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Osmotic and Elastic Properties of Root and Shoot Tissue of Four Maize Genotypes Differing in Drought Sensitivity

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SUMMARY : Leaf and root tissue water relations of four maize genotypes differing in drought sensitivity were examined to compare their ability to adjust osmotically under water stress. There is some evidence that high solute content in the leaves of drought tolerant varieties contributed mainly to the ability to withstand drought. Under water stress osmotic adjustment in roots as compared to shoots was favored through the higher tissue elasticity of roots.

1 INTRODUCTION : Drought stress in plants is the result of a complex interaction encompassing soil, plant and atmospheric variables. Plant yield is not under direct genetic control, but there is a wide range of physiological and biochemical traits which influence final yield. In case of water stress, numerous plants have the possibility to adapt osmotically. This response occurs in both shoots and roots and results in the maintenance of high turgor at low total water potential (Morgan 1984, Turner 1986). Schmidhalter et al. (1991) found a difference in the ablility of root and shoot tissue to adjust osmotically. The purpose of this study was to investigate reaction mechanisms and adaptive traits to water stress of maize genotypes differing in drought sensitivity.

2 MATERIALS AND METHODS : One-day pregerminated maize seeds (*Zea mays L.)* of four genotypes differing in drought sensitivity were sown in pots (10 cm in diameter, 20 cm in height) containing a silty soil (Aquic Ustifluvent). The pots were watered regularly for the first 11 days (Ψ_m > -0.03 MPa), thereafter half of the pots were allowed to dry to a soil matric potential (Ψ_m) of -0.3 MPa, whereas the other half were well watered. The experiment ran for 17 days under controlled environmental conditions (12 hours day/night; 20°C/18°C; 50/60% relative humidity and 450 μmol $m^{-2}s^{-1}$ photon flux density).
Water and osmotic potentials of the roots and the shoots were measured and additionally pressure-volume curves of roots and leaves were determined. The data were evaluated using a self-programmed computer spreadsheet template.

3 RESULTS AND DISCUSSION : Results are presented for the drought sensitive ISSA and the drought tolerant variety IRAT 42. Pressure-volume curves for shoot and root tissue of the drought sensitive variety ISSA are depicted in the figures 1 and 2.
The drop in water potential resulting from a decreased relative water content was much more gradual in the roots than in the leaves. Roots exhibited turgor loss at lower values of relative water content. Osmotic potential at full turgor and at turgor loss were also significantly lower.

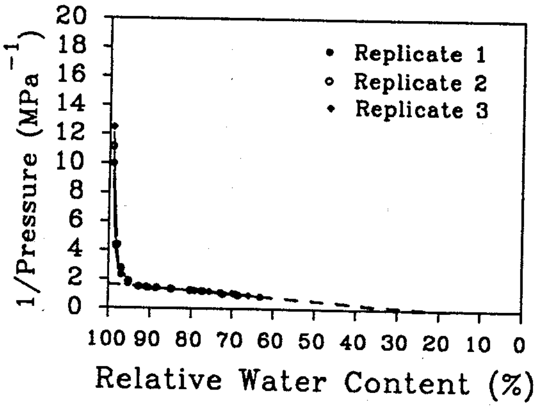

Fig. 1 : Pressure volume curves of leaves of the well-watered maize genotype Issa.

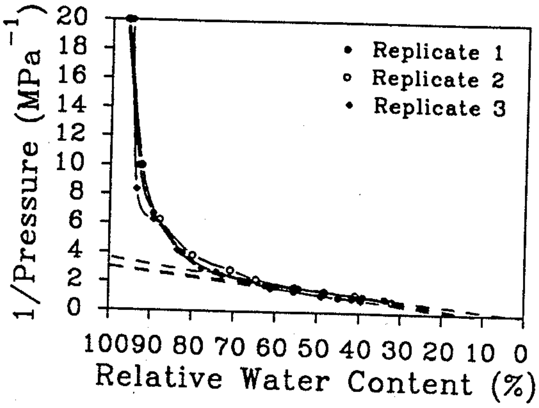

Fig. 2 : Pressure volume curves of roots of the well-watered maize genotype Issa.

Under well-watered conditions and under mild water stress, the osmotic potential at turgor loss (Ψ_s^0) and at full turgor (Ψ_s^{100}) of leaves were lower in the drought tolerant variety IRAT 42 as compared to the drought sensitive variety ISSA. The osmotic adjustment (defined as a decrease in osmotic potential at the turgor loss point in response to water deficits) was not significantly better in the drought tolerant variety than in the drought sensitive one. The better drought withstanding of Irat 42 is probably related to a higher tissue solute content. Mild water stress significantly decreased the bulk modulus of elasticity (ε) and increased the capacitance (C) in the drought sensitive variety. These properties were not modified in the drought tolerant variety (Fig. 3).

Osmotic and elastic properties were more markedly affected by water stress in root tissue than in shoot tissue. Mild water stress decreased Ψ_s^0 and Ψ_s^{100} in both varieties. Water stress affected elasticity and capacitance differently in root tissue as compared to shoot tissue. These differences were most pronounced in the drought tolerant variety (Fig. 4).

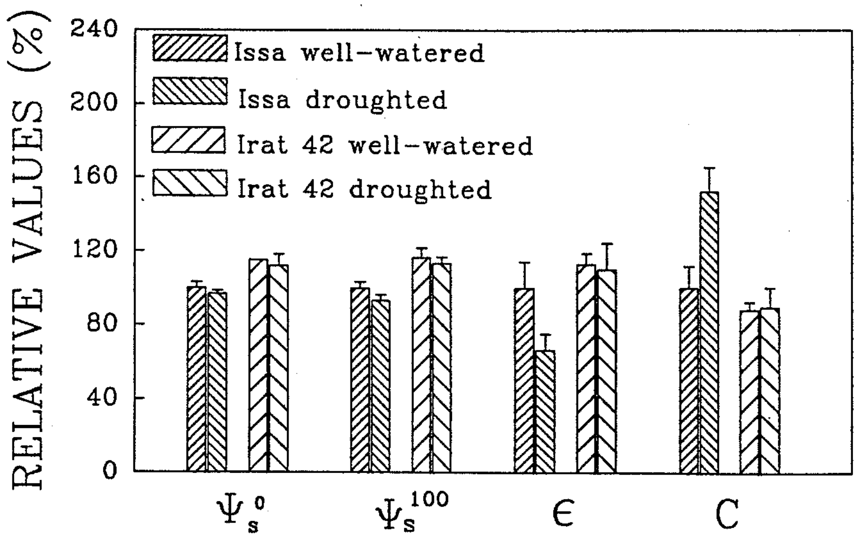

Fig. 3 : Osmotic potential at turgor loss (Ψ_s^0) and at full turgor (Ψ_s^{100}), bulk modulus of elasticity (ε) and capacitance (C) of the leaves of two maize genotypes differing in drought sensitivity.

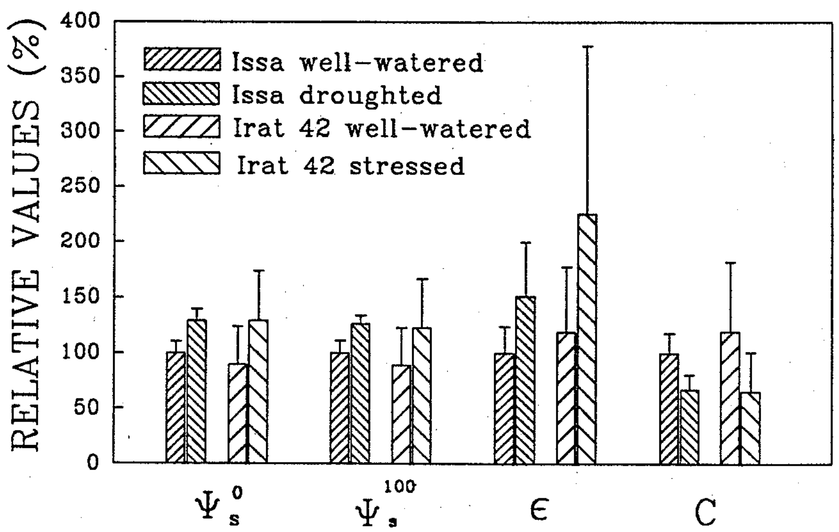

Fig. 4 : Osmotic potential at turgor loss (Ψ_s^0) and at full turgor (Ψ_s^{100}), bulk modulus of elasticity (ε) and capacitance (C) of the roots of two maize genotypes differing in drought sensitivity.

Irrespective of water supply the bulk modulus of elasticity (ε) and the capacitance (C) differed significantly in root and shoot tissues (Fig. 5 and 6). These properties certainly play a contribute to the different ability of roots and shoots to adjust osmotically (Schmidhalter et al. 1991).

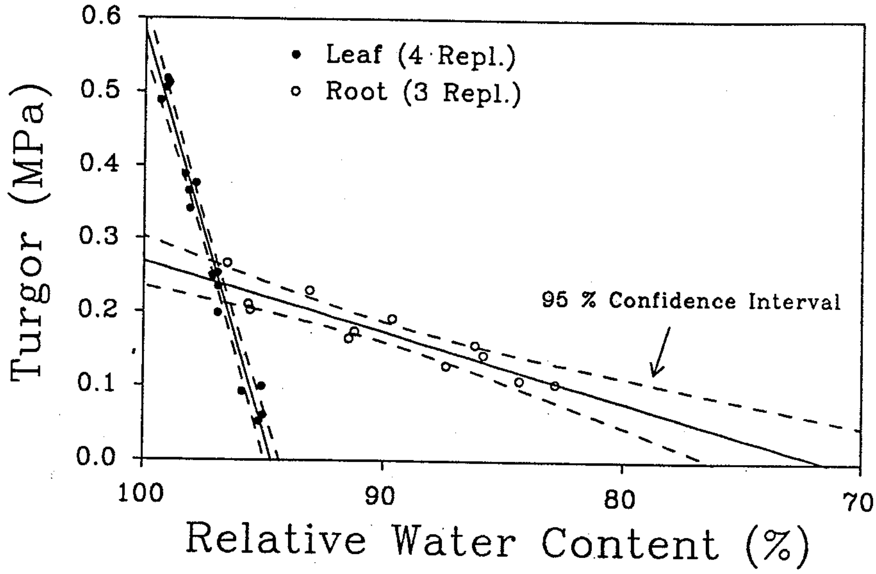

Fig. 5 : Bulk modulus of elasticity of leaf and root tissue of the drought sensitive maize variety Issa.

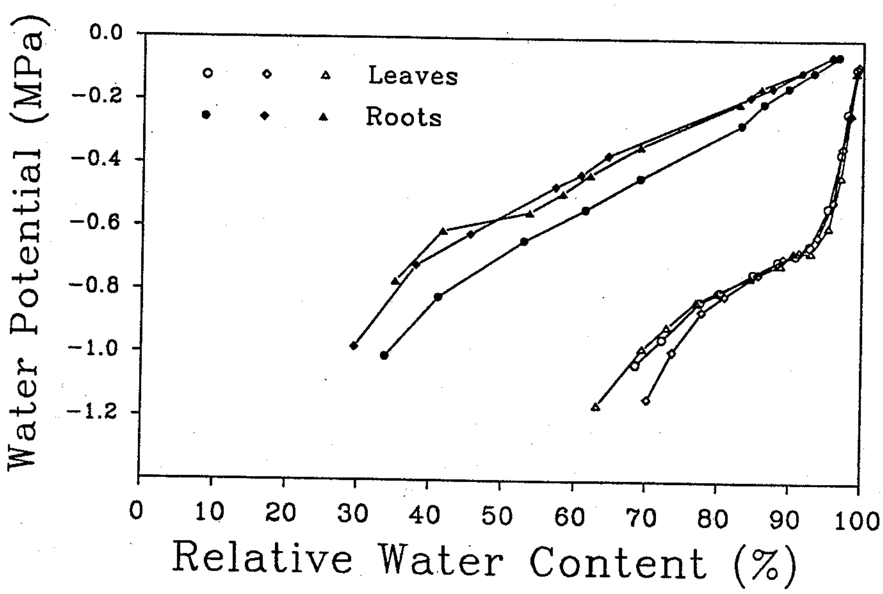

Fig. 6 : Capacitance of leaf and root tissue of the drought sensitive maize variety Issa.

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