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On the way to roots: The journey of water across the soil-plant system

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The experiment

Plants can survive only if water continuously is provided to the roots. In its journey to plants, water flows from heterogeneous soil to the soil-root interface, and then is being taken up by roots before it is transported to the leaves where it delivers minerals and departs the plant system. Although many studies have acknowledged the importance of the root-soil interface in water uptake by plant roots, there is gap of knowledge about how water flows from soil to roots. The main reason for this gap is the technical difficulties resolving the water distribution in such a small area around the roots. Our understanding of water dynamics around the roots has been limited to speculations from models of water uptake by roots which ignore the role of soil-root interface. Spatially and temporally resolved data on the water movement from soil to roots is needed in order to improve our understanding of mechanisms controlling water uptake by roots. Neutron radiography and tomography are non-destructive imaging techniques enabling us to map water distribution around the roots in-situ. We grew chick pea, maize, and lupine in for 2 weeks at a water potential of -15 hPa. The samples then were imaged for consecutive days over day and night and during a drying period and after rewetting. In contrary to what models of water uptake by roots predict, we observed an increase in water content towards the root surface for all plants. This increase is due to specific properties of the soil in immediate vicinity of the roots, i.e. rhizosphere. It has been demonstrated that roots excrete mucilage and other polymeric substances into their rhizosphere. These materials contain more than 90% water even at very negative potentials. In another words, the roots modify the physical and chemical properties of their rhizosphere. Using modeling scenarios we showed that the presence of rhizosphere with higher water-holding capacity than the bulk soil facilitates the root uptake of water especially as soil dries out. Most of the present modeling approaches neglect this effect.

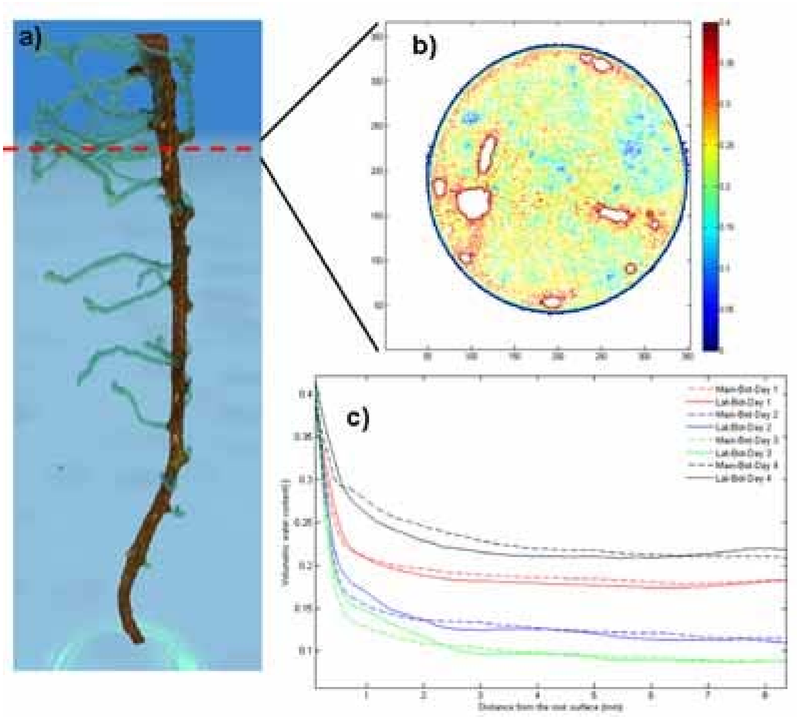
The facility

Experiment at: NEUTRA station, SINQ, Paul Scherrer Institute (PSI), Villigen, Switzerland

Publications:

Carminati, A., Moradi, A. B., Vetterlein, D., Vontobel, P., Lehmann, E., Weller, U., Vogel, H., Oswald, S. E., (2010). Dynamics of soil water content next to roots: the role of the rhizosphere, Plant and Soil, (in press).

Moradi, A. B., Carminati, A., Vetterlein, D., Vontobel, P., Lehmann, E., Weller, U., Vogel, H., Oswald, S. E., (2010). Micro-scale distribution of water around plant roots using neutron tomography, (prepared for submission to European Journal of Soil Science).



Root structure of Chick pea segmented and reconstructed from tomography data (a), horizontal 2-d water content map through the tomography data showing higher water contents around the roots (b), and quantified water content profile over time as a function of distance from the root surface (c). Our results show that rhizosphere holds more water than the bulk soil due to the root modification of their immediate environment.