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Deep rooting plants influence on soil hydraulic properties and air conductivity over time

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Crop sequences are commonly suggested as an alternative to improve subsoil structure. A well structured soil can be characterized by enhanced transport properties. Our main hypothesis was, that different root systems can modify the soil's macro/mesopore network if enough cultivation time is given.
We analyzed the influence of three crops with either shallower roots (Festuca arundinacea, fescue) or taproots (Cichorium intybus, chicory and Medicago sativa, alfalfa). The crops where cultivated on a Haplic Luvisol near Bonn (Germany) for one, two or three years. Undisturbed soil cores were taken for measurement of unsaturated hydraulic conductivity and air permeability. The unsaturated conductivity was measured using the evaporation method, monitoring the water content and tension at two depths of each undisturbed soil core. The van Genuchten–Mualem model (1991) was fitted to the measured data. Air permeability was measured in a permeameter with constant flow at low pressure gradient. The measurements were repeated at -1, -3, -6, -15, -30 and -50 kPa matric tension and the model of Ball et al. (1988) was used to describe permeability as function of matric tension. Furthermore, the cores equilibrated at -15 kPa matric tension were scanned with X-Ray computer tomography. By means of 3D image analysis, geometrical features as pore size distribution, tortuosity and connectivity of the pore network was analyzed.
The measurements showed an increased unsaturated hydraulic conductivity associated to coarser pores at the taprooted cultivations. A enhanced pore system (related to shrink-swell processes) under alfalfa was observed in both transport measurements and was confirmed by the 3D image analysis. This highly functional pore system (consisting mainly of root paths, earthworm channels and shrinking cracks) was clearly visible below the 75 cm of depth and differentiated significantly from the other two treatments only after three years of cultivation, which shows the time needed to modify soil structure under these conditions.