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Water distribution at the root-soil interface: is there more water next to roots?

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Plants are big water movers and have a significant impact on soil water dynamics as well as on the global water cycle. Despite the relevance of root water uptake in terrestrial ecology, the movement of water from soil to roots still presents important open questions, e.g the following two. Which are the properties of the soil near the roots? And what effect do these properties have on soil plant water relations? Most models are based on brute-force spatial averaging of soil properties and assume that the bulk soil has the same properties as the rhizosphere. However, there is evidence in the literature that the rhizosphere has specific properties that may affect water and nutrient uptake (Young 1995, Gregory 2007).

In order to investigate the rhizosphere hydraulic properties and their effect on soil plant water relations, we used neutron radiography and neutron tomography to image the water content distribution in soils during plant transpiration. Rectangular (quasi-2D) and cylindrical containers were filled with sandy soil and planted with lupins (Lupinus albus). Three weeks after planting, the samples were equilibrated at water potentials of -10 and 30 hPa and have been imaged for 5 days at intervals of 6 hours. At day 5 the samples were irrigated again via capillary rise and the water distribution was monitored for 4 more days.

During the first day of the drying period, regions of water depletion formed around the central part of the tap root where first order laterals were present. As the soil dried up, the picture changed: instead of less water around the roots, as commonly supposed by models, we observed that more water was present around the lateral roots. Interestingly, these regions during drying were retaining high water content, but after irrigation remained markedly drier than the bulk soil.

Our hypothesis is that high water content near roots during drying and lower water content during rewetting are explained by the presence of bio-polymers exuded by roots forming a hydrogel that consists of up to 99% water at very negative water potentials (Read et al. 1999). Thanks to its high water holding capacity, this hydrogel maintains a continuous hydraulic pathway across soil and roots for an extended period of time during drying. During rewetting it adversely affects water redistribution, like a storage that needs time to fill up again. These data show for the first time in situ the potential role of mucilage in controlling water dynamics in the rhizosphere and consequences for plant water extraction.

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