Proc. 3rd ESA Congress, Abano-Padova, 1994

MEASURING AND MODELING WATER UPTAKE BY ROOTS AT SPATIALLY VARIABLE SOIL MATRIC POTENTIALS

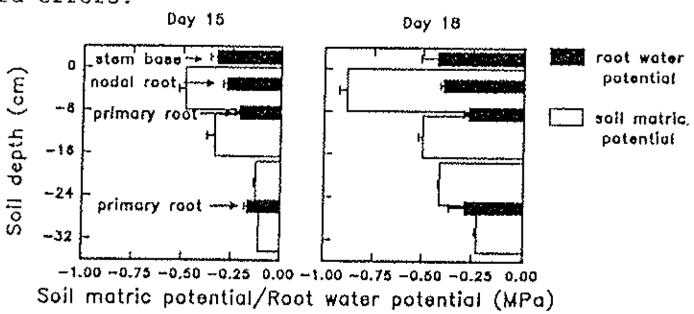
U Schmidhalter, Institute of Plant Sciences, ETH Zürich, 8315 Lindau, Switzerland

Water and nutrients are non-homogeneously distributed in the rhizosphere. This is caused by root activity and management practices or as a result of site- and climate-specific factors. Vertical gradients are especially pronounced in soils which dry out or are rewetted. Therefore, there is seldom a uniform soil matric potential in the root zone and instead, spatially variable soil matric potentials prevail. Conclusive evidence demonstrating the principles of water uptake from this "normal" situation is still missing.

Methods: Water uptake by roots at spatially variable soil matric potentials was measured. For a better understanding of this situation, divided root section techniques were developed to create discontinuous water distribution in vertically separated soil compartments (Schmidhalter et al 1992) and to quantify the water uptake by roots. Maize plants (*Zea mays* L var Issa) were grown for 20 days with and without any watering in tubes filled with a silt loam soil, (fine mixed mesic Aquic Ustifluvent) at different soil matric potentials in four vertically separated compartments. Water potentials of individual roots (seminal, primary, nodal) and of the whole root system were determined with a newly developed modified pressure chamber/osmometer technique (Schmidhalter et al 1992). Additionally, leaf and shoot water potential components were determined.

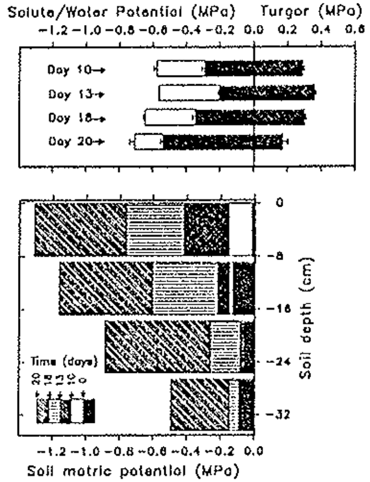
Results: As long as the evaporative demand could be met by roots present in zones with high matric potentials, water uptake essentially occurred there. If the water stress was not too severe, roots (figure 1) and shoots (figure 2) tended to equilibrate during the night with the wetter zones. Roots in drier zones were supplied with water from roots growing in wetter zones.

Figure 1. Soil matric potentials and pre-dawn root water potentials measured at different soil depths after 15 and 18 days in a drying soil. Positions of filled bars indicate location of root measurements. Horizontal bars indicate standard errors.



Small amounts of water delivered to the drier top compartments were found. The above findings have consequences for a postulated transfer of root signals indicating soil drying. If the evaporative demand exceeded the amount of water supplied by the roots, water potentials of leaves (figure 2) and roots decreased, thus enabling the roots to extract water from drier zones.

Figure 2. Pre-dawn solute, water and turgor potentials of maize leaves measured after 10, 13, 18 and 20 days in a drying soil (upper figure). Soil matric potentials prevailing at different soil depths are given in the lower figure. Horizontal bars indicate standard errors.



Root water uptake (RWU, g water day^{-1}) at very different soil water distributions can be best described by a simple model taking into account root dry mass (RDM, mg), a time-factor indicating its activity and the water potential gradient in the soil-leaf continuum (GRA, MPa). Illustrative examples are given below:

$$RWU_{day13-18} = 0.11\ RDM_{day13-18} + 96\ GRA_{day13-18} \quad (R^2=0.91^{**})$$

$$RWU_{day18-20} = 0.13\ RDM_{day18-20} + 9\ GRA_{day18-20} \quad (R^2=0.81^{**})$$

Conclusions: This work shows that a mechanistic understanding of the water uptake by roots can be obtained by considering a time-factor indicating root activity and by measuring the gradients in the soil-root-shoot continuum.

Schmidhalter U et al 1992 In "Root Ecology and its Practical Application" (Ed. Kutschera L et al). Klagenfurt: Eigenverlag Verein für Wurzelforschung. pp 767-768
Schmidhalter U et al 1992 In "Root Ecology and its Practical Application" (Ed. Kutschera L et al). Klagenfurt: Eigenverlag Verein für Wurzelforschung. pp 93-96

Nr. 6