Long-term evaluation of tillage methods in fallow season for soil water storage, wheat yield and water use efficiency in semiarid southeast of the Loess Plateau

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Introduction

In semiarid southeast of the Loess Plateau, the yield reduction due to soil compaction is more remarkable owing to insufficient rainfall storage in fallow season (Jin et al., 2008). Therefore, the efforts aimed to break compacted soil layers should be made to maximize the positive effects of conservation tillage on crop productivity. Deep ploughing to a depth more than 30 cm is one of the useful practices to alleviate soil compaction through destroying hard pans and decreasing soil bulk density in drought susceptible crop-lands. Subsoiling is other effective solution for the breaking-up of soil compaction and increasing water storage but without distribution of soil structure (Hou et al. 2012; Hu et al. 2013). Yet, a long-term evaluation on soil water dynamics under these techniques is sorely missing. So a 7-years exploration on annual variation of grain yield and soil water storage under deep-ploughing and subsoiling is needed to clarify the rainfall influences on validity of both tillage methods.

Objective

The objective of this study therefore is to analyze the spatial dynamics and annual changes of soil water storage in the 0–300 cm layer, to evaluate the overall effects and annual variation of tillage methods on yield and components, water use efficiency, water storage efficiency.

Materials and Methods

Site: A 7-year field study was established at the Wuxi Dryland Wheat Agriculture Station, Shanxi Province of China between 2009 and 2015.

Experimental design: In this experiment, three different tillage methods in fallow season were designed as: 1) deep ploughing to 25–30 cm; 2) deep subsoiling to 30–40 cm and 3) no tillage in fallow season as control. In each year, previous wheat was harvesting in end of June. Thereafter, tall stubble (20–30 cm) was remained to reduce water evaporation and increase soil organic carbon for next season. In the 10th to 15th day after previous harvesting, three tillage methods were initiated by using two different ploughing machines. In later August, rotary tillage and land leveling were performed for sowing.

Results

Our results indicated that compared to no-tillage, the soil water storage (0–300 cm depth) was averagely increased by 7.8% and 6.0% during fallow season, 13.7% and 9.8% in growing season under deep ploughing and subsoiling respectively. Furthermore, the increasing magnitude in soil water due to deep ploughing and subsoiling was, on average, 10.1% and 5.5% higher in dry season than that in wet one. Improved soil water condition under deep ploughing and subsoiling significantly increased the ear number and grain yield by 20.2% and 15.9%, 30.8% and 25.8% respectively, but did not affect seed number and weight of thousand seed over the experimental seasons. Moreover, grain yields under deep ploughing and subsoiling were averagely increased by 35.2% and 24.8% in dry season, 28.7% and 20.6% in wet season respectively. Accordingly, water use efficiency and precipitation use efficiency were increased by 12.1% and 31.9% under deep ploughing, 11.1% and 25.0% under subsoiling respectively. Critically, we found that with an increase of 10% water storage efficiency during fallow season, ear number, grain yield and WUE could be increased by 0.2 million ha⁻¹, 24.1 kg ha⁻¹ and 0.6 kg ha⁻¹mm⁻¹ respectively.

Conclusions

Results clearly indicated that deep ploughing in fallow season should be adopted as a promising strategy to retain soil water availability and hence boost wheat productivity in semiarid southeast Loess Plateau.