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Wurzel-Boden-Wechselwirkung und physikalische Prozesse in der Rhizosphäre

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Titel

Root hairs enable high transpiration rates in drying soils

Abstract

What processes facilitate the ability of roots to take up water from the soil? Are root hairs advantageous for water uptake? Despite the well documented role of root hairs in phosphate uptake, their role in water extraction is controversial and the experimental data contradictory. We proposed a novel experimental method to address this question. We grew barley (Hordeum vulgare L. cv. Pallas) and its root-hairless mutant in a pressure chamber whereby the transpiration rate could be varied while monitoring the suction in the xylem. We monitored xylem water potential as function of different transpiration rate during a drying cycle. The relationship between transpiration rate and xylem suction linearly increased in wet soils and did not differ between genotypes. The slope of this increase was equal to the plant hydraulic resistance. When the soil dried the xylem water suction rapidly increased, particularly at high transpiration rates. The root-hairless mutant showed a more marked increase in the xylem suction, indicative of a lower capacity to take up water. Interestingly, the high rise in xylem suction at high transpiration rates did not quickly decrease as the transpiration rate was reduced. To quantitatively understand the relationship between transpiration rate and xylem suction and the role of root hairs, we employed a 3D root architectural model coupled with water flow in soils. The model was parametrized based on measured root architecture and soil hydraulic properties. The role of the root hairs was simulated by extending the root radius in presence of root hairs. This implicitly simulates the ability of root hairs to take up water from their tips, potential softening the drops in water potential across the rhizosphere. The simulations predicted that that as the soil dries a bigger drop in water potential develop around the roots of the root-hairless mutant. Extension of the root radius by 0.7 mm (to simulate the uptake of root hairs) reduced the drop in water potential around the roots and softened the decrease in the xylem water potential, particularly at high transpiration rates. We conclude that the root-soil interface plays a key role in root water uptake and that root hairs reduce the gradient in water potential around the roots and enable plants to sustain high transpiration rates in drying soils.