Soil management effects on soil organic matter properties and carbon sequestration, SOMPACS

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SOMPACS is the project realized in the 1st external call of EJP SOIL program entitled "Towards Healthy, Resilient and Sustainable Agricultural Soils". The aim of the project is to identify management practices and systems enriching soils with the organic matter pools that are stable and the most resistant to microbial decomposition for various soil and climatic conditions in Europe and the USA while ensuring high yields. For this purpose, soil samples from eight long-term field experiments with different soil management and cultivation systems (conventional tillage vs. no-tillage; mineral vs. organic fertilization; management with and without catch crop; arable land vs. grassland; and cultivated vs. non-cultivated soils) will be investigated. Field experiments will include trials of increasing duration: 22-year (Lithuania); 26-year (Italy); 30-year (Poland, Ireland); 46-year (Poland); 54-year (Lithuania); 100-year (Poland) and 178-year Broadbalk experiment (UK). Experiments will also be conducted in production fields, where, in addition to the most innovative cultivation methods, additives will be applied that stimulate root growth and at the same time provide very stable C (commercial humic products, biochar, and biogas digestate). The effects of these additives on the content and properties of SOM will be investigated in plots of long-term field experiments, as well as incubation studies on the microbial decomposition of SOM and these additives. Parallel to soil sampling, plant productivity will be measured in all field experiments. Basic soil properties will be supplemented by the following investigations based on state-of-the-art approaches: SOM composition and stability by Py-GC-MS; aggregate size classes and C pools of increasing physico-chemical protection; microbiological properties (community-level physiological profiling, selected functional genes involved in C and N cycles, microbiome and mycobiome analyzes via next-generation sequencing, genetic diversity using terminal restriction fragment length polymorphism); analysis of δ13C and δ15N of the separated SOM pools; enzymatic activity; soil water retention and soil water repellency; mineral composition of clay fraction; soil structure stability. The most resistant SOM pools (humin) will be isolated by different methods and examined for chemical composition and structure, using spectrometric and spectroscopic techniques (mass spectrometry, NMR, FTIR, EPR, UV-Vis-NIR,

fluorescence). The C stocks in the soil will be evaluated and the extractable cold water C will be determined to assess the potential leaching and microbial availability of C. CO2 emissions from the soil will be measured directly under field conditions.

Keywords: soil management, carbon sequestration, soil organic matter, spectroscopic properties, soil organic matter pools

LIFE Nadapta: Soil-based indicators for the assessment of soils vulnerability and resilience in a regional adaptation strategy of agriculture to 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 to climate change of a region of 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: agricultural soils.

Considering the diversity of the region and the variety of agricultural practices spread throughout it, the work was conducted at four levels:

- First, a zoning of the territory was conducted based in biophysical characteristics (series of vegetation) and agroclimatic conditions, where 12 homogeneous zones were identified. A vulnerability study of agricultural soils was conducted at the regional level identifying critical soil characteristics in each of them.
- Second, soil vulnerability and resilience indicators were set for the different expected impacts for each area, considering a set of climate drivers identified for the region based on the study of the climate variations in the XXth century and projections of 2100. The proposed set of indicators includes those potentially modifiable by management (dynamic indicators): Soil organic C (SOC) storage, as well as water retention capacity and bulk density.

- Third, a network of up to 150 control plots was created, in groups for each zone, encompassing the diversity of both soil types and management systems. In these groups of plots, farmers using resilient strategic methodologies such as organic matter management, rotations or conservation agriculture are identified, together with conventionally managed farmers.

- Finally, the set of indicators were monitored in the network of plots, allowing for, firstly, the definition of a reference state in each zone, and, secondly, the estimation of the effect size associated with each strategic management both by zone and the overall region.

The response associated to the adoption of the three adaptive strategies tested in this region showed uneven results on the proposed soil indicators. Although uniform across the region, most of the strategies presented positive effects, in general, on SOC, where organic matter addition was the most effective practice for SOC storage while conservation agriculture seemed to show a tendency to be less effective as aridity decreases. The effectiveness of rotations seems to be strongly influenced by the type and intensity of management. The response of the physical indicators to the adoption of the strategies was more irregular, with no clear relationship between the effect of the strategies considered on the physical indicators and their effect on SOC.

Keywords: CC adaptation; regional approach, soil indicators

Arable interventions to mitigate greenhouse gas emissions

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Agriculture must provide food security for all sustainably and in the face of climate change. There is concern about the effects of cropping on soils quality (losses of structural stability, soil organic carbon (SOC), biological functioning), and greenhouse gas (GHG) emissions from soil.

Soils vary globally, but there is widespread interest in how conservation agriculture (CA) might increase the sustainability of cropping from intensive temperate systems in the global north to smallholder and subsistence production in tropical and subtropical systems of the global south. In all, zero or minimum tillage (ZMT) is implemented to reduce the disruption of soil structure. The retention of organic residues, or other means to build SOC, and the diversification of cropping systems through rotations or intercropping are all components of CA, particularly in the global south.

While there is evidence that CA can increase the resilience of crop yields to climate variations and improve the structure of soils, the question of its impact on GHG budgets remains open. In particular, it is likely that different GHGs respond differently to changes in tillage practice and increase in SOC status, so a strong evidence base is needed to assess the trade-offs between components of the soils GHG budget under CA, and the net effect on global warming potential (GWP) given differences in the climate impact of different gases.

This study will make a substantive contribution to the evidence base for the impact of CA practices on GHG budgets for agricultural soils spanning temperate

European and warmer climate in sub-Saharan Africa. The project consortium brings together researchers and institutions from Europe and Africa who have been active in CA and GHG research, and who currently manage field sites where aspects of CA practice are examined in long-term experiments, mainly ZMT, use of cover crops and legumes, and incorporation of crop residues.

We will use existing experiments in the UK, Ireland, and Poland that include locally relevant ZMT and crop rotation interventions with conventional cultivation comparisons. Similarly, existing experiments in South Africa, Zambia, Zimbabwe and Malawi which compare conventional management of a maize crop with ZMT and residue retention combined with other CA interventions (e.g. intercropping) will be used.

We will test the following hypotheses:

H1: the relative importance of CO_2, CH_4 and N_2O in GHG emissions from managed soils varies between treatments, with reduced CO_2 emissions under ZMT relative to conventional cultivation, possibly due to less mineralisation and reduced gas diffusion; reduced CH_4 emission and increased N_2O under CA practices due to increased water retention and SOC content.

H2: the treatment effects outlined above result in a net reduction in soils GWP from GHG emissions from the CA treatments, due to the reduction in CO_2 from respiration and CH_4 emissions offset by increased N_2O emissions.

H3: Process-based models of C and N fluxes from soil which do not explicitly account for soil pore structure are not able to predict the impact of ZMT on GHG emissions, whereas models which incorporate characterizations of structure are able to do so.

Keywords: conservation agriculture; crop rotations, greenhouse gas emissions

The effect of tillage, manuring and mineral P-K fertilization on soil structural stability in three long-term field trials in the loess belt of Belgium

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Many soils of the Belgian loess belt have a poor structural stability related to a silt-dominated texture and a low soil organic carbon content, which makes them particularly sensitive to compaction and erosion. In this work, we investigated how soil structural stability respond to contrasting tillage treatments, organic matter inputs and PK fertilization at three long-term field trials in the silt loam region of Belgium. Soil structural stability was evaluated by a new, simple test consisting in the dynamic weighting of a structured soil sample once immersed in water, referred to as the QuantiSlakeTest (QST). In total, 40 different fields were sampled and for each of them, QST curves were compared to the three tests of Le Bissonnais, targeting specific mechanisms of soil disaggregation. QST indicators calculated from curves were also related to soil properties.

The overall structural stability of soil was linearly related to the SOM status of soil, well captured by the SOC:Clay ratio. Nevertheless, for a similar C input, green manure and crop residues were more efficient in decreasing clay dispersivity whereas farmyard manure promoted SOC storage and was more efficient against slaking. QST curves had a strong discriminating power between reduced tillage and ploughing regardless of the indicator, as reduced tillage increases both total SOC content and root density in the topsoil. In contrast, long-term mineral P and K under- and over-fertilization had no significant effect on soil structural stability.

Our results confirmed, for the soils of central Belgium, the validity of the SOC:Clay ratio as a proxy to estimate the intrinsic “potential” structural stability of soil, whereas the QST mass increase recorded shortly after immersion of soil provides a quantitative measurement related to the overall soil structural stability. The QST has several advantages: it is rapid to run, doesn’t require expensive equipment or consumables and provides a high density of information on both specific mechanisms of soil disaggregation and the overall soil structural stability. As an open-access program for QST data management is currently under development, the test has a strong potential for adoption by a widespread community of end-users.

Keywords: Soil structural stability, soil management practices, tillage, organic matter, P and K fertilizers, SOC:clay ratio, QuantiSlake test

Use of hemp stem residues for soil quality

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Increase of carbon stocks in the soil forces researchers and technology creators to look for innovative agricultural technologies all around the Europe. It is known that rotting plant residues supply bioavailable organic carbon together with essential nutrients to the soil. One of the most promising way to increase soil organic matter is growing of perennial grasses. They do not require much input, but have many benefits for the environment. Nevertheless, the use of grass biomass is decreasing with lowering level of husbandry in most countries. Therefor there is a need to look for alternatives. Nowadays the growing of hemp is increasing and as this crop has very rich root system, it is expected that they could have benefit to the soil. Hemp loosens and softens the soil and fallen foliage forms mulch that preserves substances and bacteria in the soil. After harvesting, the root system quickly disappears. If hemp is grown for the extraction of phytocanabinoids, up to two-thirds of the organic matter returns to the soil. Hemp plants reduce the population of nematodes and pathogenic fungi in the soil and can be grown without the use of pesticides, herbicides or fungicides. The introduction of hemp in crop rotation has been shown to improve soil conditions. Nevertheless, there is lo information about the degradation of hemp stems in the soil if they are left and their potential for soil quality and soil carbon content improvement. The aim of this study was to investigate the speed of hemp residues degradation under different management systems. Different amendments: ammonium nitrate (KNO_3), liquid nitrogen fertilizers (KAS) and liquid organic fertilizers have been used to accelerate the decomposition of hemp stem residues. Hemp stem residues was applicate on the top of soil and mixed with the soil. The results showed that the faster degradation was then hemp stem residues were mixed with the soil and applied with liquid nitrogen fertilizers (KAS).

Keywords: hemp, soil, residues.