Geophysical Research Abstracts,
Vol. 10, EGU2008-A-10164, 2008
SRef-ID: 1607-7962/gra/EGU2008-A-10164
EGU General Assembly 2008

Soil-plant interactions: X-ray tomography of the soil-root interface

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Soils are actively and dynamically modified by plants. As roots grow and take up water, they alter the soil structure. Cracks and dense regions form during root growth; fissures along roots are consequence of root shrinkage during drought periods; soil aggregation close to roots has also been reported. These and other coupled chemical and biological processes make a complex system out of the soil-root interface, whose properties differ from those of the bulk soil. The hydraulic properties of the soil-root interface and their impact on plant water uptake are not well understood and properly modeled. Objective of this study is to image the pore geometry of soils close to roots and to derive the related hydraulic properties.

We used the technique of X-ray tomography to visualize the pore space in a soil-plant system. The samples were cylinders with a diameter of 3 cm and a height of 7 cm, which were filled with different repacked soils where lupin or maize plants were grown. The plants were irrigated at regular intervals and illuminated with day/night cycles. The samples were tomographed at different stages of plant growth and water saturation.

For the used experimental set-up, we obtained tomograms with a resolution of 0.05 mm. The tomograms yielded the three-dimensional internal structure of the soil-plant system. Large pores, cracks, roots, and the fine-porous soil matrix are distinguishable. Spatial variation in soil porosity is related to variation in the X-ray attenuation coefficient. We observed fissures along the tap root of Lupin plants. These fissures are potential pathways for preferential flow, and they can limit the root water uptake under well drained conditions. Based on the pore geometry along the roots, we calculated the water-filled contact surface between soils and roots. Properties of the soil-root in-

terface in other soil types and plant species are being currently investigated.
With this imaging methods, formation of soil structures by plants and impact on water fluxes can be investigated. Particular attention was dedicated to the properties of the soil-root interface, which controls the plant water uptake and is a habitat for myriads of biological agents.