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Soil Wind Erosion, Nutrients, and Crop Yield Response to Conservation Tillage in North China: A Field Study in a Semi-Arid and Wind Erosion Region after 9 Years

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Abstract : Context: Soil erosion is a global issue that poses a significant threat to agricultural sustainability, particular in northern of China, which experiences the most severe wind erosion worldwide. Conservation tillage is vital in arid regions for preserving soil, enhancing water retention, and sustaining agricultural productivity in the face of limited rainfall. However, the long-term impacts of conservation tillage in semi-arid regions, especially its effects on soil health, wind erosion, and crop productivity, are poorly understood. Objective: Assess the impacts of conservation tillage on soil hydrothermal properties, wind erosion rates, nutrient dynamics, and crop yield, as well as elucidating the underlying mechanisms driving these impacts. Methods: A 9-year in-situ study was conducted in Chifeng, Inner Mongolia Province, comparing conventional rotary tillage (CK) with two conservation tillage methods: no-tillage with straw mulching (CT-1) and no-tillage with standing straw (CT-2). Results: Soil bulk density increased significantly under CT-1 and CT-2 in the topsoil layer (0–20 cm) compared with CK. Soil moisture content exhibited a significant increase pattern under CT-1 and CT-2, while soil temperature decreased under CT-1 but increased under CT-2, relative to CK. These variations in soil hydrothermal properties were more pronounced during the early (critical) crop growth stages and higher temperature conditions (afternoon). Soil loss due to wind erosion, accumulated from a height of 0–50 cm on the land surface, was reduced by 31.3 % and 25.5 % under CT-1 and by 51.5 % and 38.2 % under CT-2 in 2021 and 2022, respectively, compared to CK. Furthermore, the proportion of soil finer particles (clay and silt) increased under CT due to reduced wind erosion. Soil organic carbon significantly increased throughout the soil profile (0–60 cm), particularly in the deeper layers (20–40 cm and 40–60 cm), compared to the surface layer (0–20 cm), with corresponding increases of +57.0 % and +0.18 %, +66.2 % and +80.3 %, and +27.1 % and +14.2 % under CT-1 and CT-2, respectively, relative to CK in 2021. The concentrations of soil nutrients such as total nitrogen, available nitrogen, and available phosphorus and potassium, consistently increased under CT-1 and CT-2 compared to CK, with notable enhancements observed in the topsoil layer (0–20 cm) before seedling time, albeit declining after crop harvest. Generally, CT treatments significantly increased dry matter accumulation (+4.8 % to +30.8 %) and grain yield (+2.22 % to +0.44 %) of maize compared to CK in the semi-arid region over the 9-year study period, particularly notable in dry years and with long-term application. Conclusions and implications: Conservation tillage in semi-arid regions enhanced soil properties, reduced soil erosion, and increased soil nutrient dynamics and crop yield, promising sustainable agricultural practices with environmental benefits. Furthermore, our findings suggest that no-tillage with straw mulching is more suitable for dry and wind erosion sensitive regions.

Keywords : no tillage, conventional tillage, soil water, soil temperature, soil physics
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