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CARBON SEQUESTRATION BY ORGANIC CONSERVATION TILLAGE – A COMPREHENSIVE SAMPLING CAMPAIGN IN NINE EUROPEAN LONG-TERM TRIALS

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Abstract: Conservation tillage is suggested to sequester carbon although a stratification of soil organic carbon rather than a total increase is mostly observed. It is not clear whether conservation tillage in combination with organic farming practices has a higher potential. Beyond, many datasets are biased in terms of sampling depth. A joint sampling campaign in nine European long-term trials considered soil organic carbon stocks until 100 cm soil depth comparing reduced tillage with ploughing under organic farming conditions. First results show a significant increase of carbon stocks in 0-30 cm and also in 0-100 cm depth with the conversion to reduced tillage.

Introduction: Aggravation of weather extremes increases awareness of climate change consequences. Mitigation options are in demand which aim at reducing the atmospheric concentration of greenhouse gases. For carbon dioxide (CO_2), sequestration as soil organic carbon in the pedosphere is discussed globally. Amongst others, the conversion from ploughing to conservation tillage is argued to increase soil organic carbon (SOC) stocks as an accumulation of SOC in topsoil layers is commonly reported (Powlson *et al.*, 2014). Conservation tillage includes tillage systems from no-tillage (or direct seeding) to different forms of reduced tillage, where tillage is still accomplished but less intensive compared with traditional ploughing. Yet, main findings of reviews and meta-analyses that compare SOC stocks between conservation tillage and ploughing changed over time: from a significant increase of SOC stocks to the question if there is any effect at all (Powlson *et al.*, 2014). The reason for this change is a sampling bias as in a lot of campaigns only topsoil layers were assessed. However, changing the tillage regime redistributes SOC within the profile resulting in an increased stratification and often lower SOC stocks in deeper soil layers in conservation tillage systems. Apart from sampling depths, there are also other constraints in the assessment of SOC stocks including different methods of SOC concentration determination, bulk density determination (Walter *et al.*, 2016) and the discussion on the comparison of SOC stocks based on equivalent soil masses instead of equal sampling depths (Powlson *et al.*, 2014).

Organic farming differs compared to conventional agriculture in the diversification of crop rotations, increased organic matter input by organic fertilisation, perennial leys and cover crops as well as in non-chemical weed control. Thus, it is questionable if results on SOC sequestration in conventional systems (and thus the majority of studies available) can be directly compared to organic farming with more complex SOC dynamics. Some data on SOC stocks in organic arable farming experiments are available that compare different tillage systems (Krauss *et al.*, 2017) and an assessment of SOC in topsoils showed higher SOC stocks in organic conservation tillage (Cooper *et al.*, 2016). Yet, methodologies and sampling depths vary between studies challenging the comparability. For this reason, a systematic sampling campaign was elaborated to a soil depth of 100 cm to answer the question if the combination of conservation tillage and organic farming does really increase SOC stocks.

Material and methods: In autumn 2017 and spring 2018 a joint soil sampling campaign was organised in nine organic long-term field trials (Table 1) across four countries in temperate Europe. All trials represent mixed organic farming systems typical for the respective region with organic fertilisation and crop rotations including leys. While climatic conditions are similar, soil types vary from sandy to clayey soils.

All trials were sampled with the same technique and equipment. Undisturbed soil cores were taken with a driving hammer (8 cm in diameter) to a maximum depth of 100 cm. The soil core was divided into the soil layers 0-30, 30-50, 50-70, 70-100 cm. The topsoil layer (0-30 cm) was further divided into the different tillage depths of the respective trial (Table 1). Bulk density was calculated and corrected for compaction according to Walter *et al.* (2016).

All samples were analysed in the same laboratory. Total carbon concentrations were determined by dry combustion on a VarioMax cube (Elementar Analysensysteme GmbH, Hanau, Germany). We determined inorganic carbon concentrations by dry combustion on the same machine after removing organic matter by heating the sample in a muffle furnace at 450°C for 4 hours. Organic carbon concentrations were calculated as the difference between total and inorganic carbon concentrations.

Soil texture and $pHCaCl_2$ were determined on pooled samples per plot and soil layer for each trial as covariates and yields were compiled for each trial to assess average carbon inputs.

Results: First analysis reveals a significant increase in SOC stocks by conservation tillage in 0-30 cm and 70-100 cm and thus also in 0-100 cm soil depth across all nine sites. Across a range of pedoclimatic conditions within Europe, it can be shown that conservation tillage in organic farming has a potential for CO_2 sequestration.

At this stage, clay and silt content explain differences between sites best. Further analysis will include also C-input and climatic variables. Final results will be presented at the conference.

Table 1. Overview on long-term experiments included in the sampling campaign

Country	Trial name	Starting date	Mouldboard plough (control treatment)	Reduced tillage

France	Thil trial, ISARA Lyon	2004	30 cm	Chisel, 5 cm
Germany	Organic Arable Farming Experiment Gladbacherhof, University of Giessen	1998	30 cm	Cultivator, rotary harrow 30 cm + 15 cm
	UHOH KH6, University of Hohenheim	1999	25 cm	Chisel, 15 cm
	V501-505 Puch, Bavarian State Research Center for Agriculture	1997	25 cm	Chisel, 10 cm
	V501-505 Neuhof, Bavarian State Research Center for Agriculture	1997	25 cm	Chisel, 10 cm
Netherlands	BASIS, Wageningen University	2010	25 cm	Chisel, 15 cm
Switzerland	FAST, Agroscope	2009	20 cm	Disc/rotary harrow, Geohobel 5 cm
	Frick trial, FiBL	2002	18 cm	Chisel, 10 cm
	Aesch trial, FiBL	2010	18 cm	Chisel, 10 cm

Discussion: Conversion from ploughing to reduced tillage in organic farming shows similar effects as no-till systems. SOC stocks are redistributed in the upper soil layers as described by Luo et al. (2010). An increase in the uppermost layer and reduction in and just below the old plough layer display the new tillage regime with the lack of deeper incorporation of organic material. However, with the consequent application of the same sampling method to 100 cm soil depth, we were able to show another increase in SOC stocks in 70-100 cm across a range of soil types. We presume that differences in rooting may explain this subsoil enrichment which was however not assessed in this study. Across sites, soils with a higher clay content had a larger potential for carbon sequestration. In total, a significant increase of SOC stocks in 0-100 cm suggests that reduced tillage in combination with organic farming practices has a high potential for carbon sequestration.

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