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How the soil-root interface affects water availability to plants

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Water supply to roots is essential for plant life. To sustain the root water uptake, a continuous liquid phase has to be maintained at the interface between soil and roots. Gaps between soil and roots may interrupt the liquid-phase continuity across the soil-root interface, acting as capillary barriers for the water flow. Additionally, due to the radial geometry of the flow to roots and the non-linearity of the soil hydraulic conductivity, a drop in water potential and consequently of water content is expected to occur next to the roots, in particular when soil dries and transpiration demand is high. Such a drop in water content may limit water and nutrient uptake by roots.
How plants can overcome these mechanical and hydraulic flow resistances at the root-soil interface?
Recent experiments with neutron radiography showed that during transpiration the water content next to roots was larger than in the bulk soil. Immediately after rewetting, the picture reversed and the soil next to roots remained markedly dry. During the following days the water content next to roots increased, exceeding that of the bulk soil. These water dynamics cannot be described by models assuming homogeneous soil around roots.
Our hypothesis is that the observed moisture dynamics at the soil-root interface were caused by mucilage exuded by roots. Mucilage is mainly composed of polymeric substances and has a high water holding capacity. Mucilage is known to be exuded by roots but its effect on water uptake is not known.
By calculating the water flux to roots we demonstrate that mucilage weakens the drop in water potential at the root-soil interface, increasing the conductivity of the flow path across soil and roots and reducing the energy needed to take up water. Additionally, mucilage improves the mechanical contact between soil and roots, avoiding formation of gaps as roots shrink in response to high transpiration demand or drought stress.
In conclusion, mucilage works as hydraulic and mechanical connector between soil and roots, favoring water availability to plants. However, under severe drought conditions, mucilage becomes dehydrated and reduces the wettability of the soil next to roots. Such a temporary low wettability may have harmful consequences for the water storage in the root zone and should be taken into account in irrigation policy.