Understanding Plant Available Water Capacity in Long Term No-Tillage Systems

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Abstract

Improving soil water retention is critical for sustaining crop productivity and enhancing climate resilience in modern agroecosystems. Plant available water capacity (PAWC) is a key indicator of soil physical quality that regulates water storage and supply to plants. However, long term field evidence linking management practices with PAWC and soil pore structure remains limited. This study evaluated the legacy effects of organic amendments and cover cropping on PAWC and pore size distribution in an Alfisol under a 27 year no-tillage (NT) system in central Ohio, USA. Four treatments were examined: fallow with no input, cover crop, compost applied at 15.3 Mg/ha/yr, and cow manure applied at 23.3 Mg/ha/yr, arranged in a randomized complete block design with four replications. Soil samples were collected from 0 to 20 cm and 20 to 40 cm depths. Water retention was measured using tension tables and pressure plate extractors, and PAWC was calculated as the difference between field capacity at pF 2.5 and permanent wilting point at pF 4.2. Results showed that manure treated soils had the highest PAWC in the surface layer, reaching 5.14 ± 1.31 cm, while fallow soils showed higher PAWC in the subsurface layer at 5.88 ± 1.04 cm. Water content at field capacity ranged from 44.4 ± 0.8 % in manure treated soils to 35.8 ± 2.0 % in cover crop treatments. PAWC exhibited a strong positive relationship with storage pores, with $R^2 = 0.92$ to 0.94 and $p < 0.001$, indicating the dominant role of mesoporosity in controlling plant available water. These findings demonstrate that long term organic amendments, particularly manure, significantly enhance soil water retention and improve the resilience of temperate agroecosystems under NT management.

Keywords

Plant available water capacity, No-tillage system, Organic amendments, Soil pore size distribution, Water retention characteristics, Alfisol.