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Long-term orchard management effects on some soil hydraulic and biological properties

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Introduction

Conversion of arable soil to no tillage systems with perennial crops like orchards often results in carbon sequestration and changes in soil structure. Interrelationships between soil structure and soil organisms that form aggregates and create biopores affect water retention and transmission functions of soil. The sensitivity of the hydraulic properties to changes in soil structure depends on the length of time since application of no tillage systems and organic matter content. We assessed the effects of 15 yr and 35 yr of orchard management compared with continuous application of tillage system on some hydraulic, mechanical and biological properties of soil.

Materials and methods

The experimental site was located on silty loam derived from silt formations, non-uniform on chalk marl in the Agricultural Experimental Station at Felin, near Lublin, on the Świdnicki Plateau. The experimental plot treatments included 15 yr (15O) and 35 yr (35O) apple orchards and conventionally tilled field (CT). Infiltration of water into the soil was determined by the double ring infiltrometer. To analyse the water-conducting pores (preferential flow) Brilliant blue solution was infiltrated from the soil surface with a constant head of 15 mm. Core samples of 100 cm^3 volume were used to find the soil water characteristic curve. Sorptivity of soil aggregates (25 mm) was measured using the device that infiltrated water through a circular surface area of the sponge. Aggregate crushing strength was determined by a strength-testing device and aggregate bulk density – by standard wax method.

Results and discussion

Mean soil organic C under CT, 15O and 35O was respectively 1.15, 1.61 and 1.68% at 0-20 cm layer and 0.87, 0.89 and 1.28% at 20-40 cm layer. Depending on depth pH (in H_2O) varied from 5.8 to 6.0 in TT and from 6.4 to 7.7 in both orchard soils. Acidification of tilled soil can arise from the stimulation of nitrification and the leaching of Ca^{2+} from the soil surface layer without protective plant cover. Soil bulk density was the lowest under 35O.

The sensitivity of the water retention to soil management systems was related to the soil water potential and depth. At water potential (0 to – 3.1 kPa) soil water retention at the depth of 0-10 cm was highest in conventionally tilled soil, however in deeper soil (till 40 cm) it was higher in 15 and 35-year orchards with maximum in 35 yr orchard. Soil water retention at –1500 kPa was the greatest in soil under 15 yr orchard. This could be partly a result of somewhat higher clay content in this soil. Retention of plant available water at intermediate water potentials (–15.5 kPa to –1554 kPa) was the highest in soil under 35 yr orchard with the greatest organic C content in most layers. Water infiltration into the soil under both orchards was several times greater than into tilled soil due to likely high contribution of flow active surface open earthworm channels in the former.

Bulk density of soil aggregates was highest under CT and successively decreased in 15y and 35y orchards at most depths. Mean values of crushing strength of aggregates were lowest at all depth under 35 yr orchard and can be related with higher soil organic C and associated better friability. Sorptivity of soil aggregates at 0-20 cm was higher under both orchards than under CT whereas at 20-40 cm it was similar in all treatments. Water stability of air-dry soil aggregates was not very different between the treatments. Soil respiration as measured by CO_2 emission was greater under orchard than conventionally tilled soil.

Conclusion

Under the conditions of the experiment, long-term orchard management increased soil organic C content, macroporosity, plant available water and sorptivity of soil aggregates. Water infiltration into the orchard was substantially greater than into the tilled soil. Aggregate crushing strength was lowest under 35 yr orchard soil having highest organic C content.