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WATER RELATIONS AND DROUGHT TOLERANCE IN TWO WHEAT VARIETIES UNDER WATER STRESS

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Abstract

A drought resistant variety of wheat (Pak-15800) was compared with a susceptible variety (Sarsabz) under water stress and the relationship between leaf water, osmotic, turgor potentials and relative water contents (RWC) were studied. The water stressed plants had lower leaf water potential than control and at a given RWC Pak-15800 had lower water potential than Sarsabz which partly accounts for its better drought resistance. In both the varieties pre-stressed plants maintained osmotic potentials lower than control. In Pak-15800 osmotic potential was signifi cantly lower (-0.06 to -0.11) than Sarsabz. Both control and pre-stressed Pak-15800 plants had higher turgor (0.1 to 0.15 MPa) than Sarsabz at RWC between 65 and 80%. Both pre-stressed and control Pak-15800 had greater elasticity (a lower elastic modulus) than Sarsabz. An understanding of the differences between osmotic and turgor potentials between varieties could be used as a tool in breeding program for wheat.

Introduction

In some plants the relations between turgor and water potential can be changed by exposure to water stress. Pre-stressed plants maintained more stomatal resistance at lower water potential than the control plants (Jordon & Ritchie, 1971; McCree, 1974; Brown *et al.*, 1976). Maintenance of stomatal opening at higher stress has also been reported due to osmotic adjustment of the abaxial guard cell (Brown *et al.*, 1976). In a preliminary study variety Pak-15800 was found to be less sensitive to drought than Sarsabsz (Ashraf & Khan, 1990). Visual observation indicated that it had larger, thicker and turgid leaves. Experiments were therefore carried out to compare the osmotic and turgid respose of these varieties to water stress and whether osmotic and turgor potentials could partially explain the differences in drought tolerance.

Material and Methods

Seeds of two wheat varieties viz., Pak-15800 and Sarsabz were obtained from the Agriculture Univesity, Faisalabad, and Atomic Energy Agricultureal Research Centre, Tandojam, Pakistan. A total of 200 seeds of each variety were sown in Petri dishes and after 6 days, 4 seedlings of comparable size of each variety were planted at equidistance into 24 cm plastic pots containing 4.5 kg oven dried sandy loam soil. The experiment was conducted in open air during November-December 1990 with an average maximum and minimum daily temperatures of 22°C-19°C. Plants were watered daily to field capacity. The stress treatments were started 15 days after planting by withholding irrigation for 10 days until the plants showed visible symptoms of wilting. Stressed plants were then

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rewatered and stressed again for 3 drying cycles. Control plants were watered on every third day to field capacity.

After completion of the third drought cycle, measurements were taken daily for 5 consecutive days. Youngest fully expanded leaves (2 per variety/replicate) on randomly chosen tillers of comparable sizes were taken. No tiller was sampled on consecutive sampling dates and measurements were taken between 1100-1300h. Leaf water potential (Ψ) measurement were made from the excised leaf using pressure chamber (Model No. OSK 2710 OGAWA).

For osmotic potential (π) measurements a leaf was taken in a tube filled with chloroform vapours and was transferred to a deep freezer. After 24 h they were taken out, allowed to thaw and then squeezed in a hypodermic syringe to extract leaf sap (Slavik, 1974). The osmotic potential of extracted leaf sap was determined with a calibrated micro-osmometer (Model No.5004, Precision System INC, USA).

Turgor potential (TP) was calculated as the difference between water potential and osmotic potential.

$$TP = \Psi - \pi -$$

For relative water content (RWC) measurements 5 leaf discs 0.6 mm in diameter were punched from the leaf (two leaves per variety/replicate), weighed and floated on water for 24 h at 25°C under light. The discs were blotted dry, their turgid weight recorded and dried for 24 h at 80°C in an oven for determining their dry weight. RWC was determined by the relation outlined by Barrs & Weatherley (1962) as follows:-

$$RWC = \frac{\text{Fresh wt. - Dry wt.}}{\text{Turgid wt. - Dry wt.}} \times 100$$

The volumetric eslastic modulus (E) was calculated over the range of 65 to 100% RWC by the relation between TP and RWC as outlined by Jones & Turner (1987) as follows:

$$E = \frac{TP}{RWC} \times 100$$

Results and Discussions

The relationship between leaf water potential and RWC in the 2 varieties is shown in Fig.1. Pre-stressed plants had lower water potenials than the controls below 85% RWC. When compared to drought susceptible variety, the tolerant variety had higher RWC at a given leaf water potential. At -1.25 MPa, Pak-15800 and Sarsabz pre-stressed plants had RWC values of 61 and 45% respectively, whereas, at 65% RWC the pre-stressed varieties had lower water potential values of -1.15 and -1.0 MPa respectively, drought resistant plants indicated a decrease in water potential at a given RWC as compared to less resistant plants (Weatherley & Slatyre, 1957). Pak-15800 can therefore be rated as more drought resistant than Sarsabz and that pre-stressing increased the drought resistance than their controls.

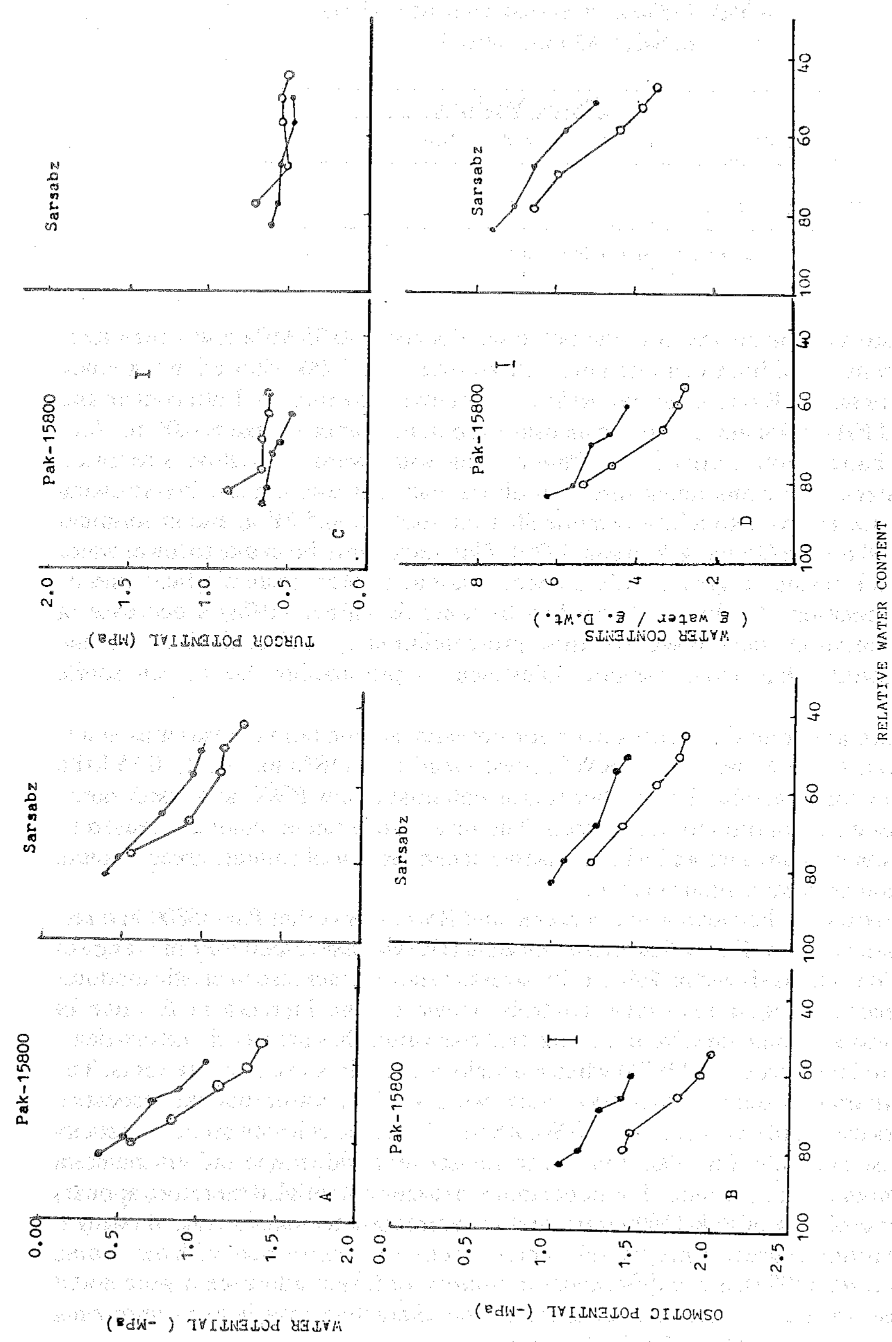

Fig.1. Relationship between relative water content and leaf water potential (A), osmotic potential (B), turgor potential (C) and water contents (D) of wheat varieties Pak-15800 and Sarsabz control (O) and pre-stressed (O) plants. Vertical bar represents L.S.D at 5% level.

Table 1. Bulk volumetric modulus (E) for Pak-15800 and Sarsabz wheat varieties between 65 and 100% RWC.

Treatment	Elastic Modulus (MPa) Pak-15800	Sarsabz
Control	0.8	0.87
Pre-stressed	2.14	2.86

$LSD_{0.05}$: Treatment = 0.051, Varieties = 0.075

In pre-stressed plants leaf osmotic potential was about -0.35 MPa lower than their respective controls of both varieties (Fig.1). However, Pak-15800 showed much lower osmotic potentials at RWC values below 85% as compared to Sarsabz. Both control and pre-stressed Pak-15800 plants showed an osmotic potential approximately 0.06 to - 0.11 MPa lower than Sarsabz. Cutler *et al.*, (1980) working with several rice cultivars reported that the capacity for maintaining turgor in all the cultivars was similar. Pre-stressing caused the rice cultivars to adjust osmotically from -0.30 to -0.5 MPa, and in sorghum from -0.5 to -0.6 MPa (Jones & Rawson, 1979). This might have been due to lower water content, which results in greater solute concentration; greater tissue elasticity and or active accumulation of solutes. According to Jones & Turner (1978) a decrease of osmotic potential at 100% RWC by stress pre-conditioning combined with no tissue elasticity indicate that active osmotic adjustment is presumably due to cell solute increase.

There are apperent differences in turgor potential among both the varieties at low RWC (Fig.1). At 65% and 80% of RWC, prestressed Pak-15800 had - 0.1, -0.15 MPa higher turgor than Sarsabz. This higher turgor potential at low RWC and water poten tial indicates its adaptation to water stress. The turgor adjustment could be caused by a combination of many factors including active accumulation of solutes, greater solute concentration or greater tissue elasticity.

The relationship between water contents and RWC shows that Pak-15800 had less moisture than Sarsabz (Fig.1). The elastic modulus (E) was calculated over the range of 65-100% RWC and is shown in Table 1. Prestressed showed increase in elastic modulus when compared to their respective controls. However, the increase in E value of Pak-15800 was less than Sarsabz, indicating that this variety has greater tissue elasticity. According to Hellkvist *et al.*, (1974) when elasticity is high, E is low and vice versa. The value of both prestressed and Pak-15800 plants were 8 to 56% lower than the respective value of Sarsabz (Table 1). According to Weatherly (1970) the cell with greater elasticity or lower elastic modulus (eg., Pak. 15800) can adjust over a wide range and still maintain a certain amount of turgor. Since E is dependent on turgor potential, it therefore appears that greater elasticity of Pak-15800 represent an adaptation to water stress, allowing it to maintain turgor at greater stress levels. These results are in agreement with the finding of Johnson *et al.*, (1984). Since differences in osmotic or turgor adjustment were noted among these varieties, a better knowledge of the characters may help in improving drought resistance by inter varietal hybridization.

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