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Mucilage exudation facilitates root water uptake in dry soils

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As plant roots take up water and the soil dries, water depletion is expected to occur in the rhizosphere. However, recent experiments showed that the rhizosphere of lupines was wetter than the bulk soil during root water uptake. On the other hand, after irrigation the rhizosphere remained markedly dry and it rewetted only after one-two days. We hypothesize that: 1) drying/wetting rates of the rhizosphere are controlled by mucilage exuded by roots; 2) mucilage alters the soil hydraulic conductivity: in particular, wet mucilage increases the soil hydraulic conductivity and dry mucilage makes the soil water repellent; 3) mucilage exudation favors root water uptake in dry soil; and 4) dry mucilage limits water loss from roots to dry soils.

We used a root pressure probe to measure the hydraulic conductance of artificial roots sitting in soils. As an artificial root we employed a suction cup with a diameter of 2 mm and a length of 45 mm. The root pressure probe gave the hydraulic conductance of the soil-root continuum during pulse experiments in which water was injected into or sucked from the soil. First, we performed experiments with roots in a relatively dry soil with a volumetric water content of 0.03. Then, we repeated the experiment with artificial roots covered with mucilage and then placed into the soil. As a model for mucilage, we collected mucilage from Chia seeds. The water contents (including that of mucilage) in the experiments with and without mucilage were equal. The pressure curves were fitted with a model of root water that includes rhizosphere dynamics. We found that the artificial roots covered with wet mucilage took up water more easily.

In a second experimental set-up we measured the outflow of water from the artificial roots into dry soils. We compared two soils: 1) a sandy soil and 2) the same soil wetted with mucilage from Chia seeds and then let dry. The latter soil became water repellent. Due to the water repellency, the outflow of water from the root in this soil was significantly reduced.

The experiments demonstrated that mucilage increased the hydraulic conductance of the root-soil continuum and facilitated the extraction of water from dry soils. The increase in conductivity resulted from the higher water content of the soil near the roots. Mucilage has a lower surface tension than pure water and a higher viscosity, resulting in a slower penetration of mucilage into the soil. After mucilage was placed into the soil, it did not spread into the bulk soil, but it remained near the roots, maintaining the rhizosphere wetter and more conductive than the bulk soil. However, as mucilage dried, it turned water repellent and reduced the back flow of water from the root to soil.

We hypothesize that mucilage exudation is a plant strategy to locally and temporally facilitate water uptake from dry soils. After drying, mucilage becomes water repellent and may limit the local uptake of water after irrigation. On the other hand, mucilage water repellency may as well be a strategy to reduce water loss from roots to dry soils.