Geophysical Research Abstracts,
Vol. 11, EGU2009-8096, 2009
EGU General Assembly 2009

Waterflow visualized by tracer transport in root-soil-systems using MRI

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Water supply for root and plant growth is one of the most important soil functions, which is mainly controlled by water fluxes in this unsaturated porous medium. Here, the rhizosphere i.e. the region directly between the rhizoplane and bulk soil is of special interest, since in this area the immediate root water uptake takes place. Using MRI as a powerful non-invasive method the water content can be visualized, but the water flow velocities themselves are too slow to be monitored directly by MRI flow imaging. Therefore indirect methods like monitoring the flux of paramagnetic tracers must be applied.
Using infiltration experiments we have investigated for the first time the behaviour of a Gd-DTPA tracer solution in an unsaturated, heterogenous model soil that held maize and lupin plants, respectively. The tracer content was imaged by a fast spin echo sequence over a period of 60 minutes and a resolution of 0.4 mm. The infiltration process can be divided in several stages:
i) While the plume moves homogeneously into the bulk soil, the tracer does not get into the im-mediate surrounding of the roots during the first three minutes. ii) After this initial period a con-tinuously increasing enrichment of tracer in this region is observed for about 12 minutes. This means that the tracer moves from the environment towards the root-soil interface. iii) However, there are no hints that tracer is taken up by the root-system. So we can conclude that this nega-tively charged paramagnetic Gd-complex behaves conservatively.
The studies show that Gd-DTPA is a very convenient tracer for monitoring flow processes in soil – root systems and the investigations will be extended in future to natural soil cores.