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Environmental and management impacts on temporal variability of soil hydraulic properties

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Soil hydraulic properties underlie temporal changes caused by different natural and management factors. Rainfall intensity, wet-dry cycles, freeze-thaw cycles, tillage and plant effects are potential drivers of the temporal variability. For agricultural purposes it is important to determine the possibility of targeted influence via management. In no-till systems e.g. root induced soil loosening (biopores) is essential to counteract natural soil densification by settling.

The present work studies two years of temporal evolution of soil hydraulic properties in a no-till crop rotation (durum wheat-field pea) with two cover crops (mustard and rye) having different root systems (taproot vs. fibrous roots) as well as a bare soil control. Soil hydraulic properties such as near-saturated hydraulic conductivity, flow weighted pore radius, pore number and macroporosity are derived from measurements using a tension infiltrometer. The temporal dynamics are then analysed in terms of potential driving forces.

Our results revealed significant temporal changes of hydraulic conductivity. When approaching saturation, spatial variability tended to dominate over the temporal evolution. Changes in near-saturated hydraulic conductivity were mainly a result of changing pore number, while the flow weighted mean pore radius showed less temporal dynamic in the no-till system. Macroporosity in the measured range of 0 to -10 cm pressure head ranged from 1.99e-4 to 8.96e-6 m3m-3.

The different plant coverage revealed only minor influences on the observed system dynamics. Mustard increased slightly the flow weighted mean pore radius, being 0.090 mm in mustard compared to 0.085 mm in bare soil and 0.084 mm in rye. Still pore radius changes were of minor importance for the overall temporal dynamics.

Rainfall was detected as major driving force of the temporal evolution of structural soil hydraulic properties at the site. Soil hydraulic conductivity in the slightly unsaturated range (-7 cm to -10 cm) showed a similar time course as a moving average of rainfall. Drying induced a decrease in conductivity while wetting of the soil resulted in higher conductivity values. Approaching saturation however, the drying phase showed a different behaviour with increasing values of hydraulic conductivity. This may be explained probably by formation of cracks acting as large macropores.

We concluded that aggregate coalescence as a function of capillary forces and soil rheologic properties (cf. Or et al., 2002) are a main predictor of temporal dynamics of near saturated soil hydraulic properties while different plant covers only had a minor effect on the observed system dynamics.

Or, D., Ghezzehei, T.A. 2002. Modeling post-tillage soil structural dynamics. a review. Soil Till Res. 64, 41-59.