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Effect of different tillage systems on aggregate structure and inner distribution of organic carbon

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ABSTRACT

Tillage is a common agricultural practice affecting soil structure and biogeochemistry. Pore network geometries are crucial to oxygen concentration, gas diffusivity, water location and water movement. Soil aggregates, 4–6 mm in diameter and collected from silty loam in Belgium and sandy loam in China, were scanned using a micro-computed tomography scanner. Images with a pixel size of 6.9 μm were then processed with ImageJ software for pore network analysis. The treatments were no tillage (C-NT) and conventional tillage (C-CT) in China, and shallow tillage (G-ST) and conventional tillage (G-CT) in Belgium. The results showed that aggregates in conservational tillage (G-ST and C-NT) had numerous connected pores compared with conventional tillage (G-CT and C-CT). The Euler number (Ev) was significantly lower and visible total porosity and surface area (SA) were significantly higher in conservational tillage (G-ST and C-NT) than in conventional tillage (G-CT and C-CT) in both studied locations.

The predominant size of pores was significantly higher in conservational tillage (G-ST and C-NT) than in conventional tillage (G-CT and C-CT) (>150 μm vs 90–120 μm). Pore location within the aggregates also showed differences, with porosity being evenly distributed in the aggregates under conventional tillage (G-CT and C-CT). Under conservational tillage (G-ST and C-NT), the aggregates were heterogeneous, showing higher porosity at the center of the aggregates. There was a higher soil organic carbon (SOC) content in the external layer than in the internal layer in conservational tillage in Belgium (G-ST). In no tillage in China (C-NT), the SOC in the external and internal layers, however, showed similar results.

Overall, conventional tillage (G-CT and C-CT) reduced the proportion of the largest pores within soil aggregates, whereas there was no significant relationship between pore morphologies and SOC content. Further investigation is required to measure the active and slow carbon pool distribution in the different layers and under different tillage practices.

1. Introduction

The management of agricultural systems is known to affect soil quality and structure through tillage, fertilization and other practices (Madari et al., 2005). Soil aggregates, especially macro-aggregates, have been widely used to evaluate soil quality and the response of soil to agronomic management and environmental change (Six et al., 1999;Yu et al., 2016). Recently, attention has been paid to soil organic carbon (SOC) levels within soil aggregates as a potential C sink. This sequestration may be a result of intra-aggregate structuration under different tillage practices (Smucker et al., 2007).

Structure plays a role in oxygen concentration, gas diffusivity, water location and water movement. All these variables control the pedoclimatic conditions in which the microorganisms develop (Lützow et al., 2006; Grandy and Robertson, 2007). The pore structure of macro-aggregates, however, is difficult to measure because of the lack of efficient measurements on an aggregate scale (Wang et al., 2011). In recent years, X-ray computed tomography has shown considerable promise in the non-destructive exploration of soil structure in 3D at different scales (Young et al., 2001;Peth et al., 2008). Some studies have scanned soil cores from 3 to 20 cm with a 15–500 μm resolution in order to visualize and quantify macro-pore characteristics and thus predict soil hydro-geochemical functions (Katuwal et al., 2015; Bottinelli et al., 2016). X-ray computed micro-tomography could produce high-resolution images and detect the microstructure changes in soil aggregates. Peth et al. (2008) applied synchrotron radiation micro-computed tomography (SR-μCT) and characterized the pore

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