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Dynamics and reversibility of global hydropatterning in a split-root experiment

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Plant water uptake is often a limiting factor for above-ground productivity and therefore models of soil-vegetation-atmosphere transfer strongly rely on a precise characterization of the spatial organization of root systems. However, roots display plasticity in morphology and physiology under environmental fluctuations. Plants, in fact, can adjust their root length distribution to soil moisture. The phenomenon of hydropatterning consists of preferential lateral root development in water-rich soil areas and suppression of lateral root growth in dry soil areas. The preferential root growth in wet soil areas was previously observed in large portions of root systems exposed to wet soil patches, including diverse types of roots and both pre-existing and newly grown roots. Here we refer to this phenomenon as “global hydropatterning”. However, the capacity of the root systems to adapt to fluctuating soil water availability at daily time scales, for example after a rainfall event, are less clear.

We conducted an experiment with the aim to answer the following research questions: (a) can we detect global hydropatterning in response to a water pulse in a hydraulically isolated soil layer, (b) how fast does global hydropatterning occur and (c) does the phenomenon get interrupted in the previously wetted layer and promoted in another layer when a second pulse is applied there?

We grew maize in 45 cm long cylindrical soil columns organized in four hydraulically isolated soil layers separated by vaseline barriers. After six days of water depletion by the plant, water pulses to reach 15% VWC were injected specifically into selected layers while the remaining layers remained unwatered.

For quantifying dynamic responses of the root systems to the water pulses, we measured root distribution repeatedly and non-destructively every 48 hours using a Magnetic Resonance Imaging (MRI) for four weeks. Vertical soil moisture distribution was quantified using the Soil Water Profiler (SWaP) [1].

A preliminary analysis indicates that roots grew preferentially in layers where water pulses had been applied and that allocation to root growth changed dynamically in response to water pulses.

Our non-invasive measurements suggest that the global hydropatterning appears in less than 48 hours, and that plants adjust root growth to highly dynamic soil moisture conditions.

A more detailed analysis of root growth rates in response to water pulses in different soil layers will be presented and will provide insights into the response time of maize root systems to changing soil moisture conditions and in how far allocation of carbon to different portions of the root system is an absolute response to soil moisture or a relative response to soil moisture distribution.

[1] van Dusschoten, D., Kochs, J., Kuppe, C., Sydoruk, V.A., Couvreur, V., Pflugfelder, D., Postma, J.A., 2020. Spatially resolved root water uptake determination using a precise soil water sensor. Plant Physiol. https://doi.org/10.1104/pp.20.00488