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PHYSIOLOGICAL RESPONSES OF WHEAT (*TRITICUM AESTIVUM* L.) GENOTYPES UNDER WATER STRESS CONDITIONS AT SEEDLING STAGE

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Abstract

Twelve wheat genotypes/lines were tested for different levels, 0.00 (control), -0.5 and -0.75 MPa of osmotic stresses (PEG-6000) for 20 days in a growth cabinet under a 10 h photoperiod (41.69 μmol m^{-2} s^{-1}) to study growth and physiological attributes including nitrate reductase activity (NRA), proline and potassium contents. It was observed that root and shoot length, NRA and potassium (K^+) contents decreased however the proline contents increased by the imposition of osmotic stress. Comparatively less reduction in all these attributes and ion contents was observed in tolerant genotypes.

Introduction

Water deficiency is generally considered as one of the limiting factors for crop productivity which affects physiological as well as biochemical processes in plants (Osborne *et al*., 2002). Wheat (*Triticum aestivum* L.) is a major crop of rainfed agriculture in Pakistan (Asghari & Nadia, 2003). Recent research has shown that root responses to drought include a number of metabolic changes which can be interpreted as signals passing from root to shoot (Bahrun *et al*., 2002). Drought stress can affect seed germination either by osmotic effects (Welbaum *et al*., 1990) or ionic toxicity (Bliss *et al*., 1986; Huang & Reddman, 1995). A lot of work has been made on physiological aspects in response to drought stress but evidence suggests that low water potential of the germination medium is a major limiting factor (Bradford, 1994).

Osmotic adjustment is an active accumulation of solutes within the plant in response to decrease in soil water potential, thus reducing the harmful effects of water deficit. As a consequence of solute accumulation, the osmotic potential of the cell is lowered, which in turn attracts water into the cell and thereby tends to maintain its turgor. Accumulation of solutes in roots leads to lowering of the osmotic potential of the root, which maintains the driving force for extracting soil water under water deficit conditions. Osmotic adjustment has been reported as an important mechanism adopted by number of crops under drought conditions (Khan *et al*., 1993; Santos-Diaz & Alejo, 1994; Subbarao *et al*., 1995; Hare *et al*., 1998).

The present study describes the seedling growth and accumulation of solutes in wheat in response to increased osmotic stress (PEG-6000).

Materials and Methods

To study growth attributes and biochemical changes in response to osmotic stress, a series of experiments were conducted in glass bowls (15∅ and 10cm in depth). Thirty imbibed seeds of 12 wheat genotypes viz., Marvi-2000, H-68, CM-24/87, Khirman, V-

7015, WL-711, GP-II, SARC-I, 7004, 7003, TJ-83 and ESW-9613 were sown over plastic screen (Naqvi *et al*., 1994) containing PEG solution of three different grades including control (0.00), -0.5 and -0.75 MPa. Each treatment was replicated thrice according to completely randomized design (CRD) and placed in a programmed growth cabinet under a 10 h photoperiod (41.69 μmol m^{-2} s^{-1}). The seedling were harvested after 20 days and analyzed for growth and various biochemical attributes. Nitrate reductase activity was determined according to Ramarao *et al*., (1983) and free proline contents of leaves by following Bates *et al*., (1973). Growth attributes were studied in terms of shoot and root length and potassium (K^+) contents of plant shoot was determined after extraction with 0.2 M acetic acid (Jackson, 1958).

Statistical analyses of the data: The data were analyzed statistically by Analysis of variance technique and comparison among treatment means was made by Duncan's Multiple Range Test (DMRT) using appropriate computer software.

Results and Discussion

Under water stress, a decrease in shoot and root length of all genotypes was recorded. However at 0.75 MPa, Marvi-2000 showed the minimum reduction (53.04 and 42.93 %) in shoot and root length, respectively; whereas, maximum reduction was noted in root shoot length by TJ-83 (91.89 and 82.35%) at same concentration (Table 1). The reduction in shoot and root length of Marvi-2000, H-68, CM-24/87 and Khirman was comparatively less than that of V-7015, WL-711, GP-II and SARC-I. The reduction was more pronounced in sensitive genotypes viz., 7004, 7003 and ESW-9613 at -0.75 MPa than the tolerant ones viz., Marvi-2000, H-68, CM-24/87 and Khirman. The NRA decreased significantly under water stress (Table 2). The genotype Marvi-2000, H-68, CM-24/87 and Khirman collectively showed 95.71% decrease in the activity of nitrate reductase as compared to V-7015, WL-711, GP-II, SARC-I, 7004, 7003, TJ-83 and ESW-9613, which showed average decrease of 97% at -0.75 MPa. These findings are in line with the results of Ashraf *et al*., (1994) and Larsson *et al.,* (1989). A variation was noted in accumulation of proline, as an osmolyte, in all genotypes. The proline accumulation was higher in genotypes Marvi-2000, H-68, CM-24/87, Khirman and SARC-I (196.50%), whereas the lowest proline accumulation was found in genotypes V-7015, WL-711, GP-II, 7004, 7003, TJ-83 and ESW-9613 (71.13%) at -0.75 MPa (Table 3). These results also coincide with the earlier reports of proline accumulation with increasing salinity/water stress (Ashraf *et al*., 1994; Khan *et al*., 1993; Naqvi *et al*., 1994). The results showed that K^+ contents were reduced in all the wheat genotypes under water stress condition. The tolerant genotypes i.e., Marvi-2000, H-68, CM-24/87 and Khirman showed marked reduction in potassium contents than the sensitive genotypes i.e., V-7015, WL-711, GP-II, SARC-I, 7004, 7003, TJ-83 and ESW-9613 (Table 4). The reduction in potassium contents (K^+) in the wheat genotypes under water stress condition at seedling stage is already well-documented (Turner & Jones, 1993; Welbaum *et al*., 1990).

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Table 1. Growth response of wheat genotypes under water stress (PEG-6000).

Wheat genotypes	Shoot length (cm)			Root length (cm)		
	Control	-0.75 MPa	% dec. over control	Control	-0.75 MPa	% dec. over control
Marvi-2000	19.23 a	9.03 a	53.04	15.14 a	8.64 a	42.93
H-68	16.72 b	8.54 ab	48.92	14.91 ab	7.71 b	48.28
CM-24/87	15.32 b	8.06 b	47.38	14.12 ab	4.55 c	67.77
Khirman	15.53 b	7.77 b	49.96	13.88 bc	4.47 c	67.79
V-7015	15.40 b	7.75 b	49.67	14.49 ab	3.72 cd	74.33
WL-711	15.36 b	6.42 c	58.21	14.19 ab	3.91 cd	72.44
GP-II	15.26 b	4.18 d	72.61	13.91 abc	3.28 de	76.42
SARC-I	15.19 b	3.99 d	73.73	14.16 ab	2.08 g	85.31
V-7004	15.08 b	2.49 e	83.48	14.45 ab	3.13 def	78.34
V-7003	14.85 b	2.65 e	82.15	13.88 bc	2.67 efg	80.76
TJ-83	14.69 b	1.19 f	91.89	12.75 c	2.25 fg	82.35
ESW-9613	11.65 c	1.52 f	86.95	8.54 d	1.89 g	77.86

Means followed by same letters are not significant at $p \leq 0.05$ according to DMRT.

Table 2. Nitrate reductase activity in wheat genotypes under water stress (PEG-6000).

Wheat genotypes	NRA (µmole NO_2 g^{-1} F. Wt. h^{-1})			
	Control	- 0.75 MPa	% dec. over control	
Marvi-2000	1.94 a	0.090 a	95.36	95.71 %
H-68	1.93 a	0.080 ab	95.85	
CM-24/87	1.82 ab	0.080 ab	95.61	
Khirman	1.77 ab	0.070 ab	96.04	
V-7015	1.76 ab	0.070 ab	96.02	97%
WL-711	1.68 abc	0.060 ab	96.43	
GP-II	1.58 bc	0.060 ab	96.21	
SARC-I	1.48 c	0.050 ab	96.62	
V-7004	1.44 c	0.050 ab	96.53	
V-7003	1.43 c	0.040 ab	97.21	
TJ-83	1.08 d	0.030 b	97.22	
ESW-9613	1.02 d	0.030 b	97.05	

Means followed by same letters are not significant at $p \leq 0.05$ according to DMRT.

Table 3. Proline content in wheat genotypes under water stress (PEG-6000).

Wheat genotypes	Proline (µmole g^{-1} F. Wt.)			
	Control	- 0.75 MPa	% inc. over control	
Marvi-2000	6.65 a	30.17 a	353.68	196.50 %
H-68	6.17 ab	22.39 b	262.88	
CM-24/87	5.66 b	13.40 c	136.75	
Khirman	5.86 ab	11.86 d	102.38	
SARC-I	4.10 c	9.30 e	126.83	
V-7015	5.51 b	9.73 e	76.58	71.13 %
WL-711	5.35 b	9.67 e	80.74	
GP-II	5.32 b	9.38 e	76.32	
V-7004	3.90 cd	6.12 f	56.92	
V-7003	3.69 cd	5.81 f	57.45	
TJ-83	3.54 cd	6.21 f	75.42	
ESW-9613	3.10 d	5.41 f	74.52	

Means followed by same letters are not significant at $p \leq 0.05$ according to DMRT.

Table 4. Potassium contents (%) in wheat genotypes under water stress (PEG-6000).

Wheat genotypes	Potassium (K^+) conc. in leaves (%)		
	Control	- 0.75 MPa	% red. over control
Marvi-2000	1.83 a	0.900 a	51
H-68	1.21 b	0.650 b	46
CM-24/87	1.18 b	0.580 bcd	51
Khirman	1.17 b	0.660 b	43
V-7015	1.16 b	0.620 b	46
WL-711	1.15 b	0.660 b	43
GP-II	1.13 b	0.600 bc	46
SARC-I	1.00 b	0.570 bcd	43
V-7004	0.65 c	0.510 bcd	22
V-7003	0.62 c	0.430 d	31
TJ-83	0.53 cd	0.460 cd	13
ESW-9613	0.34 d	0.230 e	31

Means followed by same letters are not significant at $p \leq 0.05$ according to DMRT.

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