The Relevance of Subsoil C and N for the Assessment of Cropping System Impact on Soil Organic Matter

LUCAS A.D. KNEBL[1], GÜNTER A. LEITHOLD[2], CHRISTOPHER J. BROCK[3]

Key words: soil organic matter, subsoil, tillage

Abstract

The aim of this study was to verify the importance of subsoil SOC and STN amounts in the evaluation of the effects of tillage treatments on soil organic matter (SOM). The research was carried out in the Organic Arable Farming Experiment Gladbacherhof (OAFEG). It could be observed that tillage does not show any significant effects on SOC and STN in the topsoil, but influences their dynamics in the subsoil. In particular, SOC and STN decreases with all reduced tillage treatments, while FIT had no significant effect on SOC in the topsoil, and even showed a significant STN and SOC increase in the subsoil. The consideration of subsoil SOM changes therefore makes a difference in the interpretation of treatments compared to an evaluation based on topsoil-data.

Introduction

For a sustainable agriculture it is indispensable to develop management practices which are most appropriate for the specific site where crop production takes place. In this context it is necessary to include all nutrient sources available. Although the subsoil contributes to a remarkable extend to plant nutrition, little is known about the dynamics of nutrients in deeper soil layers (Kautz et al., 2013). This is mostly due to the extent and the costs of analyses needed to provide such information. The aim of this study is to assess the relevance of the subsoil in the assessment of long-term effects of soil management types with focus on the organic long term field experiment at the experimental station Gladbacherhof (Knebl et al., in prep.).

Material and methods

The OAFEG has been carried out at the experimental station Gladbacherhof. The station is located in Villmar in the Taunus hill landscape in Hesse, Germany (altitude 170 masl., mean annual temperature 9.5°C, mean annual precip. 649mm, orthic luvisol, silt with high clay content). The experiment includes three different crop rotations/fertilizations and four tillage treatments in a two-factorial design (Schulz et al., 2014). Crop rotations correspond to mixed farming, stockless cash crop farming and stockless cash crop farming with rotational ley. The different tillage treatments comprise full inversion tillage at 30 cm (FIT), two layer plow at 15/30cm (TLP), reduced inversion tillage at 15 cm (RIT), and non-inversion tillage at 15cm (NIT). The experimental setup is a split plot design with four replications. Soil samples were taken in 0-30cm, 30-60cm and 60-90cm soil depth prior to sowing and after the harvest in four replications per field plot. Additionally the bulk density of each sampling layer was determined and crop yields of each plot were recorded. Amounts of SOC and STN were analyzed by dry combustion. Statistical analyses were performed with STATISTICA (StatSoft) using the GLM procedure.

[1] Justus-Liebig-University Giessen, Professorship of Organic Farming, Karl-Gloeckner Str. 21C, D-35394 Giessen, Germany, organ.landbau@agrar.uni-giessen.de, eMail: lucas.a.knebl@agrar.uni-giessen.de.

[2] Justus-Liebig-University Giessen, Professorship of Organic Farming, Germany, organ.landbau@agrar.uni-giessen.de, eMail: guenter.leithold@agrar.uni-giessen.de

[3] Justus-Liebig-University Giessen, Professorship of Organic Farming, Germany, organ.landbau@agrar.uni-giessen.de, eMail: christopher.j.brock@agrar.uni-giessen.de

Results

Figure 1 illustrates the losses and increases in STN and SOC over an eleven year period in the sampling layers 0-30cm, 30-60cm and 60-90cm. Letters and symbols denote significant differences between the tillage treatments and their effects on STN and SOC levels. Considering the STN and SOC amounts in the sampling layer of 0-30cm soil depth, the tillage treatments RIT, TLP and NIT led to significant decreases in STN and the treatments RIT and TLP resulted in a significant decrease in SOC. In deeper soil layers the FIT treatment is showing a significant increase in STN SOC in the layer 30-60cm, whereas RIT, TLP and NIT result in significant decreases in SOC in the subsoil. The SOC decrease under RIT and NIT is even higher than the decrease observed in 0-30cm soil depth. The treatment TLP stands out with a considerable SOC decrease in the sampling layer of 60-90cm. As one can see, the four examined tillage treatments do not differ in their effect on topsoil STN and SOC. Considering the subsoil. Only the FIT treatment differs significantly in its effect on the STN and SOC amounts in the 30-60cm layer.

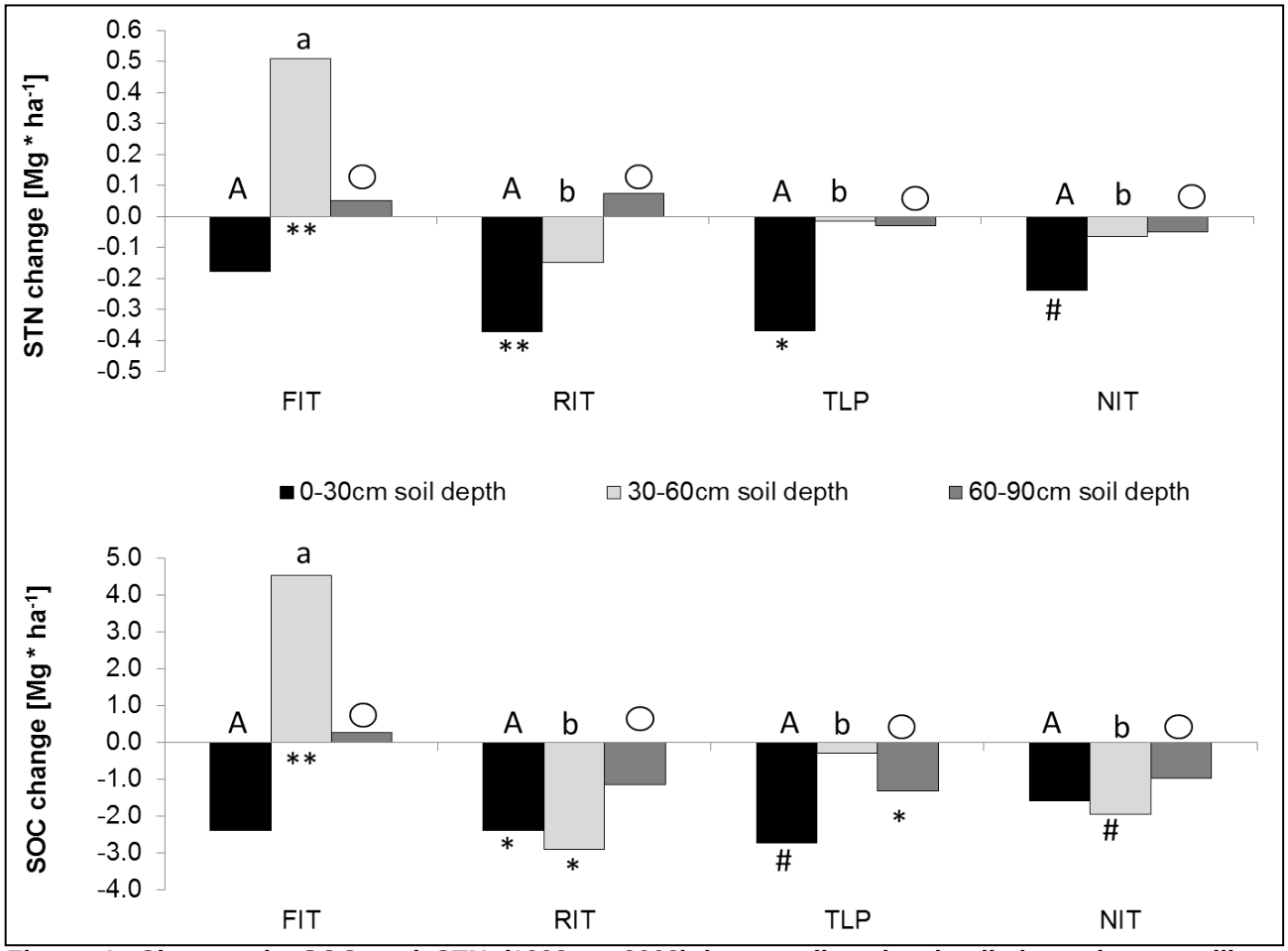

Figure 1. Changes in SOC and STN (1998 to 2009) in topsoil and subsoil dependent on tillage intensity.

** significant change at α = 0.01; * significant change at α = 0.05; # significant change at α = 0..10.
Different letters/symbols denote significant differences between treatments at α = 0.05. Upper case = differences in the level 0-30cm; lower case = differences in the level 30-60cm; symbols = differences in the level 60-90cm; RIT= reduced inversion, FIT= full inversion tillage, NIT= non inversion tillage, TLP= two layer plow

Discussion

The consideration of subsoil soil organic matter changes does make a difference in the interpretation of treatments compared to an evaluation based on topsoil-data. The significant increase in STN as well as SOC in the 30-60cm layer of the tillage treatment FIT may be a result of incorporated plant residues and dissolved organic matter. This reason thus fails to explain the contrary effects observed in the RIT and TLP treatments. Up to now, no similar results of other studies could be found. This indicates the demand for further

investigations. It is to verify whether the results of this study are unique findings for the long-term field experiment Gladbacherhof. If similar results occur, the evaluation of full inversion tillage compared to a reduced and/or non- inversion tillage needs to be revisited.

References

Kautz, T.; Amelung, W.; Ewert, F.; Gaiser, T.; Horn, R.; Jahn, R.; Javaux, M.; Kemna, A.; Kuzyakov, Y.; Munch, J.-C.; Pätzold, S.; Peth, S.; Scherer, H. W.; Schloter, M.; Schneider, H.; Vanderborght, J.; Vetterlein, D.; Walter, A.; Wiesenberg, G. L. B.; Köpke, U. (2013): Nutrient acquisition from arable subsoils in temperate climates: A review. Soil Biol. Biochem., 57, pp. 1003–1022.

Knebl, L.; Leithold, G.; Brock, C. (in prep.): Consideration of the subsoil can change the assessment of management impact on soils in arable farming. Soil Till. Res.

Schulz, F., Brock, C., Schmidt, H., Franz, K.-P., Leithold, G. (2014): Development of soil organic matter stocks under different farm types and tillage systems in the Organic Arable Farming Experiment Gladbacherhof. Arch. Agron. Soil Sci., 60 (3):313-326. DOI: 10.1080/03650340.2013.794935