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Observing plants dealing with soil water stress: Daily soil moisture fluctuations derived from polymer tensiometers

Martine van der Ploeg (1) and Gerrit de Rooij (2)

(1) Wageningen University, Environmental Sciences, Soil Physics and Land Management, Wageningen, Netherlands (martine.vanderploeg@wur.nl), (2) Helmholtz Centre for Environmental Research GmbH - UFZ, Halle, Germany

Periods of soil water deficit often occur within a plant's life cycle, even in temperate deciduous and rain forests (Wilson et al. 2001, Grace 1999). Various experiments have shown that roots are able to sense the distribution of water in the soil, and produce signals that trigger changes in leaf expansion rate and stomatal conductance (Blackman and Davies 1985, Gollan et al. 1986, Gowing et al. 1990 Davies and Zhang 1991, Mansfield and De Silva 1994, Sadras and Milroy 1996). Partitioning of water and air in the soil, solute distribution in soil water, water flow through the soil, and water availability for plants can be determined according to the distribution of the soil water potential (e.g. Schröder et al. 2013, Kool et al. 2014). Understanding plant water uptake under dry conditions has been compromised by hydrological instrumentation with low accuracy in dry soils due to signal attenuation, or a compromised measurement range (Whalley et al. 2013). Development of polymer tensiometers makes it possible to study the soil water potential over a range meaningful for studying plant responses to water stress (Bakker et al. 2007, Van der Ploeg et al. 2008, 2010).
Polymer tensiometer data obtained from a lysimeter experiment (Van der Ploeg et al. 2008) were used to analyse day-night fluctuations of soil moisture in the vicinity of maize roots. To do so, three polymer tensiometers placed in the middle of the lysimeter from a control, dry and very dry treatment (one lysimeter per treatment) were used to calculate water content changes over 12 hours. These 12 hours corresponded with the operation of the growing light. Soil water potential measurements in the hour before the growing light was turned on or off were averaged. The averaged value was used as input for the van Genuchten (1980) model. Parameters for the model were obtained from laboratory determination of water retention, with a separate model parameterization for each lysimeter setup.
Results show daily fluctuations in water content changes, with both root water uptake and root water excretion. The magnitude of the water content change was in the same order for all treatments, thus suggesting compensatory uptake.

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