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Root water uptake and rhizosphere dynamics

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Is root water uptake controlled by the hydraulic properties of the rhizosphere? Recent experiments showed that during drying the rhizosphere held more water than the bulk soil. After irrigation the rhizosphere remained temporarily dry and it slowly rewetted after a few days. How to explain such hysteretic and dynamic behavior of the rhizosphere? And what are the implications for soil-plant water relations?
Our hypothesis is that the observed hydraulic behavior was caused by mucilage exuded by roots. Mucilage is a polymeric material that is capable of holding large amount of water, but that contains also lipids that makes it hydrophobic when it dries. Here it is proposed a model of root water uptake coupled with shrinking/swelling of mucilage. Water flow is modeled solving the Richards' equation in radial coordinates. During drying, mucilage is in equilibrium with the bulk water and the rhizosphere is at the equilibrium water retention curve. After irrigation, which typically is a quick process, mucilage does not rehydrate immediately and the rhizosphere rewets only partly. The swelling rate of mucilage is driven by the difference between the water potential in the rhizosphere and the potential that the rhizosphere would have at the actual water content.
The calculations reproduce well the observed water dynamics in the rhizosphere. According to this model the rhizosphere conductivity is not univocally determined by the soil water potential, but it is variable and depends on the drying/wetting history. The study illustrates the dynamic and interacting nature of the water flow to roots.