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Where do roots take up water? A method to quantify local root water uptake

M. Zarebanadkouki, Y. Kim, and A. Carminati
Georg-August Univeristy Goettingen, Soil Hydrology, Germany (acarmin@gwdg.de)

During the past decades, considerable advances have been made in the conceptual understanding and mathematical description of root water uptake process. A large number of models of root water uptake with different degrees of complexity are now available. However, effective application of these models to practical situations for mechanistic description of root water uptake requires proper experimental data. The aim of this study is to introduce and test a non-destructive method for quantifying local water flow from soil to roots.
We grew lupin in $30\times25\times1$ cm containers. Each container was filled with a sandy soil which was partitioned into different compartments using 1cm-thick layers of coarse sand. Deuterium (D_2O) was locally injected in soil near the root surface of 18-day old plans. The flow of D_2O into transpiring plants (day) and non-transpiring plants (night) was traced using time-series neutron radiography.
The results showed that: 1) D_2O entered the roots faster during the day than night; 2) D_2O quickly transported inside the roots towards the shoots during the day, while at night this flow was negligible. Differences between day and night were explained by convective flow of water into the root due to transpiration. To quantify the transport of D_2O into roots, we developed a simple convection-diffusion model. The root water uptake predicted by the model was compared with the direct measurements of axial water flow in the roots. This new method allows for quantifying local water uptake in different parts of the root system.