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Assessing agricultural management effects on structure related soil hydraulic properties by tension infiltrometry

G. Bodner (1), W. Loiskandl (2), and H.-P. Kaul ()

(1) Inst. of Agronomy and Plant Breeding, University of Natural Resources and Applied Life Sciences (BOKU), Gregor Mendel Str. 33, 1180 Vienna, Austria, (2) Inst. of Hydraulics and Rural Water Management, University of Natural Resources and Applied Life Sciences (BOKU), Muthgasse 18, 1190 Vienna

Soil structure is a dynamic property subject to numerous natural and human influences. It is recognized as fundamental for sustainable functioning of soil. Therefore knowledge of management impacts on the sensitive structural states of soil is decisive in order to avoid soil degradation. The stabilization of the soil's (macro)pore system and eventually the improvement of its infiltrability are essential to avoid runoff and soil erosion, particularly in view of an increasing probability of intense rainfall events.
However structure-related soil properties generally have a high natural spatiotemporal variability that interacts with the potential influence of agricultural land use. This complicates a clear determination of management vs. environmental effects and requires adequate measurement methods, allowing a sufficient spatiotemporal resolution to estimate the impact of the targeted management factors within the natural dynamics of soil structure.
A common method to assess structure-related soil hydraulic properties is tension infiltrometry. A major advantage of tension infiltrometer measurements is that no or only minimum soil disturbance is necessary and several structure-controlled water transmission properties can readily be derived. The method is more time- and cost-efficient compared to laboratory measurements of soil hydraulic properties, thus enabling more replications. Furthermore in situ measurements of hydraulic properties generally allow a more accurate reproduction of field soil water dynamics.
The present study analyses the impact of two common agricultural management options on structure related hydraulic properties based on tension infiltrometer measurements. Its focus is the identification of the role of management within the natural spatiotemporal variability, particularly in respect to seasonal temporal dynamics. Two management approaches are analysed, (i) cover cropping as a "plant-based" agro-environmental measure, and (ii) tillage with different intensities including conventional tillage with a mouldboard plough, reduced tillage with a chisel plough and no-tillage.
The results showed that the plant-based management measure of cover cropping had only minor influence on near-saturated hydraulic conductivity (kh) and flow weighted mean pore radius (m). Substantial over-winter changes were found with a significant increase in kh and a reduction in the pore radius. A spatial trend in soil texture along the cover cropped slope resulted in a higher kh at lower pressure heads at the summit with higher fractions of coarse particles, while kh tended to be highest at the toeslope towards saturation. Cover crop management accounted for a maximum of 9.7% of the total variability in kh, with a decreasing impact towards the unsaturated range. A substantial difference to bare soil in the cover cropped treatments could be identified in relation to a stabilization of macro-pores over winter.
The different tillage treatments had a substantial impact on near-saturated kh and pore radius. Although conventional tillage showed the highest values in kh and m, settling of the soil after the ploughing event tended to reduce differences over time compared to the other tillage methods. The long-term no-tillage (10 years) however had the lowest values of kh at all measurement dates. The high contents of silt and fine sand probably resulted in soil densification that was not counterbalanced sufficiently by biological structure forming agents.
The study could show that soil structure related hydraulic properties are subject to a substantial seasonal variability. A comprehensive assessment of agricultural measures such as tillage or cover cropping requires an estimate of these temporal dynamics and their interaction with the management strategies. Particularly for plant-based management measures such as cover cropping, which represent a less intense intervention in the structural states of the soil compared to tillage, this was evident, as the main mechanism revealed for this measure was structure stabiliza-

tion over time.

While spatial variability is mostly controlled in designed experiments, the role of temporal variability is often underestimated. From our study we concluded that (i) a proper understanding of processes involved in management effects on soil structure must take into consideration the dynamic nature of the respective soil properties, (ii) experimental planning for studies regarding management impacts on soil structure should allow an estimation of temporal variability, and (iii) for this purpose tension infiltrometry provides an efficient measurement tool to assess structure related soil hydraulic properties.