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Does the rhizosphere hydrophobicity limit root water uptake?

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The ability of plants to extract water from the soil is influenced by the hydraulic conductivity of roots and their rhizosphere. Recent experiments showed that the rhizosphere turned hydrophobic after drying and it remained dry after rewetting [1]. Our objective was to investigate whether rhizosphere hydrophobicity is a limit to root water uptake after drying.

To quantify the effect of rhizosphere hydrophobicity on root water uptake, we used neutron radiography to trace the transport of deuterated water (D_2O) in the roots of lupines experiencing a severe, local soil drying. The plants were grown in aluminum containers ($30\times30\times1$ cm) filled with sandy soil. The soil was partitioned into nine compartments using three horizontal and three vertical layers of coarse sand (thickness of 1cm) as capillary barrier. When the plants were 28 days old, we let one of the upper lateral compartments dry to a water content of 2-4%, while keeping the other compartments to a water content of 20%. Then we injected 10 ml of D_2O in the dry compartment and 10 ml in the symmetric location. The radiographs showed that root water uptake in the soil region that was let dry and then irrigated was 4-8 times smaller than in the wet soil region[2].

In a parallel experiment, we used neutron radiography to monitor the rehydration of lupine roots that were irrigated after a severe drying experiment. Based on root swelling and additional data on the xylem pressure, we calculated the hydraulic conductivity of the root-rhizosphere continuum. We found that the hydraulic conductivity of the root-rhizosphere continuum was initially 5.75×10^{-14} m $s^{-1}$and it increased to 4.26×10^{-12} m s^{-1}after four hours.

Both experiments show that rhizosphere hydrophobicity after drying is associated with a reduction in root water uptake and a big decrease in hydraulic conductivity of the soil-root system.

[1] Carminati et al (2010) Plant and Soil. Vol. 332: 163-176.

[2] Zarebanadkouki and Carmianti (2013) Journal of Plant Nutrition and Soil Science. Vol. 177: 227-236.