Restoration of a Compacted Clayey sol with Cover Crop: Recovery Rate and Processes Involved.

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Introduction

Soil compaction is one of the major threats to soil quality because all soil functions are impacted. Both mechanical (e.g. tillage) and biological (e.g. cover crops) tools are commonly used to restore soil structure. However, the role of soil constituents on soil structure forming and protection has also been emphasized. Clay minerals are at the origin of abiotic structuration through shrink-swell processes. The role of soil organic carbon (SOC) on the soil structure has been widely studied (Kay, 1998). SOC is correlated to structure quality, stability and structure resilience, hence it strongly determines structure vulnerability. Moreover, SOC content is modified, positively or negatively, by agricultural practices, and significant changes may occur within 5 years, i.e. this factor can be controlled by farmers contrarily to e.g. texture or mineralogy. Because of the growing concerns on soil quality and the increased focus on soil functions, the protection of soil structure in arable land becomes a priority. Though techniques allowing structure restoration are documented, the operational question for farmers is at which rate the structure can be improved and its vulnerability decreased. This question is less documented, to our best knowledge, in particular if production requirements must be taken into account. The objective of this study is to quantify and analyze the processes of structure recovery, in a clayey cambisoil under intensively cropped orchard, after soil tillage and one season of cover-crop growth.

Methods

The soil is a clayey cambisol developed on morain, and cultivated with apple trees since 1990. Its average clay content is 35%, and it is strongly depleted in organic carbon with a Corg:clay ratio of 5. The soil is compacted with an average bulk density of 1.45 at -10 hPa and 1.7 at dry state. The average visual evaluation of soil structure (VESS) on the spade test is 4. After sampling the soil at 5-10 cm and 20-25 cm depth for initial situation, the soil was ploughed with a digging machine and a cover crop of *Sorghum bicolor* was seeded in April.
Sorghum growth was characterized, and in September the soil was described for structure and root growth, and sampled for analyses. The physical properties were obtained using shrinkage analysis (ShA) performed on undisturbed samples. VESS and CoreVESS were also performed, and the soil samples were analyzed for texture, SOC, pH and CEC.

Main results and discussion

The SOC content of the soil increased significantly of 0.9 % at 5-10 cm depth, due to incorporation of the very first cm of topsoil by tillage, and remained constant at 20-25 cm depth. On the top layer, the Corg:clay ratio increased from 5 to 7 %. The VESS scores decreased significantly in both layers. The top layer VESS average score was 2 after treatment.
The ShA parameters were significantly modified in the top layer, with in particular a sharp increase of the soil and structural porosity volumes. Moreover, the relationships between these parameters and SOC were significantly changes: the increase in pore volumes was only

partly due to SOC increase and the additional pore volume corresponded to a shift in the intercept of the relationship (Figure 1). These changes are analogous, but inverse, to the changes reported in the case of soil compaction in previous studies, thus featuring a general pattern of structure quality changes. According to these results, the structure recovery is partly due to root development and biological activity. However the structure remains vulnerable since the SOC:clay ratio is far below the required values for good structure quality (Johannes et al., 2017).

Main conclusions

In a season, the structure quality and the VESS scores were greatly improved from degraded to good structure in the top layer. The changes were concordant with the root development, and significant changes were also observed below the plough layer. Therefore, the *Sorghum bicolor* root system was largely responsible for the improvement of the structure, though it was not possible do make distinction with the effect of the soil tillage. A significant SOC increase was also observed but accounted for a small part of the structure recovery only. Further SOC increase is necessary to secure the structure recovery and decrease its vulnerability.

References

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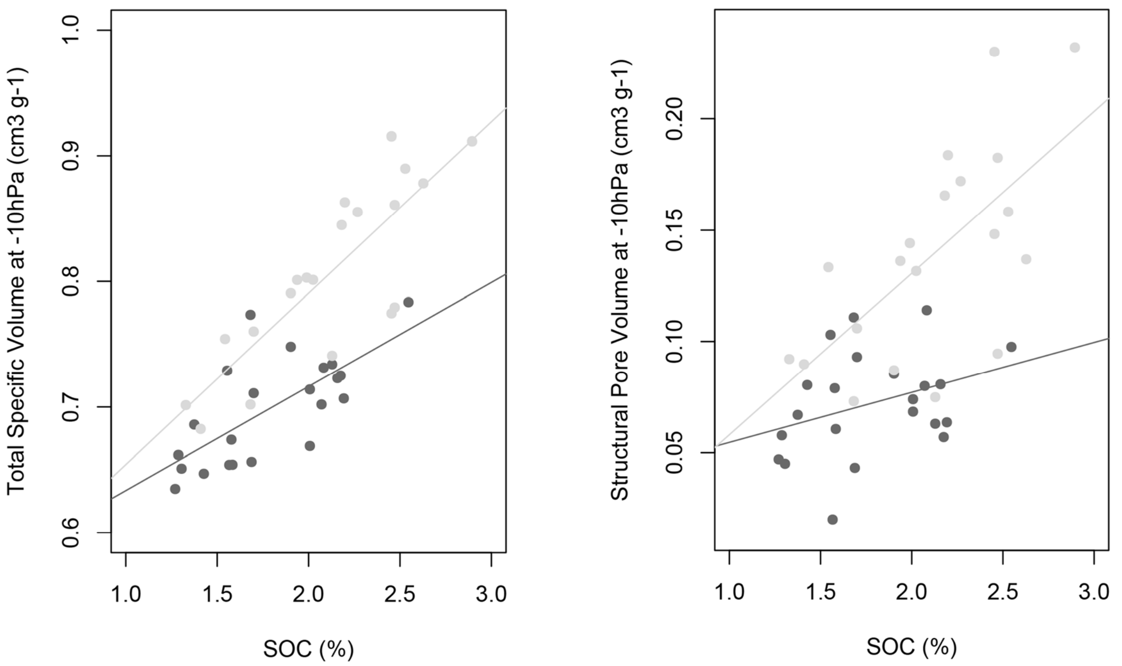

Figure 1. Soil specific volume (left) and specific structural pore volume (right) as a function of soil organic carbon content (SOC). Grey: after recovery, dark grey : before recovery. Dots: experimental values, lines: regression. Adapted from (Fell et al., 2018)