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# Measuring and modeling three-dimensional water uptake of a growing faba bean (Vicia faba) within a soil column

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A faba bean was grown in a column filled with a sandy soil, which was initially close to saturation and then subjected to a single drying cycle of 30 days. The column was divided in four hydraulically separated compartments using horizontal paraffin layers. Paraffin is impermeable to water but penetrable by roots. Thus by growing deeper, the roots can reach compartments that still contain water. The root architecture was measured every second day by X-ray CT. Transpiration rate, soil matric potential in four different depths, and leaf area were measured continously during the experiment.

To investigate the influence of the partitioning of available soil water in the soil column on water uptake, we used R-SWMS, a fully coupled root and soil water model [1]. We compared a scenario with and without the split layers and investigated the influence on root xylem pressure. The detailed three-dimensional root architecture was obtained by reconstructing binarized root images manually with a virtual reality system, located at the Juelich Supercomputing Centre [2]. To verify the properties of the root system, we compared total root lengths, root length density distributions and root surface with estimations derived from Minkowski functionals [3]. In a next step, knowing the change of root architecture in time, we could allocate an age to each root segment and use this information to define age dependent root hydraulic properties that are required to simulate water uptake for the growing root system.

The scenario with the split layers showed locally much lower pressures than the scenario without splits. Redistribution of water within the unrestricted soil column led to a more uniform distribution of water uptake and lowers the water stress in the plant. However, comparison of simulated and measured pressure heads with tensiometers suggested that the paraffin layers were not perfectly hydraulically isolating the different soil layers. We could show compensation efficiency of water uptake by the roots in the lower and wetter compartments. By comparing transpiration rates of experiments with and without additional paraffin layers, we were able to quantify restrictions of plant growth to available soil water.

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