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Soil wet aggregate distribution and pore size distribution under different tillage systems after 16 years in the Loess Plateau of China

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ABSTRACT

In the Loess Plateau of China, conventional tillage is defined as the tillage without crop residues left on the soil surface and ploughed twice a year. The use of alternative practices is a way to reduce soil erosion. Our objectives were to assess the long-term impacts of different soil tillage systems on soil physical and hydraulic characteristics, emphasizing management practices to improve the soil physical qualities (reduce bulk density and increase stability of aggregate) under the conservation tillage system in the Loess Plateau of China. Conventional tillage (CT), no tillage (NT), and sub-soiling (SS) were applied in this experiment. Soil wet aggregates distribution and stability, soil organic carbon (SOC) content, soil water retention curves and pore size distributions were measured. The results showed that in the 0–10 cm and 10–20 cm depth soil layers, NT and SS treatments showed a significantly higher proportion of wet aggregates > 250 μm (macroaggregates) compared to CT. In these two layers, the proportion of wet aggregates < 53 μm (microaggregates) was significantly higher in CT with respect to NT and SS. SOC content increased as the aggregate fraction size increased, and was higher within wet aggregates > 250 μm than within the 250–53 μm and < 53 μm (silt + clay) fractions at both depths. In addition, the conservation tillage (NT and SS) can result in improved total porosity and reduced soil bulk density compared with CT in the surface layer. Pore size distribution in CT soil was unimodal, with the maximum in the 10–30 μm matrix pores of the surface layer. However, in the surface layer the pore size distributions from NT and SS showed a dual porosity curve, with two peaks in the matrix and structural pore areas. The 10–20 cm layer showed similar pore size distributions in each treatment. After scanning the soils by micro-computed tomography, we visualized the pore characteristics. The images showed that CT reduced the long and connected macropores compared with conservation tillage. Overall, soil aggregate stability and soil macropores are most improved under conservation tillage. Conservation tillage with crop residues should be adopted instead of conventional tillage, as an effort to improve crop yield and control soil erosion in the Loess Plateau of China.

1. Introduction

The Loess Plateau accounts for one-third of the arable land in China, and plays a vital role for the agricultural production of the country (Li et al., 2016; Qiu et al., 2016). In this region, the average annual precipitation varies 200 and 750 mm. The rainfall is mainly occurring in summer (June to September) (Li and Huang, 2008; Lin and Liu, 2016), and heavy thunderstorms cause severe soil erosion and nutrient losses (Hessel et al., 2003).

Conventional tillage is the dominant tillage practice, normally ploughing twice a year with stubble removal, in this area. However, this type of tillage practice system can cause alterations to the soil physical characteristics (bulk density, aggregate stability and pore size distribution) (Hill, 1990; Tagar et al., 2017) and increase the risk of erosion (Liu et al., 2015). In order to reduce the severe erosion under conventional tillage, considerable attention has been paid recently on the conservation tillage as a long-term sustainable practice for agricultural ecosystems (Su et al., 2007).

There are many different conservation tillage systems, such as no tillage, sub-soiling and reduced tillage (Blevins et al., 1983; Holland,

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