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Root hairs bridge the gap between roots and soil water

Patrick Duddek[1], Mutez Ahmed[1], Mohsen Zarebanadkouki[1], Nicolai Koebernick[2], Goran Lovric[3], and Andrea Carminati[1]

[1]University of Bayreuth, Faculty of Biology, Chemistry and Earth Sciences, Department of Soil Physics, Germany
[2]Department of Soil Science and Soil Protection, Martin Luther University Halle-Wittenberg, 06120, Halle, Germany
[3]Swiss Light Source, Paul Scherrer Institute, 5232, Villigen, Switzerland

Although 40% of total terrestrial precipitation transits the rhizosphere, there is still substantive lack of understanding of the rhizosphere biophysical properties and their impact on root water uptake. Our hypothesis is that roots are capable of altering the biophysical properties of the rhizosphere and hereby facilitating root water uptake. In particular, we expect that root hairs maintain the hydraulic contact between roots and soil at low water potentials. We have recently shown that root hairs facilitate root water uptake in dry soils at high transpiration rates. Our explanation was that root hairs extend the effective root radius decreasing the flow velocity at the root surface and hence the drop in matric potential across the rhizosphere.

To test this hypothesis, we used synchrotron X-ray CT to image the distribution of root hairs in soils. The experiments were conducted with two maize genotypes (with and without root hairs) grown in two soil textures (loam vs sand). Segmenting the different domains within the high-resolution images enabled us to quantify the contact area of the root surface and root hairs with the soil matrix at different water potentials. Furthermore, we calculated the geodesic distance between the root and the soil matrix as a proxy of the accessibility of water to the root.

The results show that root hairs increase the total root surface by approx. 30% and the contact area with the soil matrix by approx. 40%. Furthermore, the average distance from the soil to the root surface decreases by approx. 40% due to hairs, which is the effect of root hairs preferentially growing through macropores. In summary, root hairs not only increase the root surface and the root-soil contact area, but also bridge the air-filled pores between the root epidermis and the soil matrix, thus facilitating the extraction of water. On top of that, the segmented CT images are also the basis for image-based models aiming at quantifying root water uptake and the effect of root hairs.

References

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