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Effect of Moisture Stress on Leaf Water Potential and Relative Leaf Water Content in Wheat *(Triticum aestivum* L.)

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Abstract: Physiological response of six wheat genotypes to Water defibit conditions was studied. Leaf water potential (LWP) and relative leaf water content (RLWC) were used to asses the influence of water stress at four leaf, heading, anthesis and senescence stages. Different stages of plant appeared to be negatively correlated with LWP because with growing age, LWP became more negative. The treatment effects dr, LWP at different stages of plant were significantly different, maximum value was recorded for full irrigation folloWed by gradual decrease in one-half and one-fourth irrigation. Genotypes appeared to differ significantly at anthesis only Unlike LWP, treatments as well as genotypic differences for RLWC at heading and anthesis were significan$_i$ Among the genotypes, Barani-83 and Khushal-69 maintained higher LWP at anthesis, may be due to having drought avoidance potential, as their yield was comparatively less affected by external water stress. Sonalika and PR-33 appeared to tolerate lower LWP to produce reasonable yield hence can be regarded drought tolerant.

Key words: Moisture stress, leaf water potential.

Introduction

Moisture stress is the most seriout environmental factor limiting plant productivity (Carter *et al.,* 1982; Wright *et al.*, 1983; Shalaby *et al.*, 1988) through influencing vital plant's processbs such as water uptake, stomatal function, photoyhthesis, respiration, transpiration, enzymatic activities, growth, abatement of tissues development etc. (Theodore and Kozlowski, 1904). Importance of soil water availability to wheat production in arid and semi arid regions has led several studies on the morphological, physiological and anatomical response of wheat to water stress conditions (Johnson and Kanemasu, 1982; Shalaby *et al.*, 1988; Singh *et al.*, 1989; Zahoor *et al.*, 1991). Focus of a number of studies in the past two decades has been on the plant water relationships and have resulted in the development and use of many techniques to determine water stress intensity in leaves. These include gravimetric techniques to measure leaf water content or saturation deficit (Dedio, 1975), water potential (Sojka *et al.*, 1979; Keim and Kronstad, 1981), water retention (Winter *et al.*, 1988) and other. Nevertheless, leaf water potential have widely and successfully been used to asses the water stress intensity/resistance in different crop species like wheat (Rascio *et al.*, 1987; Entz and Fowler, 1990), rice (O'Toole and Moya, 1977; Tomar and O'Toole, 1982), corn (Cary and Fisher, 1971), alfalfa (Brown and Tanner, 1981), sunflower (Boyer, 1968), sorghum and cotton (Grimes and Yamada, 1982) and different stages of plant growth (Singh *et al.*, 1989). Relative leaf water content is another physiological parameter used by many scientists as a good predictor of drought stress (Schonfeld *et al.*, 1988; Shimshi *et al.*, 1982; Wright and Smith, 1983).

Present research was conducted to asses the effect of moisture stress on leaf water potential and leaf water content hence determine level of drought resistance in six adapted genotypes of wheat. It was also intended to establish whether it is water storage per se (relative water content) or the potential energy of plant water (water potential) that is more important in affecting plant's growth and performance.

Materials and Methods

Source of material included six wheat genotypes viz Barani-83, C-518, Sonalika, PR-33, Khushal-68 and Pirsabak-85 were planted in plastic containers (48 cm dia. x 26 cm deep) kept in screen house in split plot arrangement following randomized complete design with three replications. To avoid unwanted rain interruption, top of the screen house was covered with plastic sheet. Each plastic container was filled with 30 kg of soil supplemented with 2.5 gm of urea (46% N) and 3.8 gm of DAP (21% N). After plantation, a thin layer of river sand was spread over to avoid excessive evaporation from the surface. In each container additional number of seeds were sown and on germination thinned to six plants per tub for physiological studies. Based on predetermined water holding capacity of the soil three levels of drought including fifteen days application of 4500 ml (T1), 2250 ml (T2) and 1125 ml (T3) of water after every fifteen days interval., representing full, one half and one fourth of the water holding capacity, respectively, were imposed.

The dew point microvoltmeter WESCOR model HR-33T with C-52 sample chamber was used to measure leaf water potential (LWP) at four leaf stage -- after sixty days of sowing when 4th leaf was collard and 5th in whorl, at heading stage -- after 95 days of sowing when spikes had fully emerged from boot and vegetative growth was stopped, at anthesis -- after 120 days of sowing when anthers had extruded from florets and at the on set of senescence -- after 135 days of sowing when leaves of lower portion of the plants showed yellowish signs of senescence. Measurements at each stage were taken on

Table 1: Mean square values of leaf water potential and relative leaf water content at different stages of growth in wheat

		Leaf water potential				Relative leaf water content	
Sov	df	Four leaf	Heading	Anthesis	Senescences	Heading	Anthesis
Replications	2	6.80	31.13	19.91	22.17	1.21	4.20
Treatments	2	106.79**	997.80**	806.91**	95.17**	1458.88**	67.15**
Error (a)	4	2.74	19.77	9.91	16.00	0.22	4.74
Genotypes	5	19.86	83.45	52.56**	21.20	462.50**	39.50**
Treatments x Genotypes	10	8.15	39.77	28.13**	17.90	215.88**	51.43**
Error (b)	30	12.14	36.58	8.77	18.28	0.97	11.88

**Significant at 0.01 probability level

Table 2: Average leaf water potential at four leaf and heading stages in response to different Levels of water stress in wheat

	Four leaf stage				Heading stage			
Genotype	T1	T2	T3	Mean	T1	T2	T3	Mean
Barani-83	-19.39	-25.86	-28.38	-24.54	-23.67	-33.67	-44.33	-33.89
C-518	-25.93	-26.33	-29.10	-27.12	-26.67	-34.00	-41.33	-34.00
Sonelike	-25.26	-25.59	-26.47	-25.17	-29.67	-28.67	-29.00	-29.11
PR-33	-24.34	-27.38	-27.72	-26.48	-29.67	-32.67	-41.00	-34.45
Khushal-69	-22.23	-25.26	-27.01	-24.83	-31.00	-36.33	-40.67	-36.00
Pirsabak-85	-25.05	-27.78	-32.90	-28.51	-34.60	-38.33	-42.00	-38.33
Mean	-23.70A	-26.37B	-28.56C		-29.22A	-33.95B	-39.72C	

Means followed by different letters differ significantly at 0.05 level of significance

fully expanded flag leaf of three randomly chosen plants from each variety ,treatment and replication.

Relative leaf water content (RLWC) was determined at heading and athesis stages by using the following equation (Schonfeld *et al.*, 1988);

$$\text{RLWC} = \frac{\text{Fresh weight} - \text{Dry weight}}{\text{Turgid weight} - \text{Dry weight}}$$

Where fresh weight was taken by weighing 6 mm discs (immediately after excision) drawn from randomly selected three leaves from each container while for turgid weight, discs were soaked in distilled water for 16 to 18 hours at room temperature and after quick and carefully blotting with tissue paper were weighted to record turgid weight. Dry weight was obtained after oven drying the samples for 72 hours at 70°C. Data recorded were subjected to Analysis of Variance and LSD test to determined variation if any exit among the genotypes in response to different water regimes.

Results and Discussion

Analysis of variance for leaf water potential at different stages of plant growth revealed significant differences between treatments et all stages of growth, however, genotypic differences and interaction between genotypes and treatments were significant at anthesis only (Table 1). Differences among treatments as well as among genotypes and interaction between genotypes and treatments were highly significant for relative leaf water content at heading and anthesis.

Each increasing level of water stress (T1 through T3) significantly reduced the leaf water potential at all the growth stages. At four leaf stage, average leaf water potential -23.70 bars under full irrigation (T1) was dropped to -26.70 bars at half irrigation (T2) and -28.56 bars at one-third irrigation (T3) (Table 2). Rizwan and Rahman (1993) working with Brassica and Maize, respectively, found sirriilar trend of leaf water potential in water stressed plants. Similarly its values declined from -29.22 bars (T1) to -33.95 bars (T2) and -39.75 bars (T3) at heading (Table 2), -28.61 bars (T1) to -35.83 bars (T2) and -42.00 bars (T3) at anthesis and -32.05 bars (T1) to -38.39 bars (T2) and -46.56 bars (T3) at senescence stages (Table 3). These findings are in complete agreement with the results of a similar studies reported by Carter *et al*. (1982). Among the genotypes, Barani-83 showed stiff resistance to water stress and scored minimum values -24.54 bars, -32.77 bars and 37.00 bars at four leaf, anthesis and senescence stage, respectively and with value of -33.89 bars was second to lowest at heading stage. Like Barani-83, Khushal-69 with statistically lowest leaf water potential values at four leaf and anthesis stages and lowest average value of -29.11 bars at heading also exhibited resistance to water stress.

Another drought resistance indicator exploited in this study was relative leaf water content. Measurements for this parameter were recorded at heading and anthesis under three levels of moisture. The results showed that retention

Table 3: Average leaf water potential values (bars) at anthesis and senescence stages in Response to different levels of water stress in wheat

	Anthesis stage				Senescence stage			
Genotype	T1	T2	T3	Mean	T1	T2	T3	Mean
Barani-83	-27.33ab	-31.00bc	-40.00efg	-32.77a	-30.67	-35.33	-45.00	-37.00
C-518	-30.00bc	-39.33efg	-41.67fgh	-37.00bc	-33.33	-38.67	-51.67	-41.00
Sonalika	-35.OOcde	-37.33def	-43.67gh	-38.67bc	-31.33	-38.67	-43.67	-37.89
PR-33	-31.00bc	-34.67cd	-46.33h	-37.33bc	-30.00	-42.33	-43.67	-38.67
Khushal-69	-24.33a	-33.00cd	-40.00efg	-32.44a	-33.00	-39.67	-48.00	-40.22
Pirsabak-85	-24.00a	-39.67efg	-40.33efg	-34.55ab	-34.00	-35.67	-47.33	-39.00
Mean	-28.61a	-35.83b	-42.00c			-32.05a	-38.39b	-46.56c

Means followed by different letters differ significantly at 0.05 level of significance

Table 4: Relative leaf water content (%) at heading and anthesis stages in response to different Levels of water stress in wheat

	Heading stage				Anthesis stage			
Genotype	T1	T2	T3	Mean	T1	T2	T3	Mean
Barani-83	96.11a	92.64b	85.35d	91.37a	85.89a	74.22ef	76.26cde	78.79a
C-518	86.26b	82.97e	62.101	77.11d	81.27abcd	76.75cde	68.37f	75.46b
Sonalika	90.52c	59.78j	62.101	70.80f	84.54ab	79.90abcde	75.16de	79.66a
PR-33	83.02e	89.04c	76.74h	82.93b	78.60bcde	83.01abc	82.79abc	81.46a
Khushal-69	94.09b	63.031	68.27h	75.13e	78.42bcde	82.15abc	79.94abcde	80.17a
Pirsabak-85	86.53d	83.55e	74.99g	81.69g	84.99ab	82.48abc	74.13ef	80.53a
Mean	89.43a	78.51b	71.60c		82.28a	79.65b	76.10c	

Means followed by different letters differ significantly at 0.05 level of significance.

ability of the plant at different growth stages was significantly different (Table 4). As plants progressed toward maturity, water retention ability decreased gradually and these findings are with complete conformity with the results of Dedio (1975). This indicator was more useful in differentiating the genotypes because the genotypic differences were significant ($p<0.05$) at both stages (Table 1). The relative leaf water content at heading showed that Sonalika and Khushal-69 were unable to maintain as higher leaf water content as Banani-83, PR-33, Pirsabak-85 and C518 when subjected to moderate stress of half irrigation while under severe stress of one-forth irrigation, C-518 also joined Sonalika and Khushal-69. As the plants matured (anthesis), except C-518 all other genotypes did well under moderate stress. Genotypes PR-33, Khushal-69 and Pirsabak 85-performed better than Barani-83, C-518 and Sonalika (Table 4). These findings are in agreement with the results of the experiments conducted with wheat cultivars under moisture stress by Schonfeld *et al*. (1988). Shimshi *et al*. (1982) advocated that that more drought resistant species delays its rapid decline in relative water content compared with the more drought susceptible species. Our results support the contention of Schonfeld *et al*. (1988) that relative water content may be used as a selection criterion in breeding for improved drought resistance in wheat genotypes.

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