tool developed by Elementar UK, created to extend the envelope of analytical data analysis beyond simple data processing. ArDB simplifies management and visualisation of data, a particularly critical issue when generating large quantities of data associated with high-resolution and/or high-throughput analysis.

ArDB allows users to construct, maintain and manage their databases of any analytical results, including (but not limited to) results from stable isotope, elemental, and total organic carbon analysis instrumentation. Data can be visualized with 2D & 3D charts and maps, reducing the need to export data to external statistical or GIS software programs. Statistical analyses such as linear discriminant analysis (LDA) and principle component analysis (PCA) are available, e.g. to generate predictive models against which unknown samples can be tested. Compatibility with R ensures further extended statistical analysis is also possible.

Recently, ArDB has been expanded to offer comprehensive quality control (QC) statistics which allows the software to also be used to monitor instrument performance over short and long-time scales. Performance of both internal QC (e.g. instrument tuning, stability, linearity) as well as external QC (analysis of certified reference materials, laboratory standards) are recorded, centralised and monitored so the base performance can be continuously evaluated for multiple instruments across multiple laboratories. Individual QC criteria can be set at an administrator level so that basic operators cannot make unauthorised alterations, ensuring a secure controlled data management environment.

ArDB performs QC statistics calculations using the Shewart Tests, which can be enabled or disabled, allowing consistent testing of all data sets. By being able to scrutinise QC results alongside sample data, the analyst can ensure that only qualified data is accepted for population of databases, and ultimately that data used for the ongoing research themes they are pursuing is demonstrably robust and reliable.

Trialing recycled organics materials (compost) to improve soils in the beef industry – North Coast NSW

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The North Coast region has a subtropical climate and a diversity of soil types. The beef industry is a major contributor to the region's economy and the single largest land use. There a number of circumstances where soils are likely to respond positively to the application of organic material and may potentially improve soil heath and structure by increasing soil organic matter.

This project combines market based analysis of the regional beef industry alongside trialing the application of source separated recycled organics material - compost. This will combine knowledge of the barriers and opportunities to the market for recycled organics with practical demonstrations of benefits of its use. This information will be targeted to expand the engagement of beef farmers to use recycled organics material as an option to improve soil health.

Beef cattle properties with a variety of scale, soil types and pasture species have been selected for the trial. Each property will have a large scale twelve hectare site, with replicated plots comprising of various compost and fertiliser rates. These sites will be part of the operating farm for the duration of the trial and will be managed inline with the current grazing regimes implemented by the land manager.

There is an opportunity for testing and promoting the use of compost in the beef grazing sector, particularly if the emphasis is on complementing existing soil improvement methods. There are a range of practical reasons to promote organic amendments in the beef grazing sector, e.g. to reduce reliance and costs of using ammonium based nitrogen fertilisers for pasture improvement.

The concept of improving soil health for the beef industry is to combine a number of different activities that complement each other to deliver comprehensive practical real world applications, is engaging for the farming community and informed by evidence.

Changes in soil properties and possibilities of reducing environmental risks due to the application of biological activators in conditions of very heavy soils

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This study aims at verifying the effect of farmyard manure (FYM) and of selected agents (Z'fix and NeoSol) on changes of soil properties. Their application should lead to improvement of soil physical properties and of organic matter fixation, to reduction of environmental risks, e.g. of water erosion, of tillage energy requirements, and to enhanced water infiltration. During 2014 – 2018, a field experiment was accomplished in locality Slovec (Czech Republic). The subject of interest was the topsoil (0–30 cm) from soil type Gleyic Phaeozem. Experimental variants (0.7ha each) were as follows: I [FYM]; II [FYM with Z'fix]; III [FYM with Z'fix + NeoSol]; IV [Control NPK only]. FYM was applied at rates: 50 t/ha (2014); 30 t/ha (2016). Additional NPK fertilizer (I–IV) was applied according to annual crop nutrient normative. The agent Z'fix was used as an activator of FYM biological transformation (5.5 kg/t). The agent NeoSol was used as soil activator (200 kg/ha; annually). In order to verify the effect, soil infiltration (circular infiltrometer 0.15m diameter); cone index (registration penetrometer PN-10); bulk density (Kopecky cylinders volume of 100 cm³); tillage implement draft (draught dynamometer with a strain gauge load cell S-38/200 kN) and chemical soil components (Corg, C:N ration and Ntot) were measured annually. Compared to the control, the application of FYM combined with the mentioned agents increased (I–III) soil infiltration by 10–15 %; Corg by 4.5–7.2 % and Ntot from 0.27 to 0.67 %. Moreover, it decreased (I–III) cone index by 13–35 %; bulk density by 5–12 %; tillage implement draft by 4.43–5.25 % (P<0.05) and C:N ratio from 9.15 to 4.50–5.16. The study confirmed that FYM application combined with utilization of activators positively influenced soil fertility and helped to reduce environmental risks. This work has been supported by the Project TH02030169.

Higher depletion of soil carbon stock by liming in maize cropping upland soil

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Liming is a common agricultural practice worldwide, used for increasing productivity in acid agricultural soils. Liming reduces Al saturation and toxicity and/or increase pH up to values where the availability of nutrients is higher. The effort of this practice on soil properties has been extensively studied. However, liming also increase the soil biological activity, thus favoring the mineralization of organic matter, which should result in carbon dioxide (CO_2) losses and a decrease of the soil organic carbon stock. From liming soil, CO_2 gas was not only emitted, but also nitrous oxide (N_2O) and methane (CH_4). These factors could be calculated as net GWP value. However, the effect of liming on net GWP in temperate upland soil was poorly unknown. In this two-year field studies, to evaluate the effect of liming on net GWP, different levels (0,2 Mg/ha/yr) of lime were consecutively applied in a temperate upland soil before maize cultivation, and soil carbon (C) balance was analyzed using the net ecosystem C budget (NECB). The net primary production (NPP) of cash crop, weed and amendment C were considered as C input sources, and the respired C loss (CO_2 - C, CH_4 - C) and harvested C removal were included in C output source. Each net GWP factors are calculated as fallow as "net GWP (kg CO_2-eq. ha-1) = 28 x CH_4 flux (kg ha-1) + 265 x N_2O flux (kg ha-1) – NECB x 44/12". Total CH_4 fluxes were not specific trend between lime application levels and years. however, total N_2O fluxes were increased by liming. NECB value were decreased with liming application level. Net GWP was increased with increasing liming application level, mainly due to increased N_2O flux. However, CH_4's portion was ignorable (12~24%). The largest portion was N_2O's portion (75~88%).

Impact of land use on soil organic carbon stock in gibbsic ferralsols of Maré, Loyalty Island (New Caledonia)

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The Loyalty Islands, part of the French Archipelago of New Caledonia, are old raised coral atolls on which soils develop from pumice and volcanic ashes. These soils have a very high content of organic matter ('humic') but they are very thin, i.e., less than 50 cm-depth in average. Because of the absence of clay minerals in these soils, the organic matter plays a very important role on the soil fertility and on the quality of the freshwater lens, which is the main source of freshwater on these islands. Historically, local people have practiced slash-and-burn agriculture; several years of cultivation were followed by a fallow for which the duration could be as long as thirty years. Because of the evolution of economic and social models, the length of the fallow tends to decrease. Moreover, the development of perennial cropping systems is funded to generate revenues from the agricultural sector. We assessed the impact of land use changes on soil carbon storage by evaluating the amount of soil organic carbon (SOC) stored in the first 30 cm of Gibbsic Ferralsols occupied by forest, of a fallow of traditional farming or of Avocado orchard. SOC stocks are high, ranging between 69.5 tC.ha-1 and 170.2 tC.ha-1. However, mean SOC stocks in Avocado orchard were significantly lower, i.e., 106.0±29.0 tC.ha-1 than those of fallow and forest, i.e., 127.5±23.7 tC.ha-1 and 121.9±23.0 tC.ha-1, respectively. Even if the perennial agricultural systems are not intensive on these islands, they impact more soil organic carbon content than traditional farming. Consequently, they could endanger soil health, food security, as well as the freshwater lens quality. Moreover, even if The Loyalty Islands are small territories, the degradation of their soils could release high quantities of CO_2 in the atmosphere, whereas New Caledonia emits already as much CO_2 per capita as USA.

Arsenic mitigation and Soil health improvement by using Biochar as a organic amendment

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Abstract

The research area was selected Faridpur Sadar sub-district of Bangladesh. This area belongs to the agro-ecological zone (AEZ 12) namely Low Gangas River Floodplain (between 23o29' and 23o44' latitude and 89o 41' and 89o 56' Longitude). Arsenic contamination in crop lands has been a serious concern because of its high health risk through soil-food chain transfer. Arsenic (As) concentrations in soil, plant tissues and grain were evaluated in a field experiment following the transplantation of lentil (Lens culinaris)   heavily As contaminated soil in Faridpur district of Bangladesh (38.2 ppm total As) receiving an rice husk biochar amendment, with all fertilizer and intercultural activities. A close investigation was also performed to established lentil seeds were able to germinate in various proportions of biochar added. Biochar significantly reduced As concentrations from root, shoot and grain of lentil compared to the control treatment (without biochar). Grain As concentrations were very low (155 ppb in 10 t ha-1 biochar) indicating minimal toxicity and transfer risk and highest As concentration observed in control (396 ppb in 0 t ha-1 biochar). Grain yield was significantly higher (1574 kg ha-1) for lentil fertilized with 10 t ha-1 biochar compared with others, whereas control treatment had the lowest grain yield (1179 kg ha-1 in control where biochar is 0 t ha-1) . Application of biochar increased soil organic matter as well as improved soil nutrients content such as Ca, K, Mg and S. The highest organic matter was found in treated with 10 t ha-1 biochar and the lowest was observed in treated with control treatment. Application of biochar also increased soil nutrients content in the soil. Similar trend was found in case of Ca, K, Mg and S nutrients.

Examining correlations between organic carbon chemistry and δ15N abundance in soils across an aridity gradient.

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Storage of carbon and nitrogen (collectively soil organic matter; SOM) in soil is heavily influenced by climate change. Generally, more SOM is stored in soils due to greater inputs by plants in areas with higher rainfall. Organic nitrogen however, is mineralised by microbes into the more accessible nitrate which would show a tendency to leach out of soil in high rainfall. The effects of moisture changes on soil organic C and N across a 900 km aridity gradient in South Australia was examined. This transect was established under the Terrestrial Ecosystem Research Network (TERN) and our aim was to understand the transformations of soil organic C and N within it. Samples were collected from 42 long-term monitoring sites following the mainland portion of the Adelaide geosyncline, from the Fleurieu Peninsula in the south to Murnpeowie Station in the north. The sampling was carried out in the 2016 Austral autumn, comprising a composite of 20 individual surface soil samples from within a 25×25 m plot established at the corner of each site. Soil organic matter chemistry was quantified by 13C-CP/MAS NMR and δ15N was measured by EA-IRMS. The alkyl/o-alkyl (A/OA) ratio derived from NMR measurements is a measure of how much SOM is turned over or decomposed. The A/OA ratio was weakly positively correlated with aridity (R^2 = 0.148), whereas δ15N showed a much stronger relationship (R^2 = 0.515). Taken together, these data indicate greater cycling of SOM and fewer fresh inputs as aridity increases.

Changes in SOC content in a long term field experiment with different N rates

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There are numerous findings about the influence of mineral nitrogen fertilizer on SOC content. Results have not been consistent. Some authors report positive effects, however, some papers have shown a negative influence of nitrogen fertilization on total SOC content. Positive correlations are observed in semi arid, dry land areas in USA (Colorado and in Oklahoma). On the other hand, some scientists observed negative correlation after analyses of numerous long term cropping experiments. In addition, there are some results that conclude there is no influence of N fertilization on SOC. In our research with different amounts of mineral nitrogen (0 do 300 kg N ha-1) that was conducted on experimental field located within drained cropland in Western Pannonian subregion of Croatia, Europe (45°33′N, 16°31′E) we have found positive influence of nitrogen fertilization on SOC content. The soil type of trial site is drained distric Stagnosols. Objective of our work was to determine the effect of different nitrogen fertilization levels on changes in some soil chemical properties (pH, total N and SOC content). Soil sampling was carried out in 2010, 15 years later from the establishment of research field. Trial treatments included annual fertilization with different mineral nitrogen rates, respectively with 0, 100, 150, 200, 250 and 300 kg Nha-1. SOC and total nitrogen contents were determined by dry combustion method. SOC content in soil was in a range from 0.59-1.21 % in samples taken from treatments without applied nitrogen. In a treatment with 100 kg N ha-1 SOC content varied between 0.67 – 1.14 %. Increased rates of nitrogen increased SOC content up to maximum levels obtained in treatment with 300 kg of nitrogen – ranging between 1.00 – 2.14 %. Increased nitrogen rates caused decrease of soil pH and increase of TN content.

Soil type and residue incorporation (tillage) affects the climate change mitigation potential of grassland soils.

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Soil organic matter (SOM), the largest terrestrial carbon (C) pool, is fundamental to soil and ecosystem functions across a wide range of scales, from site-specific soil fertility and water holding capacity to global biogeochemical processes that influence carbon-climate feedbacks. Although management practices such as crop residue retention and organic amendments result in SOM accrual, their contribution to mitigating climate change may be offset by increased greenhouse gas (GHG) emissions, particularly in finer textured soils due to enhanced microbial activity. Understanding the balance between 'new' SOM from residue inputs and how this interacts with native SOC and GHG fluxes is critical to assessing the effectiveness of land management practices as a climate change mitigation strategy. We tracked the fate of above-ground residues into functionally different SOM pools (persistent mineral-associated OM versus unprotected OM) and GHG fluxes using isotopically labelled residues (13C and 15N) over 12 months in a pasture soil in sub-tropical Australia. Residues were placed on three different soil types with varying texture and mineralogy within close proximity (< 2 km2) to each other. Residue management was simulated by either placing residue on the soil surface (i.e., no tillage) or incorporating it with the top 10 cm of soil (i.e., tillage). Soils with greater clay content resulted in a greater amount of SOM formation in more persistent mineral-associated SOM fractions. However, the greater SOC accrual in finer textured soils was offset by C priming of native SOC, resulting in a net C source. The incorporation of residue resulted in ~ 4 to 5 fold increase in SOC formation, highlighting that no-till systems might not always promote C sequestration. Overall results demonstrate the need to consider both soil properties and residue management as they affect the climate change mitigation potential of residue amendment to a grassland soil.

Impact of irrigation on soil carbon and nitrogen stocks

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Irrigation in New Zealand has increased rapidly in recent decades, yet there is surprisingly little known about the impact of irrigation on soil carbon (C) and nitrogen (N) stocks. Processes affecting both C and N inputs and outputs are altered by irrigation and therefore it is not easy to predict the net effect on soil C and N stocks and direct measurements are needed. A recent study revealed that on average irrigated pastoral soils from 30 sites across New Zealand had significantly less C and N than adjacent unirrigated pastures, with differences of 7 t C ha–1 and 0.6 t N ha–1 in the uppermost 0.3 m. Causes for these differences in C and N stocks are not well understood, but could have important implications for national carbon budgets and soil quality. Subsequently, we have sampled an additional 70 paired sites to determine whether the impact of irrigation on soil C and N differs by region, soil type and irrigation duration. Initial results from a directly aligned MSc student project focusing on Pumice Soils in the Reporoa Basin are consistent with the previous study, with less C in the irrigated compared to the unirrigated soils. Soil samples from paired sites in Hawkes Bay, Wairarapa, Canterbury and Otago are currently being analysed for total C and N and results from the full set of 100 paired sites (sampled to ≥0.3 m depth) will be presented. For a subset of paired sites we are also investigating what pools of C and N differ, rates of C and N cycling, the sensitivity of respiration to temperature and microbial community composition. Our ultimate aim is to identify where and how irrigation can be used to maintain, or increase soil organic matter and the multiple associated benefits.

Nutrient availability drives carbon storage in particulate vs. mineral-associated organic matter in Antarctic soils

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Although low in total carbon, Antarctica with its pristine soils offers unique model systems to study soil organic matter cycling unbiased by high carbon inputs of vascular plants or anthropogenic disturbance. Furthermore, seabird rookeries with locally restricted high inputs of marine derived bioavailable C, N and P create natural gradients affecting vegetation distribution and productivity. Deception Island situated at the Antarctic Peninsula offers a unique setting with very young soils due to volcanic eruptions between 1968 and 70. This allows to study soil organic matter accrual, distribution and composition in newly developing soils in relation to soil nutrient availability. To this end we sampled three spatially separated sites on Deception Island distributed along a transect from higher to lower marine nutrient inputs, respectively. At the sampling sites patches below living and dead moss were sampled, to account for possible future effects on plant coverage by a changing climate. Besides bulk soil C, N, pH and EC analysis, we fractionated the top soils according to density and particle size, analysed the C and N contents of all fractions and the POM and clay fraction by 13C-CPMAS-NMR spectroscopy. Beside the clear local effect of the input of C, N and P by seabirds, we were able to also demonstrate distinct effects of dead moss cover on soil organic matter stocks, in which the dying of vegetation promotes increased soil C contents in sites with high primary productivity. Our results evidence that different nutrient availability lead to a clear shift in the dominating C pools from mineral-associated to particulate organic matter. The chemical composition of the input material is not reflected by mineral-associated organic matter in the clay fractions, indicating the microbial transformation prior to association with mineral surfaces.

Evaluation of decay rate when reed reduction(Phragmites communis Trin.) for organic matter improvement in Saemangeum reclaimed land

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Reclaimed land requires organic matter management because there is only one-tenth organic matter content compared with conventional soil. Common reed (Phragmites communis Trin.) is widespread at reclaimed land in Korea. Because common reed has high biomass, it has potential as a source of organic matter in reclaimed land.
The objective of this study was to evaluate characteristics of common reed decay by incorporation in reclaimed land soil. Common reed was exposed in mesh bags (25 x 30cm) at five sites (low salinity topsoil, subsoil, high salinity topsoil, subsoil, paddy topsoil) during 70 days. After 70 days, common reed has lost 11~30% of original dry weight, depending on salinity level and soil depth. Nutrient concentrations (C, N, P, K, Ca, Mg, Na) increased subsequently until the end of the study period. Low salinity topsoi treatments the lowest C/N ratio during 70 days. Our results suggest that it is necessary to observe the correlation common reed decay rate and soil organic matter content

Bioclimatic factors associated with soil organic carbon accrual in subtropical Indo-gangetic croplands of Nepal

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Southern Terai plains of Nepal, most productive land, represents 4% area (0.5 million ha) of the Indo-gangetic plains and 21% area of Nepal is at the threat of Soil Organic Carbon (SOC) decline. SOC accrual primarily depends upon temperature and precipitation which are the key drivers of SOC spatial variation. So, we aimed to study the degree of relationship between SOC and bioclimatic factors in the region. Soil organic matter (%) of 0-30 cm depth from 13,287 observations was retrieved from national land use planning project. Nineteen bioclimatic variables (eight precipitation and eleven temperatures variables) were taken from worldclim dataset version 2.0. Primary components of the variables were identified by principal component analysis (PCA) and the contribution of variables in the PCs using factor analysis along with covariance of OC (Cov.(OC,y)) with other variables was calculated. The minimum, maximum, average, and coefficient of variation of SOC content of the region was 0.005, 6.88, 1.04, and 61.7% respectively. There is significant (p-value = 0.013) reduction in SOC values from Western to Eastern (negatively correlated with longitude, r = -0.021) region. Among the 19 bioclimatic factors 70% of variation is explained in PC1 and PC2 with the most factor loading on precipitation of the wettest month, precipitation of the wettest quarter, annual precipitation, precipitation of the warmest quarter, longitude. Covariance analysis suggested SOC change primarily depend upon the precipitation related bioclimatic factors like precipitation of the wettest month (Cov.=0.21), precipitation of the wettest quarter (Cov.=0.20) and annual precipitation (Cov.=0.19), and precipitation of warmest quarter (Cov.=0.18) rather temperature related bioclimatic factors such as Isothermality (Cov.=0.009), temperature seasonality (Cov.=-0.01), mean temperature of wettest quarter (Cov.=0.01), and mean temperature of warmest quarter (Cov.=0.02) So, the longitudinal gradient, seasonality and distribution of precipitation pattern greatly affected the SOC accrual in the southern IG plains of Nepal.

Simulation in the changes in soil C and N stocks with the use and cover in a transitional Amazonian-Cerrado forest environment

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The increase in global food demand together with climate change require sustainable agriculture that adopts practices to maximise productivity and minimise damage to the environment by CO2 emissions, favouring stocks of soil organic matter (SOM). Over the last 30 years, the transition environments of the Amazon-Cerrado Forest in the eastern Brazilian Amazon, has seen the removal of approximately 32.3 thousand ha of native vegetation, while areas of pasture have increased by 30 thousand ha. The aim of this study was to evaluate the impact of converting forests to pasture on C and N stocks in transition environments, as well as the effects of different management practices on the sequestration of atmospheric CO2. The changes were simulated for the 0-20 cm layer using the Century model v 4.0, with adjustments to determine the parameters of biomass production. Simulated stocks of steady state SOM C and N under native vegetation were used to adjust the deforestation model and the subsequent establishment of pasture. Eight future production scenarios were simulated for 2050 and compared to the current situation of the lack of management practices (M), namely: M1: pasture managed without periodic renewal; M2: pasture with chemical control of spontaneous species; M3: pasture with top dressing only; M4: pasture with top dressing and maintenance fertiliser; M5: pasture with top dressing and maintenance fertiliser together with the chemical control of spontaneous species; M6: silvopastoral system with 30% tree cover; M7: pasture managed through the use of fire; and M8: grazing under intensive management. Except for M4, M5 and M8, all the other scenarios promoted an increase in the stocks of C and N in relation to the current situation of pasture management. The silvopastoral systems, irrespective of soil type, showed greater potential for maximising the sequestration of atmospheric C.

What change does the quantity of root mass and seasonality make to soil organic carbon?

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In recent years, considerable research interest has focused on soil carbon (C), particularly with respect to the potential for soils to store additional C in the context of climate change mitigation. To fully understand this potential it is necessary to determine the contribution and stability of C from the various sources. Roots and exudates have received little attention with regard to their contribution to the soil organic C pool.

We aimed to determine the contribution of 'new' C inputs from the root system and their stability down the soil profile across multiple growth and decomposition phases. Specifically, our objectives were to investigate 1) whether the amount of 'new' C reflects the amount of root biomass found across the depths, and 2) if multiple growth and decomposition phase's results in an accumulation of 'new' C.

Rhodes grass (Chloris gayana), was grown in a pot experiment using a soil with a history of C3 plant growth. The study ran for two seasons, with each season consisting of a growth phase and decomposition phase of three months. The above-ground biomass was removed at the end of the growth phase. After each phase a 10 pot subset was destructively harvested for soil and root analysis, at four depths. Isotope Ratio Mass Spectrometry (IRMS) δ13C analysis of soil and roots was used to determine the distribution of 'new' C inputs through the soil profile and between treatment phases.

The results showed that even though the upper depth had approximately double the root mass compared to all other depths, there was no significant difference in the soil δ13C. The relationship between soil δ13C and treatment phase was unexpected, particularly in the second growth phase where the soil became depleted of 13C despite the 'new' C inputs from the C4 plants.

N and P co-limitation of carbon turnover in a clayey loam very deep subsoil

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The growth of deep-rooted crops within agricultural soils has the potential to increase carbon deposition within deep subsoil layers potentially mitigating climate change. The growth of these deep-rooted crops and subsequent availability of both labile C substrates and nutrients such as nitrogen (N), phosphorus (P), and/or sulfur (S) have the potential to influence both C turnover and stability within deep subsoil layers. The present study utilized intact soil samples obtained from 5-6 m to study the effects of nutrient limitations for microbial C turnover when glucose or an artificial root exudate (ARE) mixture, and supplementary nutrients (N-P-S) were introduced as different treatments to deep subsoil samples during a 10-week incubation study. Our results document that C substrates alone are not the only drivers in C turnover, although significant differences between the addition of only C substrates were documented with the addition of only glucose compared to the addition of the ARE mixture. Such differences were interpreted as a partial alleviation of the N limitation due to the N-containing amino acid, L-arginine within the ARE mixture, but differences are also a likely a response to the diversity of compounds within the ARE mixture. Furthermore, we found potential effects of a co-limitation of N and P on C turnover in these deep subsoil samples to depths of 5-6 m, far exceeding depths from previous studies. As such, based on the co-limitation of N and P as observed within this study, it is important to know the N and P status of subsoils to predict the fate of organic C in deep soils as the production of microbial residues is based on the coupling of these nutrients to meet the stoichiometric microbial demand. Hence, managements removing such limitations could facilitate the stability and long-term storage of C in deep subsoil.

Temperature sensitivity of soil organic carbon decomposition and priming across a productivity gradient in Australian eucalypt forests

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Understanding temperature sensitivity of soil organic carbon (SOC) decomposition in relationship to substrate availability and priming effects is critical for predicting climate-carbon feedbacks. Here, thermal response of SOC decomposition and substrate-induced priming were investigated using 13C-labeled Eucalyptus leaf litter for surface soils sampled in six eucalypt forests and woodlands across the Southeast Australian Temperate Transect (SATT). The selected sites belong to the Australian Terrestrial Ecology Research Network and form a gradient of increasing productivity with mean annual precipitation increasing from 300 to >1000 mm. The priming effect was computed from respired CO_2 flux and associated $\delta 13C$, which were measured for 3 weeks in laboratory microcosms at incubation temperatures of 5, 15, and 25°C. Litter addition resulted in stimulation of total soil CO_2 flux as substrate-induced respiration (SIR) for all forest soils, but the magnitude of the SIR was dependent on substrate availability across the sites, indicating SIR was higher at the sites with lower productivity. Addition of fresh litter significantly decreased temperature sensitivity (Q_{10}) of SOC decomposition due to the negative correlation between Q_{10} and carbon quality. The Q_{10} of litter C was lower than that of SOC suggesting that soil C is relatively more vulnerable to climate warming, potentially due to its greater complexity. On the other hand, the priming effect of litter substrate on SOC decomposition was negative and more pronounced at higher temperature, indicating reduced SOC loss with warming in the presence of fresh litter. Our results demonstrate that temperature sensitivity of SOC decomposition was lower and (negative) priming was greater at the sites with more SOC across the SATT productivity gradient. These results suggest potential substrate-dependent mechanisms that may enhance SOC stabilization in future climates.

Soil properties predict greenhouse gas fluxes and their temperature sensitivities in three land-cover types near Sydney, Australia

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Greenhouse gas (GHG) fluxes from soils play crucial roles in regulating the Earth's surface temperature. However, our understanding of the effect of land-cover and soil depth on the potential GHG fluxes and their temperature sensitivities (Q10) is limited, which consequently increases the uncertainty to predict GHG exchange between soils and the atmosphere. Here we present an incubation study of soils with contrasting characteristics from three land-cover types (wetland, grassland, and forest) and soil depths (0–10, 10–20, and 20–30 cm) from the Cumberland Plain near Sydney, Australia. Overall, potential GHG fluxes and their Q10 values differed significantly among land-cover types and soil depths. CO2 and N2O emissions were highest in wetland followed by grassland and forest soils, and they decreased with soil depth. In contrast, CH4 uptake was highest in grassland followed by forest and wetland soils, and it increased with soil depth. Combining the three major GHGs, the global warming potential in wetland was higher than that in grassland and forest. Moreover, Q10 values of CO2 and N2O emissions were highest in wetland and lowest in forest, while Q10 value of CH4 uptake showed the opposite pattern. Q10 values of GHG fluxes all increased with soil depth. Across different land-cover types and soil depths, GHG flux rates were controlled by substrate quantity and quality; Q10 values of CO2 and N2O were controlled by soil texture, while substrate quantity and quality affected Q10 value of CH4. These results suggest that the large carbon stocks in wetland soils are vulnerable to loss and thus may amplify climate warming; upland soils are crucial CH4 sinks and thus potentially mitigate climate change. In addition, the greater temperature sensitivities of potential GHG fluxes in subsoil should be accounted for in carbon and nitrogen cycling models.

Impacts of aridity on soil organic matter and microbial communities using phospholipid fatty acid techniques

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Recent work has clearly established that by looking at the dynamic of climate change, climate gradients, and the vegetation community structure, there are multiple and interactive impacts on Soil Organic Matter (SOM) and the microbial communities living within it. This study examined soil samples taken from 42 sites within a transect that was established under the Terrestrial Ecosystem Research Network (TERN) that runs for 900 km from Cape Jervis in the south to north of the Flinders Ranges in central South Australia. Microbial communities were analysed for community structure using PLFA analysis to provide robust information on functional microbial community structure at time of sampling. Beyond microbial measurements, comprehensive analysis of soil biogeochemistry including litter and soil organic matter chemistry by NMR was conducted. Combined with vegetation community structure and climatic information, this data was then analysed to understand the strengths of relationships between vegetation, climatic, soil and microbial variability along the transect. Litter was more degraded with an increase in rainfall, therefore climate is a major driver and has a significant relationship with litter alkyl/O-alkyl (A/OA) ratio (r = 0.436, P = 0.039). There was also a significant relationship between litter and SOM chemistry (Litter x SOM) (ρ = 0.224, P =0.014) showing a statistically significant relationship between both. In examining relationships between all the variables and the PLFA data, SOM chemistry was most closely related (ρ = 0.447). Further integration of NMR and PLFA data will allow us to link the microbial communities to climate and SOM.

Evaluation of soil organic matter stability by Rock-Eval pyrolysis - Influence of organic content and texture on measured parameters

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Rock-Eval pyrolysis is a powerful technique developed for the rapid characterization of sedimentary organic matter (OM), based on its thermal reactivity. Originally designed for the study of petroleum rocks, Rock-Eval is increasingly used for soil OM characterization and more recently to assess its stability. The thermal reactivity of OM evaluated by Rock-Eval analysis could be influenced by its chemical composition, but also by interaction with minerals. It is thus necessary to take into account the soil characteristics to establish the potential of the Rock-Eval analysis to diagnose the thermal stability of soil OM in relation to their level of biodegradability and therefore their biological sensitivity. To this end, we have selected surface soil samples from the French national network for the long term monitoring of forest ecosystems. The selection comprises on the one hand, soil samples with similar amount of organic carbon content but with contrasting texture (sandy vs clayey), and on the other hand, samples exhibiting similar texture but differing in TOC content. Due to the higher level of chemical functions in soil OM with respect to sedimentary OM, the Rock-Eval parameters must be optimized. The effect of different heating rates and starting temperatures in Rock-Eval analysis on the commonly measured parameters (total organic carbon, hydrogen index and oxygen index) was first evaluated. Taken together, these analyses aimed at evaluating the influence of i) OM content, ii) texture and iii) forest litter chemical composition on Rock-Eval measured parameters and at providing a reliable protocol for soil OM analysis. Finally, in parallel to Rock-Eval pyrolysis, the released effluents have been directly characterized by GC /MS in an attempt to relate the Rock-Eval parameters to the molecular composition of the pyrolysed soil OM.

Carbon dynamics in soils: Evolution of organo-mineral interactions after a forest to vineyard transition

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Organo-mineral interactions are known to play a key role in stabilizing organic matter (OM) in soils because bonds between organic compounds and mineral surfaces minimize microbial degradation of organic compounds. A better understanding of the mechanisms that control the OM stabilization is therefore necessary, especially of those responsible for the destabilization of the nano-organo-mineral complexes following a forest to crop transition. Indeed, it is assumed that the mineral surfaces are not stable in time, but subject to weathering that leads to the formation of organo-mineral nano-complexes, called " Short Range Order minerals- Organic Matter" (SRO-OM) here after. The hypothesis is that most of the stabilized soil organic matter are consist int these complexes. The idea is to show that the latter are destabilized by a land use change.

In that frame, a pair site approach consisting in two adjacent plots with different land uses, forest and vineyard respectively, was chosen. Poorly differentiated soils on granite were sampled at Plan de la Tour (83), in the Maures Massif (France). The two plots are located on the same agricultural terrace. Analyses of aerial photos and cadastral data shows that these two plots have experience the same land use for at least 100 years. Two soil profiles, 15 m apart, were described and sampled on pit. Chemical, particle-size distribution and mineralogical characterizations were performed to determine the degree of similarity of the two soils. The distribution of organic carbon contents and stocks in soils is highly contrasted between the two land uses. A tangential filtration physical fractionation method allowed to isolate the SRO-OM in the 10kDa - 200 nm size ranges of some horizons in order to understand if the differences in organic carbon contents and stocks observed in both profiles were related to differences in nature or quantity in these SRO-OM.

The hydrophobicity characteristics and IR spectra of tropical peat soil: Case study of land use change in ex mega rice project Kalimantan

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The over drainage due big canals, deforestation and land use change in Kalimantan peatland when Mega Rice Project (MRP) starts caused environmental problems, especially fires and decreased quality of peat soils. The increase of hydrophobicity or irreversible drying is one indicator of the decline in the quality of peat soils. It's found in degraded and burned peatlands. This study aims to study the effect of land use change on FTIR spectra and its relation to the hydrophobicity of peat soil. Surface soil samples of peat soil were taken from the Mentangai Central Kalimantan region (Block A Ex-MRP Project) with different land uses (secondary forest, burnt, oil palm, and revegetation area), to determine C-organic contents, FTIR spectra and hydrophobicity. The results showed that there were differences in percent of C-aliphatic area and hydrophobicity index between each land use. The parameters of the hydrophobicity index can be used to evaluate the quality of peat soil in relation to land use changes.

Nitrogen mineralization related to light-fraction and hot-water extractable carbon in pasture and cropping soils.

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Nitrogen mineralization is an essential part of the soil nitrogen cycle, and solid knowledge of mineralization rates is crucial to optimize fertilizer application levels and avoid reactive nitrogen loading into the environment. However, mineralization rates will depend on climate- as well as management factors; most notably temperature, moisture levels and SOM contents. Here, we assessed the rate of nitrogen mineralization in soils of differing properties and land use in Southeast Australia and related these to the soils' organic matter content through light fraction separation (LFOM) and hot-water extraction (HWC). Soil (0-100mm) was collected from 10 pasture- and 6 continuous cropping systems, with pastures grazed by dairy cows, and cropping systems consisting of 2:1 wheat and canola rotation. Rates of net mineralization were measured at three temperature (10, 20, 30°C) and three moisture levels (air dry, FC, 150% FC), after 14- and 28 days of aerobic incubation. Sampling was conducted at three times over the course of a year to incorporate seasonal differences. Preliminary results indicate soil moisture as the main limiting factor of nitrogen mineralization, with significantly higher mineralization rates in the group of pasture soils at higher levels of moisture conditions. At 150% FC, variation between soils increased for both groups, which is attributed to transient waterlogging conditions. The obtained mineralization rates are to be further correlated to LFOM and HWC.

Corncob-derived low-pyrolysis temperature biochar protects soil organic (C) and improves C use efficiency and soil quality of semi-arid climate alkaline soil

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Biochar is a carbon rich product derived from pyrolysis of organic material which improves soil biogeochemical properties and crop production. This incubation study investigated the effects of corncob-derived biochar on native and fresh organic matter (corncob residue) decomposition in nutrient poor Aridisol. The surface soil (0-15 cm layer; <0.1% organic matter) used in the experiment was collected form an agricultural field under wheat cultivation. The treatments included: 1) unamended control, 2) residue (2% w/w), 3) biochar (2% w/w), and 4) residue + biochar (1% each, w/w). Rate of biochar and corncob residue application either alone or combined was equivalent to 45 tons/ha. Each treatment was replicated four times and microcosms were incubated in an incubator following completely randomized design (CRD) at 70% water holding capacity and 25 °C for 54 days. Soil C mineralization was quantified by measuring soil respiration. At the end of the experiment, soil samples were analyzed for soil C and N mineralization indicators, and some physico-chemical properties. Biochar reduced decomposition of fresh organic matter and decreased cumulative respiration by inducing negative priming effect. Decrease in C mineralization in biochar amended soil could be due to the strong adsorption of soluble soil C, nutrients and microbes on the surface of biochar resulting in enhanced C use efficiency and reduction in activity of C mineralization enzymes. Another mechanism for the reduced rate of C mineralization could be CO_2 adsorption on biochar surface as carbonate. The decrease in mineral N after biochar incorporation could indicate that organic N was assimilated into microbial biomass rather than being mineralized. In conclusion, biochar could decrease C mineralization but enhanced microbial C use efficiency. It, therefore, offers an important management strategy to improve C sequestration in nutrient and organic C deficient alkaline soil by altering mineral associated & particulate organic matter.

Microhabitat-associated hot spots and hot moments of nitrous oxide emissions (N2O) from floodplain soils

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The relative effects of soil aggregation, plant-soil-earthworm interactions and litter accumulation on the emissions of nitrous oxide (N_2O) from floodplain soils were investigated in a restored section of the Thur River (NE Switzerland). We carried out a manipulation experiment in a frequently flooded and by Phalaris arundinacea dominated zone with loamy sand by comparing separated treatment plots: (i) control, (ii) vegetaton free, (iii) reduced earthworm population, (iv) combination of (ii) and (iii). In the laboratory we performed a flooding experiment in mesocosms using silty-loamy soil from the Thur floodplains, applying the following treatments: (i) soil 250µm-4mm, (ii) (i) planted with salix viminalis, (iii) (i) mixed with willow leaves, (iv) to (vi) as (i) bis (iii) but soil < 250µm. In the laboratory experiment, the emission of N_2O during the hot moments after flooding was reduced in the planted treatment, very likely due to aeration of the rhizosphere via aerenchyma. In the field experiment, the vegetated plots emitted more N_2O under moist conditions and the hot moments after flooding occurred for a longer period. In this case, probably stimulation of microbial activity by root exudation is the dominant rhizosphere effect. Under dry conditions, the additional drying effect due to plant water uptake leads to lower N_2O emissions from plots with vegetation. According to the laboratory experiment, the formation of large aggregates increases the intensity of the hot moments during the drying phase after a flood probably due to the development of good conditions for coupled nitrification – denitrification. A local increase in litter-associated C availability appears to lead to a further increase of N^2O production only under concurrent protection in large aggregates. Temporary lower emissions from field plots with earthworms suggest that in sandy soils the aeration effect of earthworm activity is larger than the one on aggregate formation.

Acceleration in N cycling controlled by aggregate size, moisture, substrate quality and phosphorus fertilization in floodplain soil

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Semi-terrestrial soils, such as floodplain soils, undergo a characteristic changes in their physico-chemical environment which is generally conducive for nitrous oxide (N_2O) production. Being hotspots of N_2O emissions, the floodplain soils can become an important source of terrestrial N_2O flux. Processes of nitrogen (N) cycling are strongly influenced by the availability of water, oxygen and substrate, and these processes may differ between small and large aggregate. We performed a microcosm incubation experiment using soil from restored floodplain section of the Thur River in NE Switzerland to investigate the effects of aggregate size, moisture, carbon (C) sources and phosphorus (P) fertilization on N cycling. Experiment included aggregate size (<250 μm; 250 μm - 4.00 mm), moisture level (60% WHC; submerged conditions), C source (glucose; litter; litter-derived DOC) and P as experimental factors. Head space gas samples were collected for N_2O gaseous analysis and flux calculation. After 28 days incubation, the soil samples were analysed for N species (KCl-extractable NH_4-N, NO_3-N, dissolved organic N total N, water-extractable total N), water-extractable organic C, microbial biomass N, leucine aminopeptidase activity (LEU), denitrification enzymatic activity (DEA), bacterial abundance (16S-qPCR), fungal abundace (ITS- qPCR) and some N cycling pathway functional genes (nirS, nosZ & nxrB). We found strong effects of experimental factors on N cycling processes. N_2O flux was generally higher in larger aggregates and soil treated with litter-derived DOC and after P addition. Mineral N concentrations were many-fold higher for litter-derived DOC and litter treated soil amended with P under submerged conditions. Dissolved organic N varied dramatically between the treatments. LEU activity was significantly higher in soil treated with litter and P in smaller aggregates. Bacterial and fungal diversity and functional gene abundance varied significantly among the treatments. Results suggested that strong heterogeneity in environmental factors could control hotspots and hot moments of N cycling.

Farmers, advisers and researchers' perceptions of soil organic matter

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There are many different actors (farmers, agronomists, consultants, industry representatives and researchers) influencing management decisions that underpin soil organic matter (SOM) levels and soil health. In 2018, three independent surveys were undertaken as part of the CRC for High Performance Soils (Soil CRC) that were individually focused on issues of: identifying grower perceptions on soil constraints to their farming system; perceptions of advisers and key industry personnel to soil constraints and production, and what data, information, tools and methods (indicators) are being used and collected by farmers, advisers and researchers. Survey 1 (Parsons et al., 2018) involved 111 participants from 19 grower groups (five states). Survey 2 (Orgill et al., 2018) included 135 respondents (advisers) of which 96 estimated that they were working with over 3,275 clients in 6 states. Survey 3 (Dahlhaus et al., 2018) attracted 122 respondents with farmers (38%), advisers (30%) and researchers (16%) being the major response groups of this survey. Survey 1 identified that over 50% of participants soil tested every 3-5 years and that organic matter (carbon) was the third most tested analyte at nearly 80% (only pH and available phosphorus were higher). Advisers in Survey 2 listed up to six constraints of greatest concern to their client, with low organic matter rated overall as having a very high priority (only acidity and nutrient decline/deficiency rated higher). Perceptions of the use of SOM to judge soil performance varied between farmers, advisers and researchers, with advisers less inclined than farmers and researchers to use organic matter in assessment of soil performance. 53% of respondents in Survey 3 used SOM observations on an annual basis or more frequent interval, as compared to soil moisture (70%), waterlogging and drainage (59%) respectively. The surveys collectively demonstrate similar sentiment on the importance of SOM for improved management decision making.

Links between soil carbon sequestration, root elongation rate and functional traits in 12 herbaceous species

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Infrastructures are increasing rapidly, and soils are excavated, and then abandoned or revegetated. With the right type of vegetation, these soils could provide several ecosystem services, such as carbon (C) sequestration, reduced erosion rates and enhanced biodiversity. We investigated C sequestration in soil sown with 12 herbaceous species used to revegetate road embankments in southern France. Species were planted as monocultures in 78 steel boxes (0.7 m width x 0.7 m width x 0.3 m depth), that were inclined at 30° to mimic an embankment (6 replicates for each species + 6 bare soil controls). Three replicates were used for soil C analysis and three were equipped with rhizotrons (0.2x0.3m wide and 0.05m thick), for the study of root dynamics. As soon as the first root was visible in the rhizotron, we scanned every two weeks using a smartphone scanner and analyzed images with SmartRoot software. Roots were classed into fine 'absorptive' and thicker 'transport' roots depending on their topological order. Root elongation rate (RER) and root length production (RLP) were calculated. After ten months, soil samples were collected for fractioning and measurement of C in: particulate organic matter (CPOM) in the 2000-200 μm fraction, fine POM (CfinePOM) in the 50-200μm coarse silt fraction; CSILT in the 20-50 μm fraction and CSILT+CLAY in the <20 μm fraction. Overall, the total C in soil increased over 10 months under all species, but it was constantly reduced in the CSILT+CLAY fraction. RLP of old roots (>two weeks in rhizotron) and the diameter of absorptive roots were significantly correlated with an increase in CSILT only, where C has a longer residence time compared to the larger particulate fractions. Planting species with the appropriate traits could enhance C sequestration on revegetated land, but a better mechanistic understanding of the relationships between roots and C sequestration into different soil fractions is required.

Monitoring grassland management effects on soil organic carbon – a matter of scale

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Management practices determining the impact of temporary grassland on soil organic matter (SOC) include duration, fertilization, and grazing strategies or mowing regime. Increasing grassland duration appears to be the most important management practice to enhance SOC sequestration. Up to now impact of grassland management on SOC stock changes were mostly studied after replicated field sampling without taking into account spatial heterogeneity of soil at the plot scale and field scale. In the present study we used geostatistical sampling and satellite imaging to evaluate SOC loss and gain 9 years after introduction of different grassland management practices on temperate loamy soils in Western France. The soils had been under continuous crop, permanent and temporary grasslands with contrasting management in terms of fertilization, duration and harvesting (grazing or mowing). In the present study, we evaluated the impact of introduction of permanent or temporary grasslands with contrasting management on the spatial distribution of SOC storage on a decadal timescale.

Overall, after nine years of treatment, SOC increases were noted under permanent grassland, while permanent cropping reduced SOC stocks and the introduction of temporary grassland maintained SOC, except for grazed temporary grassland, which was characterized by carbon loss. SOC stock changes determined by the ground-based geostatistical approach showed treatment effects at 0.4 ha field plots. At larger scale (3ha) plots, SOC changes were variable and zones with SOC gain and loss were found under the same treatment. These differences could to some extent be explained by changes in physicochemical soil parameters. Ground based SOC stock changes showed a correlation with satellite based vegetation data (NDVI). We conclude, that evaluation of SOC stock changes at multiple scales is necessary to infer management effects on SOC. Moreover, remote sensing of vegetation may be a promising avenue to evaluate belowground SOC changes due to management.

Pattern of soil organic matter content in reclaimed tide lands with different reclamation time in Korea

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In Korea, reclamation projects have been pushed forward to build 135,100ha of reclaimed tide lands from 1965 to 2020. In order to utilize the reclaimed tide lands as competitive farm lands, the government has been pursuing comprehensive development of the reclaimed lands. To provide basic data for rational land-use and soil management, we investigated soil physical and chemical properties for 11 reclaimed tide lands with different reclamation time from 2013 to 2016. Soil analysis results showed that annual mean value of soil EC was in the range of 5.1 to 8.3 dS m-1 and continued to decrease over the years. Average value of soil organic matter(SOM) content of the reclaimed tide lands ranged from 2 to 17 g kg-1 in 2016. The reclaimed tide land with longer years after reclamation tended to have higher SOM content. The estimation equation for the SOM was $y = 4.3183e0.08x$ ($R2=0.5196$), where y = SOM content, x = years after reclamation. Cation exchange capacity(CEC) increased with the increase of SOM content. The higher SOM content in the reclaimed tide lands with longer years after reclamation was attributed to input of organic matter and growth of roots during crop cultivation. As the years after reclamation had elapsed, SOM had increased but was still far from adequate level for crop cultivation. It was found that management for continuous enhancement of SOM content would be important for efficient agricultural use of the reclaimed tide lands
Keywords: reclaimed land, soil organic matter(SOM), physical and chemical property

Enhancing soil carbon and nitrogen storage with sheep grazing in dryland cropping sequences

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Sheep grazing to manage weeds and crop residue in dryland cropping systems can enhance soil C and N storage by returning feces and urine to the soil. This study evaluated the effect of sheep grazing to manage weeds compared to tillage on soil total C (STC) and N (STN) at the 0-120 cm depth in dryland cropping sequences from 2012 to 2015 in western Montana, USA. Weed management practices were sheep grazing with no chemical input (GO), minimum tillage with chemical input (MT), and conventional tillage with no chemical input (TO). Cropping sequences were clover cover crop following safflower/clover intercrop (C-SC), lentil following winter wheat (L-W), winter wheat following clover cover crop (W-C), and winter wheat following lentil (W-L) employed in a 5-yr crop rotation of safflower/clover cover crop – clover cover crop – winter wheat – lentil – winter wheat. At 60-90 and 90-120 cm, STC increased with GO compared to TO, but STN increased with TO compared to GO and MT. The STC was greater with C-SC than other crop rotations at 15-30 cm, but was greater with W-C than C-SC and L-W at 60-90 cm. The STN was greater with C-SC than W-C at 30-60 cm. From 2012 to 2015, STC at 15-50 cm increased at 300 kg C ha-1 yr-1 with GO and STN at 60-90 and 90-120 cm increased at 20-50 kg N ha-1 yr-1 with TO. Sheep grazing enhanced soil C storage compared to tillage at the upper soil layer, but the trend reversed with soil N storage at the bottom layers. Clover cover crop following safflower/clover intercrop increased soil C and N storage compared to other crop rotations in the middle soil layers.

Soil organic matter distribution governed by aggregation and decoupled from clay content

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The accumulation of soil organic matter (OM) through organo-mineral interactions is anticipated to be stimulated by the soil clay content. The mixing of soil particles into larger aggregate structures impedes the identification of which particles comprise the aggregates and how these control the OM distribution. Here we show how the influence of clay content can be resolved based on the underlying impact of size-specific aggregation on OM sequestration. We used dynamic image analysis to differentiate the size distributions of free water-stable microaggregate size fractions (<250 μm) and those occluded in larger soil structures from their dispersible particle-size composition. Differentiating aggregated from dispersed size distributions also enabled to identify the preferential size ranges of aggregates that break down to particles and non-aggregated particles that remain. To investigate the impact of soil texture, we analyzed topsoil samples of an arable site on Cambisol soils with a gradient in clay content within a range of 16–37 %. Our results demonstrate that soil texture governs aggregate distributions and sizes. High-clay soils contain more water-stable macroaggregates (>250 μm) and larger microaggregates in the 50–180 μm size range. Non-aggregated sand-sized particles >100 μm probably impede the buildup of larger water-stable aggregates in low-clay soils. The size distribution of particles <100 μm in size fractions showed a similar prevailing pattern for all clay contents, whereas 4 % more clay-sized particles helped build up water-stable macroaggregates. In the low-clay soils, the aggregates were smaller and had higher OM concentrations. This explains the fact that higher amounts of OM could be held in aggregates of the low-clay soils despite containing coarser texture. This interaction reveals that OM sequestration is decoupled from the particle-size distribution. Instead, the occlusion of aggregate size fractions led to lower alkyl:O/N-alkyl ratios in 13C NMR spectroscopy indicating increased preservation.

Temporal and spatial variation of soil organic matter and soil acidity in surface soils under rice-based intensive farming in floodplain soils

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The assessment of temporal and spatial variation in soil organic matter (SOM) and soil reaction trend can identify the potential threats to soil fertility and long-term sustainability of farming system. This study quantified the spatiotemporal variations in SOM and soil pH of paddy soils between 1990 and 2010 in the northern Bangladesh. Soil legacy data sets collected from these two time periods were categorised according to prevailing soil series, physiographic position and major soil types. SOM status in all soil types was generally low (10-17 g/kg). SOM content has increased marginally, but remains low, which is hypothesised to be related to increasing cropping intensity and fertilisation over this same period. Inundation land type and local differences in smallholder management is hypothesised to have influenced SOM variability, however land management has yet to be investigated. Soil reaction trend between 1990 and 2010 measurements in agricultural soils has decreased by 0.5 units with a 50% increase in soils falling below a pH of 5.5 over the 20 year survey period. Soil acidification is potentially a combination of inefficient and excess use of ammonium based fertilisers with highly variable application rate, low input from crop residues, and underlying light texture topsoils and high rainfall. We speculate that whilst acidification may continue to fall with more intensive land use, SOM has reached a stable, but very low, equilibrium and is unlikely to fall further. Therefore, future research priorities addressing C and N dynamics, optimising the use of fertilisers (particularly N), better crop residue management and lime based amelioration of acidic soils will improve the sustainability of rice-based farming system in the northern Bangladesh.

Keywords: Paddy soils, Organic matter and pH changes, Inundation land types, Fertilisers, Cropping intensity

Formulation and evaluation of organo-mineral fertilizer pellets for soil and plant nutrition in low-carbon soil

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The excessive use of inorganic fertilizers can lead to a decline in soil organic matter content, increased soil acidity, degradation of soil physical properties, nutrient toxicity and increased rate of erosion. Application of organic fertilizer could improve soil's physical, chemical and biological properties. However, a notable improvement in these properties requires the application of high rate of nutrient rich organic matter with low C:N ratio. Studies were conducted at EARTH University in Costa Rica to optimize the production of organo-mineral pellets (C:N:P:K) from food waste, chicken and cow manures, peat, silicon, and inorganic fertilizers. Carbon rich C:N:P:K were tested for agronomic performance and economic viability. A guideline for the selection of raw materials was developed, an interactive computer program was designed to optimize the formulation of compost and C:N:P:K, a pilot production plant was set up, and tests were conducted to evaluate the effects of C:N:P:K on soil nutrition and crop production. The guideline included tests for compressibility, resistivity, abrasivity, particle size, hygroscopicity, moisture content, and chemical composition. The computer program helped optimize C:N ratio, water content, and compatibility of different ingredients for the production of C:N:P:K. The pilot plant design and operation provided information for scaling up the unit to a full-scale commercial production plant. The pilot plant consisted of modules for composting, sieving, drying, grinding, formulation, pelletizing, final drying, and packaging of C:N:P:K. The pellets were tested in laboratory for their nutrient release curves and in the field to compare their performance with chemical fertilizers containing only N:P:K. The C:N:P:K were more efficient in nutrient release overtime. They had positive effects on soil properties, and had low transportation and handling costs per unit active fertilizer ingredients compared to compost or municipal waste.

Effect of 50-year term different crop rotations on soil organic matter

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Soil carbon sequestration is almost only negative emission technologies which are readily available at a low cost and crop rotation is one of those. Identification and implementation of land use and soil management practices which create a positive agricultural soil organic matter and restore soil quality is specific challenge worldwide.

Long-term field experiment was established in 1966 at the Experimental Station of Vytautas Magnus University. 9 different crop rotations were arranged in time and space. In addition, Continuous rye monoculture (with and without herbicides and mineral fertilizers) as well as Continuous bare fallow were included as control treatments. Investigations were carried out in 2015 and 2018 (after 50-year term). Soil – Calc(ar)i-Endohypogleyic Luvisol.

The objective of this investigation was to compare the effect of different crop rotations and rye monoculture as well as 50-year bare fallow on soil organic matter.

The highest soil organic matter (SOM) content established in crop rotations with perennial grasses and/or with farmyard manure application: Cereal, Norfolk, Fodder and Field with raw crops. Crop rotations For green manure and Intensive, in which soil productivity supported with green manure, indicated lower SOM. The least SOM content was in Cereal and Three course crop rotations. SOM stocks were 16.9 % and 22.5 % lower to compare with Norfolk crop rotation. SOM in Continuous bare fallow obtained 2 times less. Bare fallow without farmyard manure application mostly decreased soil productivity.

Crop rotation design in modern agriculture persist as one of major instruments for soil organic carbon management and sustainable intensification.

Grazing into the future: Building soil carbon using perennial pasture species

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This study investigated the quantification and prediction of changes in soil carbon in perennial pastures under cell grazing. Limited data are available to quantify the amount of carbon that could be stored in WA wheatbelt soils using cell grazing practices. The objective was to measure the change in soil carbon associated with pasture management practices for different aged mixed perennial and annual pastures using a chronosequence of pastures sown in 2003, 2005, 2007, 2008, 2011 and 2012. Inclusion of perennial grasses in pastures is uncommon in the Arthur River region of Western Australia but they have potential to increase soil carbon. Soil carbon was highest in the oldest established perennial pastures in the chronosequence. An increase in soil carbon was measured between 2012 and 2014 for 2 of the 6 sites in the chronosequence. An increase in soil carbon between 2012 and 2014 measured for perennial pastures established in 2005 and 2007 was likely to be associated with improved soil management (including liming) that resulted in increased productivity at these sites. Both sites had a history of poor soil conditions but this had recently been observed to improve.

The farmer-researcher collaboration in this project provided two-way exchange of knowledge that has led to a number of suggestions for further investigation relevant to pasture management. For example, inconsistencies in relationships between pasture management practices and soil chemical measurements, the potential requirement for soil disturbance in management of perennial pastures, the time required for improvement in relation to soil quality, limitations in perennial productivity, the economic potential for management of perennial pastures compared with annual pastures (on soils of different quality), tipping points in relation to improvements in soil carbon and pasture production, were all areas of further potential research identified in the final workshop by farmers, consultants and researchers.

Unexpected high mitigation of methane emission via short-term aerobic digestion of cover crop biomass before flooding in rice paddy

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Soil organic matter (SOM) is used as an important indicator of soil quality and a countermeasure to mitigate global warming. To increase SOM stock, cover cropping and its biomass incorporation are strongly suggested in mono-rice paddy. However, since biomass application significantly increased greenhouse gas emission (GHG), in particular, methane (CH_4), during the flooded rice cultivation, its positive effect is confronting with the negative environmental problem. We hypothesized that the short-term aerobic digestion of cover crop biomass under the dried soil before flooding might degrade labile organic matter into carbon dioxide (CO_2), and then reduce CH_4 production during the flooded rice cultivation. In order to evaluate the feasibility of the short-term aerobic digestion of amended biomass on reducing CH_4 emission in a rice paddy, the mixture of barley and hairy vetch biomass was added inner dried soil with different time intervals from 0 to 30 days before flooding, and then CH_4 emission rates were monitored. In the two months' incubation test, more than 10 days of aerobic digestion before flooding significantly decreased CH_4 flux by 88-98% over the control, in which soil was immediately flooded without aerobic digestion. In the field test, similar results were observed. Only 10 days of aerobic digestion after biomass addition under the dried soil condition reduced seasonal CH_4 flux by approximately 60% over the control. This reduction effect was slightly increased by extending the aerobic digestion period. In contrast, rice productivities were not significantly different from 0 to 30 days of pre-aerobic digestion. As a result, more than 10 days of aerobic digestion before flooding decreased CH_4 intensity which means the yield-scaled CH_4 emission by 60% over the control. In conclusion, the pre-aerobic digestion of cover crop biomass before flooding can be good soil management to reduce CH_4 emission without productivity damage in rice paddy soil.

Carbon sequestration and stabilization in a 40-year agronomic long-term experiment

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Soils contain more carbon (C) in the form of organic matter (soil organic matter = SOM) than the entire atmosphere and global vegetation put together. They are thus a central component of the global C cycle and its largest dynamic reservoir. On the one hand, intelligent agricultural practices are discussed as a way of mitigating climate change because they can increase the amount of SOM and thus actively remove C from the atmosphere. On the other hand, all intensively used soils lose C in the long term. Central questions in this context revolve around the extent and dynamics of storage, the stabilisation mechanisms involved and the impact of agricultural use on the C budget.

The DOK experiment is an agronomic long-term experiment near Basel (Switzerland), which has been comparing biodynamic, organic and conventional management systems for 40 years (six crop rotation cycles) and has an extensive soil sample archive covering the entire period. Within the "DynaCarb" project, we are investigating how density and particle size fractions of SOM change qualitatively and quantitatively during the 40-year test period. We compare four different fertilization systems (each with four replicated plots): an unfertilized control, pure mineral fertilizer, pure organic fertilizer, and a combined mineral-organic system in the years 1982, 1989, 1996, 2003, 2010, and 2017. Using physical fractionation (density and particle sizes) and CN analyses, SOM is separated into particulate and mineral-associated fractions and their development is quantitatively investigated during six crop rotation cycles. We use solid-state 13C NMR spectroscopy, N2 gas adsorption and radiocarbon dating to estimate the C sequestration potential of soils, their saturation and the dynamics of C storage.

"DynaCarb" investigates the medium- and long-term effects of different agricultural systems on SOM. These results are of great importance for the evaluation of the C-sequestration potentials of agricultural soils and for the identification of suitable utilization and fertilization strategies.

Utilizing rapid spectral techniques to assess impacts of agriculture on soil function in pacific soils

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Intensive agricultural production systems have had a dramatic impact on the status of pacific island soils, and have changed their soil physical, chemical and biological function. Their ability to deliver crucial ecosystem services, including soil organic carbon storage, soil nutrient delivery and soil water holding capacity has been affected. The state of the soil is a key factor in farm value on pacific islands and therefore warrants monitoring to ensure the sustainability of the soil resource for future generations. However, traditional soil laboratory techniques are expensive to use for soil monitoring purposes and also hard to access at times, because of remoteness of the islands and limited laboratory capacity. Soil spectroscopic techniques offer cost-effective and rapid analyses, and hand-held, field-portable devices have the potential to be used for instantaneous soil analysis results. Spectral techniques operating in the X-ray, vis-NIR and MIR part of the electromagnetic spectrum offer the ability to predict a range of soil properties of agronomic importance including soil organic matter, pH, soil texture and macro-, micro and trace-nutrients. Here, we conducted a study to assess the suitability of soil spectral techniques to quantify aspects of soil fertility for allophanic soils of several agricultural plots on Tongatapu island, Tonga. Locations were chosen to also allow for comparison of the impact of management practices on the soil's status. This work will contribute to building a soil spectral library for pacific island soils, to make possible the use of spectral devices to gain valuable soil information.

Field testing labile soil organic carbon using potassium permanganate in tropical soils

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Permanganate (KMnO4) was used to test for oxidizable organic carbon (POXC) as labile soil organic carbon. Soil samples were collected from five different soil types based on clay mineral types; kaolinite, kaolinite+iron oxides, smectite, siliceous, and mix. Active soil organic matter was estimated visually in a range consisting of 6 levels (0.5%, 1%, 1.5%, 2%, 2.5% and >3%) of KMnO4 to evaluate the quantity of active soil organic matter using the visual solution color of deep purple color (<0.05%OM) to a lighter KMnO4 solution color (>3%OM) based on comparison with the RHS color chart. Then, the color chart was modified based on the percentage of organic carbon compared with Walkley and Black method (the routine method). The results showed that the POXC color chart was strongly correlated with the percentage of organic carbon based on the routine method in all clay mineral types. Where the red color of a clay soil had been interfered by iron oxides added as flocculants or had been allowed to stand for a longer period (10-20 min), the solution became clear. However, about 75% of all samples, potassium permanganate was able to evaluate the quantity of labile soil organic matter in same-colored shades of soil samples with different organic carbon based on the routine method. The relationships to potassium permanganate oxidized organic carbon occurred in clay mineral types and amount of organic carbon. These results suggest that this method can be used as a labile organic matter test kit that is quick and inexpensive to evaluate active soil organic carbon content in the field for use in nitrogen fertilizer recommendations.

Key words: Labile Soil Organic Carbon Test Kit, Potassium Permanganate, Tropical Soils

The Home Field Advantage theory could be used for carbon sequestration and forest management?

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Forest soils represent a third of the terrestrial area and have a key role in carbon cycle and climate mitigation, as they store between 50 and 80% of the global stock of soil organic carbon (SOC). The major precursor of forest SOC is the dead wood mainly composed by three polymers: cellulose, hemicellulose and lignin. In coniferous forest, they are recycled mainly by brown rot fungi and specific bacterial communities. Brown rot fungi are able to mineralize polysaccharidic part and only modify the lignin chemically using hydroxy radicals in a mediated-Fenton reaction. Some recent findings suggest that the associated bacterial communities could be responsible for the degradation of the persisting altered lignin residues.
According to the Home Field Advantage theory the decomposition rate is more rapid and efficient when litter is placed beneath the natural plant species than beneath a different plant species. We hypothesize that the specific bacterial communities, which co-occur with brown rot are important for the velocity and efficiency of lignin degradation. Therefore, microbial communities from a broadleaf stand would be less efficient than coniferous communities. To test this hypothesis, wood blocks from Poplar, Norway spruce and Beech were pre-degraded by Gloeophyllum trabeum a brown rot fungus. When mass loss reached around 25 %, they were buried under litter layer either in a Norway spruce stand or a Beech stand. After 6 months, wood blocks will be collected. Wood mass loss and chemical changes will be assessed. Moreover, a metabarcoding approach will be performed to determine the microbial communities potentially responsible for wood degradation. These results could be translated into recommendations for forest management to optimize soil carbon sequestration under altered lignin form.

Towards more efficient carbon, nitrogen and phosphorus cycling in European agricultural soils: Circular Agronomics program

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It is estimated that only 20% of fertilizers annually applied in European agricultural systems are converted to finished products for human consumption. These low efficiencies result in large losses of nutrients such as Nitrogen (N) and Phosphorus (P) to the environment with severe negative influences on soils, water and air. They therefore constitute unacceptable health- and environmental costs. In addition, around 45% of soils in the European countries have less than 2% soil organic carbon (SOC) in their topsoil. Besides increasing the risk of nutrient losses, low SOC stocks are also associated with negative effects on climate change and biodiversity loss. A promising strategy to replenish SOC stocks is the transformation of waste products from the food and feed sector into organic soil amendments. The aim of the H2020 European project "Circular Agronomics" is to provide a comprehensive synthesis of practical solutions to improve the current C, N and P cycling in European agro-ecosystems. Among many other things, this project explores medium and long-term effects of new versus classical organic fertilizers in six countries (Germany, Spain, Italy, Netherlands, Czech Republic and Austria). The study sites will be sampled before and after applying the new organic amendments using a hydraulic corer. A full profile assessment of the C, N and P distribution, stability and bioavailability will be released up to one meter depth using a combination of classical bulk chemical analyses and state-of-the-art imaging techniques. Undisturbed soil cores will be scanned using a hyperspectral camera to reveal hotspots of C, N and P storage in the soil profile, at the micro-scale. Soil C, N and P will be modelled as a function of spectral response using a variety of machine learning approaches. These results will provide essential information to develop management strategies that increase nutrient recycling as well as SOC stocks.

Short-term effects of re-grazing on soil microorganisms and biogeochemistry at a long-term abandoned alpine pasture

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Traditionally, grazed alpine pastures have shaped most landscapes of the European Alps for centuries. However, especially steep alpine areas have largely been abandoned since the 1950s, resulting in a fast re-forestation of mountain pastures in the last decades, which is accelerated by climate change. Without grazing by cows, the once highly diverse plant communities are increasingly replaced by grass-dominated communities. Re-grazing is a practicable opportunity to preserve the high species diversity on mountain pastures. However, there is a lack of information on re-grazing effects on soil characteristics. This study aims at investigating effects of re-grazing of a long-term abandoned mountain pasture on soil carbon and nitrogen biochemistry, microbial communities, as well as water quality. In May 2018, we set up a pilot grazing experiment at Brunnenkopfalm (1500-1700 m a.s.l.), abandoned since 1955. Four ha were fenced and a herd of rustic breeds (ca 1/ha) was introduced. Two and five months after the beginning of grazing, we investigated the short-term re-grazing effects, considering grazing-induced heterogeneity. We depicted the faster cycling carbon pool by analysing the salt-extractable organic matter for total organic carbon. We quantified and classified microorganisms using the fumigation-extraction method and the analysis of phospholipid-derived fatty acids. Organic carbon and nitrogen concentrations increased only in intensively grazed areas, contributing insignificantly to the overall area so that concentrations of dissolved organic carbon and nitrate in the draining creek remained low. Re-grazing did not affect the microbial abundance relative to organic carbon, but induced a community shift towards a smaller proportion of fungi compared with bacteria. Overall, re-grazing of pastures had limited effects on soil organic carbon availability and on the microbial community composition, highlighting the resilience of alpine soils to short-term impacts of extensive re-grazing. Our results provide urgently needed knowledge to develop management strategies that preserves alpine pastures from degradation.

Plant residues and fungal growth as drivers for microaggregate formation in the detritusphere

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Plant residues, i.e., the detritusphere, represents a hotspot for soil structure formation. The direct vicinity of labile plant residues, microorganisms and soil minerals demonstrate the perfect microenvironment for soil aggregate formation driven by microbial products as gluing agents. However, there is a lack of experimental approaches exploring this theory in intact soil samples, considering the spatial heterogeneity of soil microstructures. We aimed at depicting the sources and vectors of organic carbon during the simultaneous formation of SOM and soil structure. To exclude possible bias in differentiating between new and inherited SOM, we used an artificial soil mixture (quartz sand, illite and goethite) free of SOM, as well as spruce needles as particulate OM. Small containers filled with the artificial soil were placed in an organic layer to allow natural microbial colonization. We studied the soil structure and OM gradient formation using spectromicroscopic imaging. We used nanoscale secondary ion mass spectroscopy with subsequent digital image processing to explore the spatial distribution of mineral (^{16}O-, $^{27}Al^{16}O$-, $^{56}Fe^{16}O$-) and organic (^{12}C, $^{12}C^{14}N$-, ^{32}S-) compounds on 69 measurements. At the start of the incubation, we depicted OM free mineral surfaces in the vicinity of the needle, demonstrating the feasibility to follow subsequent OM distribution without the need of isotopic labelling. Already after 14 days, fresh OM was associated with the mineral domains surrounding the needles. After 42 days, we could demonstrate that the needles were massively infested with saprotrophic fungi, which extended into the mineral matrix of the artificial soil acting as vectors for litter derived C and N into the bulk soil. There was also an increase of the OM at greater distance to the needle and in association with mineral particles. We demonstrate the formation of micro-aggregates in the direct vicinity of plant residues as driven by microbial activity.

Impact of organic amendments on plant biomass and carbon transfer in the soil

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The agricultural use of organic amendments, such as (vermi)composts provides a sustainable method to incorporate nutrients and organic carbon in soils and to potentially mitigate climate change. However, (vermi)composting production and application to soil generates high quantities of greenhouse gases, which can be reduced using additives such as clay minerals during the production of co-(vermi)composts. Little is known about the impact of co-(vermi)composts on plant growth and the soil carbon cycle. In the present study, we investigated (1) the effect of co-(vermi)composts on root and shoot biomass production of two contrasted plants and (2) the transfer of plant-derived carbon into different soil compartments. We continuously labeled with ^{13}C plants of ryegrass and haricot, grown in microcosms filled with soil amended with four different composts: vermicompost, compost, vermicompost produced with 30% montmorillonite or compost produced with 30% montmorillonite. Six weeks after sowing, shoots, roots, rhizospheric and bulk soils were separated and the biomass of shoots and roots were quantified. Carbon, nitrogen and δ^{13}C values were obtained for plant and soil samples. To depict organo-mineral interactions and the incorporation of ^{13}C at the root-soil interface, two samples were selected for nano-scale secondary ion mass spectrometry analyses (secondary ion images of ^{12}C, ^{13}C, ^{12}C^{14}N, ^{16}O and ^{56}Fe^{16}O). Our results showed that co-(vermi)composting increased root and shoot biomass production of both plants compared with (vermi)compost. The plant biomass was significantly reduced in the presence of vermicompost compared to co-vermicompost, especially for ryegrass (around six-fold lower for roots and shoots). The rhizosphere represented a hotspot for plant-derived carbon compared to bulk soil, as reflected by the higher δ^{13}C values in this compartment, especially with co-(vermi)compost. The use of clay minerals during (vermi)composting has a beneficial impact on plant growth, likely reflecting the structuring, as well as organic carbon and nutrient adsorption capacities of clay minerals.

Impacts of biostimulants on soil biological properties and nutrient content of wheat

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Increasing agricultural productivity to improve food security while maintaining soil health is a global challenge. Given the increasing decline in soil health and a lack of productivity gain from further chemical inputs, new non-conventional sustainable farming approaches are required to increase the food production. Soil organic matter (SOM) provides the basis for healthy soils. Biostimulants are natural products derived from organic raw materials and/or microbial cultures that provide a promising alternative to sustainably maintain crop yield and potentially improve soil health including via increasing SOM levels. In this experiment we evaluated the impacts and mechanisms of two types of biostimulants, Converte universal plant food (UNP) and Converte seed primer (CSP) (https://www.converte.com.au) on soil key biological health indicators including soil respiration, enzyme activity, total C:N and wheat grain quantity and nutrient content. Soils were collected from two depths (0-10 and 10-20 cm) before harvest. Basal respiration was 38% and 57% greater in UNP treated soils compared to control and UNP+CSP treated soils respectively and significantly lower in the 10-20 cm soils compared to 0-10 cm soils. Catabolic diversity was greater in UNP+CSP treated soils compared to soils treated with UNP or CSP alone. Activity of C-associated enzymes in soils treated with UNP+CSP was significantly higher compared to UNP treated and control in the 0-10 cm soils. Bacterial abundance was 36% and 55% higher in UNP and UNP+CSP treatments respectively compared to control soils. Both UNP and CSP treatments significantly influenced the composition of soil microbial communities. Overall, the soil biological health parameters tested here responded positively to treatment and suggests that judicious use of biostimulants could simultaneously increase soil health and farm productivity.

Key words: biostimulants, soil organic matter, sustainability, microbial communities, soil functions.

Seasonal changes in soil bacterial processes associated with C and N cycling in dairy pasture after application of compost and manure

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We investigated use of manure and compost in restoration of dairy pasture via effects on soil bacterial community composition and functional diversity. Bacteria can influence both retention and loss of soil C and N during the degradation of organic matter. Bacterial communities in soil amended with manure or compost in a dairy farmer field experiment were characterized in winter and summer using community profiling of 16S rRNA genes. Inorganic fertilizer was applied with 2t/ha manure, or with compost applied at 3t/ha or 6t/ha. The dominant bacterial phyla were Proteobacteria, Actinobacteria, Acidobacteria, Bacteriodetes and Firmicutes and their relative abundance was influenced by organic amendment and application rate (for compost). The occurrence of C degrading functional genes and N functional genes were predicted using Phylogenetic Investigation of Communities by Reconstruction of Unobserved States (PICRUSt). Putative PICRUSt gene counts associated with breakdown of hemicellulose, cellulose and chitin were highest for manure in winter. Predicted C genes and N gene abundance of amoB associated with nitrification was lowest in winter for soil treated with 6 t/ha compost. The complexity of soil bacterial community responses to manure and compost applied to this dairy pasture highlighted reduced potential for degradation of soil C and mineralization of N and retention of C and N in soils when 6t/ha compared to 3t/ha compost or manure were applied. Dairy soil management practices that influence soil bacterial contributions which enhance C sequestration and N retention in dairy soils will limit C and N losses via greenhouse gas emission and leaching.

Carbon sequestration as soil organic and inorganic carbon in the agricultural land of Northern China: A review and perspective

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Soil organic carbon (SOC) and inorganic carbon (SIC) are important reservoirs of carbon in arid, semi-arid and semi-humid regions. While SOC has attracted great attention, SIC exceeds SOC greatly in arid and semi-arid lands, thus may play an important role in carbon sequestration. However, there were not much done to evaluate the dynamics of both SOC and SIC in the terrestrial ecosystems; and limited studies showed inconsistent findings on the relationship between SIC and SOC. While both negative and positive correlations between SOC and SIC may exist, water limitation and saline/alkaline conditions in the arid and semi-arid regions would be beneficial to carbonate formation. Thus, a positive relationship would be more common, in particular, when SOC and SIC stocks in deep soils are included, which implies that increasing SOC may lead to an increase of SIC in arid and semi-arid lands. Here, we present a summary of relevant studies conducted in the northern China's agricultural land, and provide a review on the SIC dynamics and its relationship with SOC. We explore the underlying mechanisms regulating the transformations of main soil carbon forms, and discuss the potential of carbon sequestration as SOC and SIC in arid and semi-arid lands.

Influences of organic amendment and phosphorus fertilization on soil organic and inorganic carbon in a saline-alkali paddy of the Yellow River Delta

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There was evidence of positive relationships between soil organic carbon (SOC) and inorganic carbon (SIC) in saline-alkali lands of arid and semi-arid areas. However, little is done to evaluate the variations of SOC and SIC and their relationship in the coastal saline-alkali paddy, especially under different amelioration/fertilization practices. This study aims to assess the impacts of various combinations of organic amendment and phosphorus fertilization on SOC and SIC and other soil properties in a coastal saline-alkali paddy field of the Yellow River Delta. Our study showed that most of the amelioration methodologies couldn't reduce soil pH and contents of salts effectively. Organic fertilization increased available phosphorus, total phosphorus and total nitrogen. Phosphorus fertilization led to an increase of SOC by 17% in subsoils，   and organic amendment resulted in a further increase of SOC by 7-17% over 0-20 cm and14% over 20-100 cm. There were little differences in SIC over 0-20 cm among the treatments, but slight decreases in SIC over 20-100 cm under organic amendment combined with lower rate of phosphorus fertilization. On the other hand, .high rate of phosphorus fertilization combined with organic amendment caused a decrease in SOC stock but an increase in SIC stock in the subsoil. There was a significant negative relationship between SIC and SOC stocks in the saline-alkali paddy of the Yellow River Delta. We explore the underlying mechanisms influencing the dynamics of SOC and SIC in association with soil amelioration.

Reducing GHGs emission and promoting SOC sequestration in the croplands of Huang-Huai-Hai Plain, China: A simulation study

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The Huang-Huai-Hai (HHH) plain produces ~1/3 wheat and maize of China with high resource inputs, particularly synthetic nitrogen (N) fertilizers since the 1980s. Although fertilizer input has substantially increased crop yield and enhanced biomass carbon (C) input to the soil and thus stimulating soil C sequestration, GHG emissions (e.g., nitrous oxide (N_2O)) relating to the fertilizers have been also dramatically increased. Yet, a systematic regional assessment on the trade-offs between crop yield, soil C sequestration and N_2O emissions as impacted by management practices and environmental conditions is lacking. Here we calibrated a farming system model to conduct comprehensive assessment on crop yield and GHG emissions (soil CO_2 and N_2O emissions) during the period 1981-2010 across the HHH plain at the resolution of 10 km. We found that soil in HHH plain was a C sink with an annual C sequestration rate of 1.53 CO2-eq ha-1 yr–1 (0-30 cm soil) during the period under typical agricultural practices, but this sink could only offset about 68% of global warming potential from contemporary N_2O emissions. By reducing the annual N input rate (from current more than 300 to ~250 kg N ha-1 yr-1) and enhancing residue retention rate (from current 30% to 100%), the HHH plain could act as a net sink of GHG without sacrificing yield. Apart from management, the effects of three key environmental factors, i.e., mean annual rainfall and temperature and initial soil organic carbon stock on dynamics of crop yield, soil CO_2 and N_2O emissions were also studied.

Vertical pattern and its driving factors in soil EEA and stoichiometry along mountain grassland belts

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Soil extracellular enzymes catalyze soil biochemical processes, and the geographical patterns of their activities and stoichiometry can reflect soil microbial functional dynamics. In previous research, latitudinal and longitudinal variations in soil extracellular enzyme activity (EEA) have been intensively investigated. However, its elevation patterns and depth variations (especially > 40 cm) received much less attention. Here, we measured potential activities of enzymes of carbon (C) (β-1,4-glucosidase), nitrogen (N) (β-1,4-N-acetylglucosaminidase; leucine aminopeptidase), and phosphorus (P) (acid phosphatase) up to 1 m soil depth along a vertical grassland belt in Xinjiang Uygur Autonomous Region, China. Soils were sampled from three elevation gradients (low, < 1000 m; mid, 1000–2000 m; high, 2000–3000 m) at five depths (0–10, 10–20, 20–40, 40–60, 60–100 cm). Soil EEA generally increased with elevation, while specific EEA normalized by microbial biomass C was lowest at mid-elevation. Both enzymatic C:N and C:P ratios were highest at mid-elevation. Soil EEA declined with depth but the extents varied with elevation. Depth variations in soil enzymatic stoichiometry also differed among three elevation gradients. Enzyme C:N and C:P ratios only decreased with soil depth at low elevation. From low to high elevation, enzyme N:P was highest at depths of 20–40 cm, 40–60 cm, and 0–10 cm, respectively. Key influential factors of soil EEA varied from low to high elevation. At low elevation, soil nutrient affected soil EEA indirectly through affecting microbial biomass. At mid-elevation, soil moisture influenced soil EEA directly and indirectly via pH. At high elevation, only soil pH impacted soil EEA directly.

Characterization of soil humic acid reacting with calcium ion and its application

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Soil humic acid (SHA) practically defined as soluble in basic solution and insoluble in acidic solution is an important component of soil organic matter (SOM). SHA was considered as the main reagent for maintaining sound physical structures of soil and providing nutrients to living plants. SHA had drawn tons of attention, but the chemical properties of SHA, even its existing, remain controversial since of the large inconsistence of characteristics data between literature studies. Here we reported a study on reactions of calcium ion with SHA samples and the online spectroscopic characteristics of SHA during the reactions. This study has two major purposes: first, to understand the overall reaction of Ca2+ and SHA in soil and to dig out underlying mechanisms; second, to illustrate the inactivation effects of Ca2+ to SHA samples, which could be qualitatively described by spectroscopic information. To achieve these purposes, three bulk SHA samples were carefully extracted from three layers of a profile of limestone soil using the recommend extraction method of IHSS, one bulk SHA from the top layer was further divided into 5 sub-fractions according to their apparent molecular weights using a tangential flow filtration system, and a continuous on-line measurement system, including automatic potentiometric titrator, UV-visible spectrometer and three-dimensional excitation and emission matrix fluorescence (3D-EEM), was set up. The idea is to allow Ca2+ reacts with SHA gradually in the apparatus of automatic potentiometric titrator and so that the optical spectroscopic signals of SHA can be monitored continuously. The preliminary results showed that the overall reaction of Ca2+ and SHA is a combined process of complexation and adsorption, the reaction with Ca2+ can modify the spatial configuration and molecular size of SHA which may be reflected by changes in the spectroscopic signals of SHA.

Changes in microbial biomass, community composition and diversity, and functioning with soil depth in two alpine ecosystems on the Tibetan Plateau

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Microbial communities play an important regulating role in soil carbon and nutrient cycling in terrestrial ecosystems. Most studies on microbial communities and biogeochemical cycling focus on surface soils (0-20 cm). However, relatively little is known about how structure and functioning of microbial communities shift with depth in a soil profile, which is crucial to understand biogeochemical cycling in deep soils. Here, we combined a number of complimentary techniques to investigate the microbial biomass, community composition and diversity, and potential functioning along soil profile (0-70 cm) in two contrasting alpine ecosystems (meadow and shrubland) on the Tibetan Plateau. Results showed that microbial biomass (MBC, MBN or PLFA) and fungi:bacteria ratio all declined greatly with depth, while the ratio of Gram-positive to Gram-negative bacteria increased with depth. Microbial community composition, by PLFA or DNA sequencing (archaea, bacteria or fungi), showed remarkable differences among different soil layers. Microbial community diversity (OTU number) also changed with depth – both bacteria and fungi richness declined with depth, while archaea richness showed the opposite trend. The co-occurrence network analysis further showed that surface soil microbes were more connected and interacted among each other compared to deep soil microbes. Moreover, total enzyme activities (per gram soil) declined with depth, while specific enzyme activities (per gram MBC) did not change with depth. Potential C mineralization rate decreased with depth, while net N mineralization rate was higher at deep soils than at surface soils. We also detected shifts in some functional guilds of bacteria (based on faprotax database) and fungi (based on FUNGuild database) with depth in both ecosystems. Taken together, we detected dramatic shifts in biomass, community composition and diversity, and potential functioning of microbial communities with soil depth, which may have important implications for driving soil organic matter dynamics along soil profile in alpine ecosystems.

Quality of soil organic matter affected by long-term organic manure input rather than synthetic fertilizer

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Understanding the mechanism of soil organic matter (SOM) sequestration under long-term fertilization is of great importance in sustaining crop productivity and mitigating climate change. We examined the responses of total SOM, mineral-associated OM, particulate OM (POM) and its light (Light-POM) and heavy fractions (Heavy-POM) to the application of synthetic fertilizers (nitrogen and phosphorus, NP) and their combinations with organic manure (MNP/K) in four long-term trials under rain-fed cropping system in the Loess Plateau. Long-term fertilization significantly increased SOC and total N (TN) storages, the sequestration rates of SOC and TN were, on average, 121 and 13 kg ha-1 y-1 under NP and 372 and 39 kg ha-1 y-1 under MNP/K, respectively. The sequestered SOM was generally distributed more in the mineral-associated OM pool than in the POM pool in NP treatment. However, the POM pool had more sequestration of SOM than mineral-associated OM pool did under MNP/K treatment. In addition, Light-POM pool was more sensitive to sequester OM than Heavy-POM pool and contributed large proportion to the total OM sequestration in POM pool. The different roles of the SOM pools in sequestration of OM are possibly related to the saturation degree of SOM, which manifested by significantly lowering proportion of mineral-associated OM pool and raising of POM pool, especially Light-POM pool under the application of MNP/K. We concluded that SOM sequestration was mainly contributed by sequestering more carbon in stable pool under application of synthetic fertilizers, but in labile pools under application of synthetic fertilizers plus manure in long-term.

Organic manure input not benefit for inorganic carbon accumulation in semiarid cropland

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Understanding soil carbon dynamics affected by agricultural practices in dryland ecosystems is helpful in mitigating climate change. This study investigated the responses in soil organic carbon (SOC) and inorganic carbon (SIC) distribution and storage in 3 m depth of soil profiles under long-term applications of chemical fertilizers (NPK) and organic manure plus NPK fertilizers (MNPK) in a loess soil in northwest China. The SOC contents decreased with increasing soil depth. The fertilizer treatments significantly enhanced the SOC concentrations at the top 20 cm depth as compared with the control (CK, no nutrient put). The amount of SOC to the depth of 100 cm in the MNPK-treated soil was significantly higher than those in the CK- and NPK-treated soils. The SIC contents showed higher values at deeper layers than at the top layers of the soil profiles. Application of MNPK significantly increased the SIC contents at the 60–140 cm depth but decreased the SIC contents at the 180–300 cm layer. Correspondingly, the SIC storage to the depth of 100 cm was significantly higher under the MNPK treatment than under the CK and NPK treatments. However, the amounts of SIC to the depth of 300 cm were not significantly different among treatments. It is concluded that manure application enhanced both SOC and SIC accumulation at top one-meter depth, but not three-meter depth.

Effects of nitrogen loss on SOC decomposition and its regulation by temperature and moisture

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Soil nitrogen (N) availability becomes the main regulator of carbon (C) cycling. At present, most researches focus on the effects of N addition on soil organic C (SOC) decomposition, but the study of N loss was very lacking. Actually, there are many processes of N loss in ecosystem, such as nitrification and denitrification, volatilization of ammonium and nitrate N, leaching/surface runoff and soil erosion, and nutrient uptake by plant roots. In addition, N availability has a significant interaction with temperature and moisture. Therefore, An ion exchange membrane technique will be used to absorb inorganic N in the soil to simulate N loss, and examine the effect of N loss on SOC decomposition and its mechanism. We collect 240 soil samples from 60 plots in the agro-pastoral ecotone of northern China. Soil samples will be subject to long-term indoor incubation experiment, which combined with N addition and N loss treatment and different temperature and water gradients. Variations of soil microbial respiration rate, decomposition rate of different carbon pools, and biotic and abiotic factors will be measured. This study will contribute to the C process simulation and theoretical improvement of terrestrial ecosystems, accurately predict the relationships among SOC dynamics and N, water and temperature and their feedback on climate change.

Topsoil water repellence increased early wheat growth and nutrition

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Soil water repellence, derived from the accumulation of hydrophobic organic compounds, is a constraint to crop and pasture production worldwide predominantly in sandy soils. Inhibited water infiltration, unstable wetting, and preferential flow are key hydrologic issues in water-repellent soil which adversely affect plant germination and establishment. However, despite the general understanding that soil water repellence can reduce soil nutrient bioavailability due to the prevalence of dry topsoil, the implications of water-repellent topsoil for plant growth and nutrition per se are unclear. A controlled glasshouse study was conducted to assess early growth and nutrition responses to severe topsoil water repellence in wheat (Triticum aestivum cv. Mace) over 51 days, under uniform plant density (15 plants per container), variable topsoil thickness (20 or 100 mm), and limited water supply (4.2 mm every two days). Wheat grown in severely repellent topsoil treatments with a wettable furrow had significantly greater tiller number per plant, dry matter, and total nutrient uptake compared to plants grown in completely wettable topsoil treatments, regardless of topsoil thickness. Preferential flow in the furrow of repellent topsoil treatments presumably increased soil water availability at depth, but did not cause leaching beyond treatment containers, resulting in conditions conducive to early wheat growth and nutrient uptake. By contrast, increased retention of water at the surface of completely wettable topsoil treatments likely decreased plant-available water due to a reduction in wetting depth and an increased rate of evaporative water loss. Increasing the thickness of wettable topsoil from 20 to 100 mm also significantly reduced wheat growth and nutrient uptake, but topsoil thickness was not important in repellent topsoil treatments. This suggests that preferential flow along a wettable furrow in water-repellent soil can be advantageous for early plant growth and nutrition by improving water capture and plant water uptake under a limited supply.

Crop straw retain increases soil organic matter content in a wheat-maize rotation system

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The North China Plain (NCP) is one of the main grain production bases in China. In pursuance of high yield, excessive application of chemical fertilizers has been becoming increasingly common and problematic, while, only little organic fertilizer was applied. As a result, soil quality has becoming degradation. Since the beginning of this century, crop straw return has been implemented in the North China Plain and it is beneficial for improving soil fertility and soil quality. In order to estimate the effect of straw retain on promoting soil organic matter, we collected topsoil samples to analyze the content of soil organic matter in wheat-maize rotation field in Nanpi county of the North China Plain in a 1.5km grid format in 2015 and explored the change characteristics of soil organic matter by comparing data on soil organic matter in the topsoil in 1981 (when the second national soil survey was conducted) with that in 2015. The results indicated a significant change in soil organic matter, increasing from 7.87~9.57 g/kg in 1981 to 12.1~16.2 g/kg in 2015, representing total increase of 62.4%, which represented an annual increase of 1.44%. There was a significant positive correlation between the amount of organic carbon returned from crop straw and the increase of soil organic matter. Under the current soil fertility and crop planting structure, it needs to return at least 2930kg/ha/y organic carbon to maintain the balance of soil organic matter in wheat-maize rotation field. There was no significant relationship between soil organic matter and wheat yield, while, the maize yield significantly increased with the increase of soil organic matter content. The yield potential of maize will increase by 532 kg per ha with the 1g/kg increase of soil organic matter content in the surface soil.

Contributions of residue-C/-N to plant growth and SOM pools under planted and unplanted conditions

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Soil microorganisms are considered the most effective decomposers of applied crop residues, but it is poorly understood which communities are primarily responsible for decomposition under different conditions. A pot experiment was conducted in a greenhouse to follow the cycling of C and N derived from maize (Zea mays L.) residues labeled with both 13C and 15N to a subsequent winter wheat (Triticum aestivum L.) crop and to soil pools under planting with winter wheat (+P) or an unplanted control (–P), both in soil maintained at field moisture capacities of 40% and 80%. Soil microbes involved in residue decomposition were investigated by 13C phospholipid fatty acid (13C-PLFA) analysis technique. At wheat maturity, a total of 68% of residue N was recovered in the +P treatments, in which 26% was recovered from wheat plants and another 42% from soil total N (TN), independent of the water regimes, while only 50% was recovered from TN in the –P treatments. More residue C was recovered as soil organic carbon in +P than –P treatments (33% vs. 27%), and the trend became more significant with soil moisture. In addition, the +P soil had 35–48% larger microbial biomass carbon (MBC) than the –P soil, and more residue C was recovered as MBC in +P than –P treatments (7% vs. 4%), suggesting the induced microbial utilization of the applied residues. The distribution of the residue-derived PLFA-C showed that only 16:1ω7c and 18:1ω7c had larger relative abundances in the +P than the –P soils, suggesting that they were mainly stimulated by the presence of wheat. Our results demonstrate that the enhanced recovery of residue-C and -N by the presence of wheat plants was mainly from the induced microbial utilization of applied residues by altering the activities of specific microorganisms.

Carbon and nitrogen recycling from microbial necromass to cope with C: N stoichiometric imbalance by priming

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The relationship between the amount of labile C input and the resulting priming effects (PEs) on soil organic matter (SOM) mineralization remains unclear, particularly under anoxic conditions and at high C input rates common in microbial hotspots. PE intensity and the relevant mechanisms were investigated by incubation of three flooded paddy soils over 60 days after 13C-labeled glucose addition ranging from 50 to 500% of microbial biomass C (MBC). CO_2, CH_4 and N_2O emissions were continuously measured and partitioned for C sources based on 13C-label. PE peaked at moderate glucose addition rates (50-300% of MBC) but decreased, and even became negative, under higher rates. Nitrate production from SOM and N_2O emission also peaked at moderate glucose loads in accordance with the N mining from SOM expected for PE. However, low or negative PE at high glucose loads above 300% of MBC posed a paradox of stronger N-acquisition accompanied by decreased SOM mineralization. Particularly at glucose input >3 g kg-1 (corresponding to 300-500% of MBC), strong N immobilization by microorganisms was confirmed by minimum levels of soil mineral N and negligible N_2O emission. Concomitantly, microorganisms intensified N acquisition from microbial necromass by increased N-acetyl glucosaminidase and leucine aminopeptidase activities without accelerating SOM decomposition. Several peaks of glucose-derived CO_2 and CH_4 effluxes were observed between days 13 and 30, confirming decomposition of glucose-derived microbial necromass (contribution to corresponding total CO_2: >80%). Contents of glucose-derived mineral-bound C, which originated from microbial biomass turnover was used as a proxy of net necromass accumulation, increased with glucose input levels over 60 days. Labile C input also accelerated the conversion of living microorganisms to necromass. Therefore, necromass recycling was a hypothesized mechanism to alleviate microbial N deficiency without priming SOM (hereafter referred to SOM components other than necromass). Compound-specific 13C-PLFA confirmed redistribution of glucose-derived PLFAs, i.e. 13C recycling, among microbial groups during the 60 days. Initially after labile C input, gram-negative bacteria (presumably r-strategists) rapidly incorporated glucose together with N and used them for growth. After glucose was exhausted and r-strategists died, their necromass became a substrate providing labile C and N for the gram-positive bacteria, actinomycetes and fungi, which were less responsive initially after glucose addition. We conclude that N sources for microorganisms depend on labile C input: to cover N demand under C excess, microorganisms switch from SOM-N mining to the N recycling from microbial necromass.

Short-term decomposition, turnover and retention of residue-derived carbon are influenced by the fertility level in a sandy loam soil

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The straw residue amendment to soil is documented as an effective measure for integrated fertility management, and residue's decomposition dynamics are closely related to the physical, chemical and biological properties of soil. This paper aimed to investigate the effects of soil fertility on residue-derived carbon (C) decomposition, turnover and retention, and to identify the linkages between these processes and soil aggregation as well as microbial community. Arable soils following 27-year applications of compost and inorganic NPK along with a control (no fertilizer) were collected to divide into the corresponding high, medium and low fertility levels, and an in situ incubation was set up with these soils amended with and without 13C-labeled maize residues. During the whole incubation, the residue decomposition was significantly affected by the fertility level, and the retentions of residue-C in soils were ranked as high fertility soil > medium fertility soil > low fertility soil. Adding straw residue and improving the fertility level were favorable for the formation of water-stable macroaggregates. Following the addition of 13C-labeled residues, although the residue-C was preferentially incorporated into the large macroaggregate (>2000 μm) and then translocated to smaller aggregates, the large macroaggregate made the greatest contribution to the residue-C retention. The distinct microbial community dynamics determined their residue-derived 13C incorporations into microbial biomass. The increasing 13C incorporations into gram-positive (G+) bacteria, fungi and anaerobes and decreasing 13C incorporations into gram-negative (G-) bacteria, actinobacteria and aerobes corresponded to improving fertility levels. Consequently, soil aggregation and microbial community composition collectively explained 92% of the variation in residue-C retention, and their interaction exerted the largest effect. It can be concluded that residue return could effectively enhance soil fertility, which in turn contributes to residue-C retention by associating with macroaggregation and microbial community in a sandy loam soil.