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How rhizosphere affects root water uptake at the plant scale: results from a model

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Current microscopic models of water flow from soil to roots showed the importance of local non-linearities of the soil hydraulic properties next to roots (Schroeder et al., 2009, Schneider et al., 2009). Most of these models are based on the assumption that the soil around roots is homogeneous. However, it is known that the soil next to roots, the so-called rhizosphere, has different hydraulic properties compared to the bulk soil. In particular, mucilage exuded by roots increases the soil water holding capacity with a potential impact for the shape of the water potential towards the roots (Carminati et al., 2010). The effects of the rhizosphere properties on root water uptake have not yet been modeled.

Within our model study, we investigate the role of the rhizosphere on root water uptake. The existing model, aRoot, couples the flow in the root network with the microscopic radial flow to the roots, solved analytically, and the macroscopic water flow in the bulk soil, solved with the Richards equation. This model has been implemented by including the rhizosphere's properties in the analytical solution of the microscopic flow to the roots. We compare the uptake behaviour of various root system realizations by simulating the root water uptake with and without rhizosphere.

The simulations showed that the rhizosphere affects the water uptake behaviour. The rhizosphere's properties weaken the drop in water potential in the vicinitiy of the roots. As a consequence, we expect the root xylem potential to decrease less over time. The presence of the mucilage might also lead to a stronger correspondence between root length distribution and water uptake, in particular in scenarios where the root radial conductivity was relatively high compared to that of the soil.

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