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Characterization of tillage effects on soil permeability using different measures of macroporosity derived from tension infiltrometry

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Soil macroporosity is a highly dynamic property influenced by environmental factors, such as raindrop impact, wetting-drying and freezing-thawing cycles, soil biota and plant roots, as well as agricultural management measures. Macroporosity represents an important indicator of soil physical quality, particularly in relation to the site specific water transmission properties, and can be used as a sensitive measure to assess soil structural degradation. Its quantification is also required for the parameterization of dual porosity models that are frequently used in environmental impact studies on erosion and solute (pesticide, nitrate) leaching. The importance of soil macroporosity for the water transport properties of the soil and its complexity due to high spatio-temporal heterogeneity make its quantitative assessment still a challenging task.

Tension infiltrometers have been shown to be adequate measurement devices to obtain data in the near-saturated range of water flow where structural (macro)pores are dominating the transport process. Different methods have been used to derive water transmission characteristics from tension infiltrometer measurements. Moret and Arrúe (2007) differentiated between using a minimum equivalent capillary pore radius and a flow weighted mean pore radius to obtain representative macropore flow properties from tension infiltrometer data. Beside direct approaches based on Wooding's equation, also inverse methods have been applied to obtain soil hydraulic properties (Šimůnek et al. 1998). Using a dual porosity model in the inverse procedure allows estimating parameters in the dynamic near-saturated range by numerical optimization to the infiltration measurements, while fixing parameters in the more stable textural range of small pores using e.g.
pressure plate data or even pedotransfer functions.

The present work presents a comparison of quantitative measures of soil macroporosity derived from tension infiltrometer data by different approaches (direct vs. inverse evaluation, capillary vs. flow weighted pore radius). We will show the influence of the distinct evaluation procedures on the resulting effective macroporosity, as well as on the relationships between macropore radius and hydraulic conductivity (Moret and Arrúe, 2007) and pore fraction respectively (Carey et al., 2007).

The infiltration measurements used in this study were obtained in a long-term tillage trial located in the semi-arid region of Eastern Austria. Measurements were taken five times over the vegetation period, starting immediately after tillage until harvest of the winter wheat crop. Three tillage systems were evaluated, being conventional tillage with plough, minimum tillage with chisel and no-tillage. Additional to infiltration measurements, also soil water content was monitored continuously by a capacitance probe in all three replicates of each tillage treatment in 10, 20 and 40 cm soil depth. Water content time series are used to derive flow velocity in the wet range by cross-correlation analysis (Wu et al., 1997). This effective parameter of water transmission will then be compared to the flow behaviour expected from the characterization of soil macroporosity.

We will show that mainly in no-tillage systems large macropores contribute essentially to flow and therefore the decision on pore measure and evaluation procedure to be used leads to substantial differences. For a detailed comparison of tillage effects on soil hydraulic properties it is therefore essential to analyse the contribution of different

tension infiltrometry based evaluation methods to explain effective water transmission through the complex porous network of the soil.

References

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