Geophysical Research Abstracts
Vol. 21, EGU2019-4169, 2019
EGU General Assembly 2019

Response of leaf xylem water potential to varying transpiration rates and soil drying in maize (Zea mays L)

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The relationship between leaf water potential, soil water potential and transpiration depends on soil and plant hydraulics and stomata regulation. Our objectives were: 1) to measure the effect of soil drying on the relation between leaf water potential, soil water potential and transpiration rate and 2) to test whether a simple model could be used to reproduce this relation. We combined the root pressure chamber method developed by Passioura, (1980) which allows measuring the suction in the leaves of transpiring plants, with sap flow sensors which measure transpiration. The method provides accurate measurements of the dynamic relationship between transpiration rate and xylem suction. A simple model of water flow toward a single root, across the root and along the xylem was used to simulate the relation between leaf water potential and transpiration rate. The experiments were carried out with 5 week-old maize grown in cylinders of 9 cm diameter and 30 cm height filled with silty soil. The relation was measured at four different soil water contents (WC). The results showed that the relation between transpiration and leaf water potential was linear in wet soils, but as the soil dried, the xylem suction increased and non-linearity were observed at high transpiration rate. The soil dried out uniformly – i.e. WC was uniform along the soil column. The model was capable of reproducing the measured changes in the soil-plant hydraulic conductance in response to soil drying. In wet soil (WC $\approx$ 24%), the soil-plant hydraulic conductance was higher than in drier soils (WC of 12.5%, 9% and 6%). The simplified model is able to reproduce the measurements. Parallel experiments performed with plants not being pressurized showed that plants close stomata to avoid excessive transpiration rates – i.e. stomata closure reduced transpiration when the relation between transpiration and leaf water potential became not linear. The proposed method allows to identify the hydraulic limits to transpiration for plants exposed to soil drying. Our results suggest that stomata regulation on transpiration can be predicted by measurements of the hydraulic conductance of soil and roots.