Visualization and quantification of nocturnal water fluxes in soil and roots

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Abstract

Drought is one of the main factors limiting plant growth and food production worldwide. Understanding what processes allows plants to maintain root water uptake and root growth during drought is of paramount importance for designing drought tolerant crops. Hydraulic lift, defined as the transport of water from deep, wet soil layers to dry, upper soil layers through the root system, has been hypothesized to allow plants to maintain growth and transpiration during drought spells. Although Hydraulic lift (HL) is well accepted, its quantification remains challenging. Here, we used neutron radiography to trace the transport of deuterated water (D_2O) from deep, wet soil layers to dry, upper soil layers through the root system of maize plant. The experiments were carried out with maize grown in silty soil in quasi 2-D aluminium slabs. The soil was partitioned in two layers separated by a coarse sand layer that allowed the roots to grow through but limited the water redistribution between the layers. We injected D_2O in the bottom soil layers and imaged the root system in the upper soil lays overnight. We found that when the top layer was dry, water was taken up from the deep soil layers and it was released during night by the roots in the upper dry layer. Interestingly, we also found that the hydraulic redistribution within the root system enables the growth of new roots in the upper dry soil layers. This information is of fundamental importance to understand how root growth is maintained during drought. In summary, this study shows the potential of combining isotope with neutron radiography to estimate hydraulic lift, redistribution of water within the root system and maintenance of root growth in drying soils.

Publications

1. Hayat, F., Ahmed, M.A., Zarebanadkouki, M., Cai, G., Carminati, A., 2018. Measurements and simulation of leaf xylem water potential and root water uptake in heterogeneous soil

water contents. Adv. Water Resour. 124, 96–105. https://doi.org/10.1016/J.ADVWATRES.2018.12.009.

2. Hayat, F., Ahmed, M.A., Zarebanadkouki, M., Javaux, M., Carminati, A., (XXXX). Response of leaf xylem water potential of maize (*Zea mays* L) to varying transpiration rates and soil drying. Frontiers in Plant Science (under review).
3. Zarebanadkouki, M., Trtik, P., Kaestner, A., Hayat, F., Carminati, A (XXXX). Quantitative imaging of root water uptake in soils: approaching the cellular scale. Springer Nature (Under review).

Biography

I am doing Ph.D in department of Soil Physics at University of Bayreuth, Germany. In my Ph.D research, I study the relation of leaf water potential and root water uptake under varying soil water contents. Drought is one of the main factors limiting plant growth and food production worldwide. Plants use different strategies to overcome drought, including numerous responses to continue water uptake at low soil water contents, to avoid water loss, and thereby minimize the reduction of yield and crop growth under drought. Understanding what processes allows plants to maintain root water uptake and root growth during drought is of paramount importance for designing drought tolerant crops.

I am working in plant-soil interaction domain and have well technical and experimental knowledge. I am eager to provide suggestions for discussion topics, roundtables and guest speakers.

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