



Root hairs facilitate root water uptake across soil textures – a numerical study

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By substantially increasing the surface area of roots available for soil resource capture, root hairs have been hypothesised to facilitate root water uptake, particularly in dry soil conditions. However, existing experimental and computational studies have shown that the effect of root hairs on water uptake cannot be generalised across soils and plant species.

The objective of our study is to investigate to what extent and under which soil conditions root hairs facilitate root water uptake. Ultimately we aim to gain a mechanistic understanding of the effect of root hairs on root water uptake across soil textures.

We scanned maize (*Zea Mays* L.) roots grown in two soil types (loamy and sandy soil) using synchrotron-based X-ray CT. We utilized an image-based modelling approach to simulate water flow through the soil-root continuum by solving the flow equations numerically. This approach allowed us to incorporate rhizosphere properties (e.g. root-soil contact) and root hair shrinkage into the image-based model.

Experimental and numerical results show that under dry soil conditions (-1 to -0.1 MPa) root hairs attenuate the gradient in soil matric potential across the rhizosphere. This results in a more effective water extraction compared to a hairless root. Our model revealed that the effect of hairs is determined by soil properties (e.g. soil porosity), root hair traits (e.g. length and density) and the capacity of hairs to remain turgid under drought stress. Compared to densely packed fine textured soils, the effect of hairs is more pronounced in coarse textured soils and loosely packed fine textured soil. This is explained by the steeper hydraulic conductivity curves of these soils.

In conclusion, our results show that the effect of root hairs is determined by root-soil contact, which depends on soil properties, and root hair shrinkage.