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Consolidation and surface sealing of nine harrowed Swedish soils

Maria Sandin, Nicholas Jarvis, and Mats Larsbo
Swedish University of Agricultural Sciences, Department of Soil and Environment, Uppsala, Sweden (maria.sandin@slu.se)

The structure of agricultural top soils varies considerably throughout the year due to interactions between climatic and biological factors and agricultural management practices. Tillage decreases soil density and increases macroporosity, but the resulting arrangement of aggregates is unstable and the soil eventually reverts back to its denser pre-tillage condition. Accounting for post-tillage changes in soil structure and related hydraulic properties could greatly improve model predictions of hydrological and transport processes. Model testing, development and parameterization is, however, currently hampered by a lack of direct measurements of the changes occurring in the structural pore system.

Samples collected from the harrowed layer of nine different fine- and medium-textured Swedish soils were subjected to subsequent wetting and drying cycles in the laboratory. Initial wetting and equilibration at -30 cm pressure potential was followed by three cycles of simulated rainfall (5 mm h-1 for 4 hours) and equilibration. X-ray tomography (image resolution of 60 μm) was used to quantify changes in surface and total porosity, pore size distribution (PSD) and connectivity of structural pores.

Total porosity decreased (by 2-24%) in all soils except for two clay soils where in one case the porosity increased slightly (3%) and in the other remained unchanged. In several of the soils, the PSD shifted significantly towards smaller pore sizes and the connectivity of the pore network also generally decreased. Surface porosity decreased most markedly (by 73 and 75%) in two silt loam soils and these changes were also strongly correlated with the silt content. Only weak correlations were found between changes in total porosity and variables reflecting soil texture and organic carbon content. Changes in the PSD appeared to be mainly controlled by the initial structure (i.e. aggregate size distribution) of the sample created at the time of tillage and sample preparation.