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Leaf xylem water potential and transpiration rates of pearl millet during soil drying

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As the soil becomes dry, the water potential and the hydraulic conductivity decrease causing a large drop in water potential around the roots which ultimately limit the water supply to the roots and transpiration. However, measuring such drops is challenging. The pressure chamber technique developed by Passioura (1980) allows measuring the drop in intact and transpiring plants. Experiments with wheat (Passioura, 1980) and barley (Carminati et al., 2017) revealed a large drop in matric potential between the soil and the root surface in dry soils and high transpiration rates, which caused a non-linear and hysteretic relationship between leaf xylem water potential (ψ_{leaf}) and transpiration rate (*Tr*). However, to what extent this relationship can be generalized to other plant species and how root and soil parameters affect it require further investigations.

In this study, we used the Passioura technique to measure ψ_{leaf} and *Tr* in a pearl millet variety that showed high drought tolerance (Kholová et al., 2010). The plants were grown in sealed cylinders with roots and soil in a pressure chamber and shoots in a cuvette where *Tr* was changed by altering the light intensity. ψ_{leaf} was measured by applying the pneumatic pressure necessary to bring the water in the cut leaf xylem to atmospheric pressure and it was measured for varying *Tr* and soil moistures. The results show that the relation between ψ_{leaf} and *Tr* was linear in both wet and relatively dry soil conditions, with the slope of the relationship gradually increasing with decreasing soil water content. The higher slope indicates a decreasing soil-root conductance in drying soils, but in contrast to previous studies with wheat and barley, the relationship remained linear also at high *Tr* and in dry soils, and there was no hysteresis. We explain the linearity with the large root surface active in water uptake, which reduces the local flux into the roots. This interpretation is supported by preliminary measurements with neutron radiography and D_2O which showed that the fraction of the root surface extracting water was large. Additionally, the intercept of ψ_{leaf} versus *Tr* was significantly higher (less negative) than the expected soil water potential. This is probably explained by more negative osmotic potential in the xylem than in the soil. We propose that the high offset in ψ_{leaf} and the linearity of ψ_{leaf} and *Tr* would confer a positive advantage to crops exposed to soil drying and high vapour pressure deficit.

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