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Visualization of nocturnal water fluxes in soil and roots

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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 (D2O) 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 aluminum 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 D2O 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.