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SOME ASPECTS OF PHYSIOLOGY OF SALT TOLERANCE IN WHEAT *(TRITICUM AESTIVUM* L.)

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Physiological parameters conferring salt tolerance in wheat were studied in two sets of experiment. Selected and non-selected population of LU 26S and LYP 73 were tested in set-I at EC of 0, 10 and 20 dS m^{-1} while LU 26S (selected and non-selected) in set-II at 15 dS m^{-1}. There was significant reduction in tillering fresh shoot and root weights, grain and straw yields in non-selected compared to selected populations of both the cultivars under saline conditions. Glume, rachis and seed of selected LU 26S, maintained lower concentrations of Na^+, Mg^{+2} and Cl^- but higher concentrations of K^+, Ca^{+2} and K^+/Na^+ compared to its non-selected population. The best correlation of grain yield was found with number of tillers, shoot and root dry weights and ionic concentrations in glumes. For salt tolerance studies, analysis of glume was found more representative than rachis and leaf cell sap.

INTRODUCTION

Wheat is cultivated on an area of about 7 million hectares with grain production of about 13 million tonnes (Bajwa *et al.*, 1983). However, within the area of irrigated wheat production it is estimated that about 1.2 million hectares are affected due to salinity/sodicity causing annual loss of 2-3 million tonnes of grain (Qayyum and Malik, 1988). This alarming situation warrants the need to develop wheat cultivar which could produce substantial yield under such adverse conditions. It is, therefore, necessary to investigate the salt tolerance potential of wheat cultivars as some lines of *Triticum aestivum* L. possess varying tolerance to salinity in a much better way than the others (Qureshi *et al.*, 1990). The present study deals with the comparison of selected vs non-selected population of two wheat cultivars LU 26S and LYP 73 for their ability to tolerate salinity.

MATERIALS AND METHODS

Two solution culture experiments (set I and II) were conducted in the net house, Department of Soil Science, University of Agriculture, Faisalabad to ascertain the differences for various physiological parameters conferring salt tolerance in selected and non-selected populations of two wheat cultivars (LU 26S and LYP 73). Selected and non-selected populations of both the cultivars (LU 26S and LYP 73) were tested in set-I at EC 0, 10 and 20 dS m^{-1} whereas in set-II LU 26S (selected and non-selected) was grown at EC 15 dS m^{-1}. The experiment was laid out in completely randomized design with four repeats. The experimental set up and the techniques used were almost similar to those of Qureshi *et al.* (1990). Fully expanded leaves from each set were sampled before harvesting for analyses of different ions from the sap. In set-I crop was harvested after 35 days of growth period

Table 1. Effect of salinity on growth characteristics and plant composition of four wheat varieties/lines (LU 26S and LYP 73)

Variety x Selection		Number of tillers plant^{-1} EC (dS m^{-1}) Control	10	20	Mean	Na^+ concentration (m mol kg^{-1}) EC (dS m^{-1}) Control	10	20	Mean
LU 26S	Selected	4.90a	2.40e	1.80f	3.00A	3.94e	47.27de	205.21c	85.47B
	Non-selected	3.80c	1.90f	0.80g	2.20C	4.76e	66.85d	258.04b	110.08AB
LYP 73	Selected	5.30a	3.30d	0.90g	3.20A	4.41e	40.35de	292.11ab	112.29AB
	Non-selected	4.50b	2.60e	0.80g	2.60B	5.34e	73.00d	307.83a	128.72A
Mean		4.70A	2.60B	1.10C		4.61C	56.87B	265.95A	
		Shoot fresh weight (g P^{-1})				K^+ concentration (m mol kg^{-1})			
LU 26S	Selected	14.04a	3.92f	1.45h	6.47A	270.06a	221.25cd	190.26efg	227.18A
	Non-selected	11.31c	3.58f	1.10hi	5.33C	258.44cde	215.96cde	179.50fgh	217.97A
LYP 73	Selected	13.14b	4.46e	0.92i	6.17B	261.40ab	234.47bc	167.17gh	221.01A
	Non-selected	10.74d	2.91g	0.70i	4.78D	235.89bc	203.08def	160.37h	199.78B
Mean		12.31A	3.72B	1.04C		256.45A	218.69B	174.33C	
		Root fresh weight (gP^{-1})				Cl^- concentration (m mol kg^{-1})			
LU 26S	Selected	5.43a	2.97f	0.99h	3.13A	32.50g	85.00f	168.00d	95.17C
	Non-selected	4.26c	2.78f	0.62i	2.55C	33.50g	93.00ef	208.00c	111.50B
LYP 73	Selected	4.67b	3.37e	0.88h	2.97B	35.50g	75.75f	238.00b	116.42B
	Non-selected	3.70d	1.91g	0.53i	2.05D	40.00g	112.50e	265.00a	139.17A
Mean		4.52A	2.76B	0.76C		35.38C	91.56B	219.75A	

Means followed by same letter(s) are statistically similar (P=0.05)

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whereas in set-II, it was harvested at maturity and data on grain and straw yield and number of tillers were recorded. Various plant parts (glume, rachis and seed) were separated and digested by HNO_3. Inorganic ions (Na^+, K^+, Ca^{++} and Mg^{++}) were determined by flame emission in a PFPI flame photometer and Pye Unicam Atomic Absorption Spectrophotometer. Chloride was determined by using Corning chloride analyser-925. The data collected were analysed statistically according to methods described by Steel and Torrie (1980).

Table 2. Effect of salinity on K^+:Na^+ of true wheat varieties/lines

(Average of 4 repeats)

Variety x	Selection	EC (dS m^{-1}) Control	10	20	Mean
LU 26S	Selected	68.00	4.68	0.93	2.65
	Non-selected	54.20	3.23	0.69	1.98
LYP 73	Selected	59.27	5.81	0.57	1.96
	Non-selected	44.17	2.78	0.52	1.55
Mean		55.26	0.384	0.65	

RESULTS AND DISCUSSION

Effect on growth: Generally, greater number of tillers ensure good crop stand and ultimately better yield. A significant interaction among wheat varieties LU 26S and LYP 73 (selected and non-selected population) as well as salinity levels has been observed (Table 1). Though tillering capacity was adversely affected under saline conditions, yet LYP 73 was superior to LU 26S in this respect up to EC of 10 dS m^{-1}, however, LU 26S showed sharp improvement over LYP 73 as well as its own normal material at 20 dS m^{-1}. Similar results have been reported by different workers (Bernal *et al.*, 1974; Rauf *et al.*, 1978; Rashid, 1986).

Shoot and root fresh weights decreased with increasing salinity, and significant differences were observed between selected and non-selected populations of both the cultivars. In general, at low salinity level LYP 73 (selected) performed better than LU 26S (selected), however, at high salinity later proved superior to LYP 73 (selected and non-selected). Shannon (1978), and Kingsbury and Epstein (1986) reported that selected lines showed remarkable performance under highly adverse conditions.

Effect on plant composition: Concentration of Na^+ increased sharply in the leaf sap (Table 1) with an increase in salinity. Selected population of LU 26S and LYP 73 had lower concentration of Na^+ compared to their non-selected counterparts. However, these differences for Na^+ accumulation were non-significant under control and at EC level of 10 dS m^{-1}. The ability of the selected population of LU 26S to retain less Na^+ in its tissues was outrightly improved at EC level of 20 dS m^{-1} indicating that salt tolerance level was much improved in case of selected population of LU 26S. Similar results were reported by Greenway and

Table 3. Effect of salinity on different physical parameters and ionic composition of selected and non-selected materials of LU 26S wheat at EC 15 dS m^{-1}

Character	Unit	LU 26S Selected	LU 26S Non-selected
Number of tillers	P^{-1}	3.10 a	1.50 b
Shoot oven dry weight	g P^{-1}	4.54 a	2.82 b
Root oven dry weight	g P^{-1}	0.60 a	0.37 b
Straw yield	g P^{-1}	2.75 a	1.60 a
Grain yield	g P^{-1}	1.79 a	1.22 b
Ionic composition in cell sap			
Sodium	m mol kg^{-1}	277.53 b	434.62 a
Potassium	"	220.20 a	159.26 a
Chloride	"	265.44 b	381.62 a
Calcium	"	11.91 a	5.95 b
Magnesium	"	20.96 a	23.72 a
Potassium/Sodium	-	0.81 a	0.38 b

Correlation between grain yield and yield components of LU 26S wheat at EC of 15 dS m^{-1}

Characters	Unit	Regression constant (a)	Regression coefficient (b)	Correlation coefficient (r)	Significance
Number of tillers	P^{-1}	0.75	0.32	+ 0.80	*
Shoot oven dry weight	g P^{-1}	0.53	0.26	+ 0.77	*
Root oven dry weight	g P^{-1}	0.54	2.0	+ 0.74	*
Straw yield	g P^{-1}	0.96	0.25	+ 0.56	NS
Shoot/Root ratio	-	0.47	0.13	+ 0.21	NS

* = Significant at P = 0.05
NS = Non-significant
Means followed by same letter(s) in each row are statistically similar at P = 0.05

Munns (1980). Concentration of Cl^- in the leaf sap followed the same pattern as that of Na^+ and the selected population of both the cultivars had shown good discriminative ability for these ions. Similar results were reported by Able and Mackenzie (1964), Ahmad and Muhammed (1969).

Potassium concentration in selected LU 26S was better over the normal material of LYP 73 at low and high salinity levels.

This could be due to the efficient exclusion of Na^+ and Cl^- reaching the shoot and maintenance of K^+ status by efficient absorption or selective exclusion of Na^+ by cortical cells in the vacuole, therefore, maintaining high K^+ concentration in cytoplasm which helped in better protein synthesis (Wyn Jones, 1985).

Table 4. Effect of salinity on ionic composition in different parts of spike of LU 26S wheat at EC 15 dS m^{-1}

Character		Unit	LU 26S	
			Selected	Non-selected
Sodium	Glume	m mol g^{-1}	0.46	0.91*
	Rachis	"	0.86	1.71^{NS}
	Seed	"	0.07	0.15*
Potassium	Glume	m mol g^{-1}	0.57	0.36*
	Rachis	"	0.48	0.32*
	Seed	"	0.19	0.18^{NS}
Chloride	Glume	m mol-1	15.50	21.75*
	Rachis	"	5.50	6.00^{NS}
	Seed	"	0.38	0.75^{NS}
Calcium	Glume	m mol g^{-1}	0.08	0.05*
	Rachis	"	0.07	0.05^{NS}
	Seed	"	0.03	0.01*
Magnesium	Glume	m mol g^{-1}	0.06	0.08^{NS}
	Rachis	"	0.03	0.02*
	Seed	"	0.07	0.09*
K+/Na+	Glume	m mol g^{-1}	1.27	0.40*
	Rachis	"	0.57	0.19*
	Seed	"	2.60	1.38*

* = Significant at P = 0.05
NS = Non-significant

K^+/Na^+ ratio (Table 2) was found far better in the selected population of the cultivars compared to their normal population under all the conditions. A careful scrutiny of Table 2 shows that there is a strong exclusion of Na^+ and Cl^- in the selected population of LU 26S and LYP 73 under saline environment. This ability was much pronounced in LU 26S and it appeared that this selected material could be developed into a new promising salt tolerant cultivar in future.

Table 5. Grain yield vs inorganic ions in different parts of LU 26S wheat at 15 dS m^{-1}

Character		Unit	Regression constant (a)	Regression coefficient (b)	Correlation coefficient (r)
Sodium	Glume	m mol g^{-1}	2.34	- 1.21	- 0.87**
	Rachis	"	2.37	- 0.66	- 0.88**
	Seed	"	2.05	- 4.92	- 0.73*
	Leaf sap	m mol kg^{-1}	2.60	- 0.00	- 0.81*
Potassium	Glume	m mol g-1	0.34	2.47	+ 0.84**
	Rachis	"	0.55	2.36	+ 0.74*
	Seed	"	1.22	1.55	+ 0.08^{NS}
	Leaf sap	m mol kg^{-1}	2.72	- 0.00	- 0.56^{NS}
Chloride	Glume	m mol g-1	2.85	- 72.01	- 0.85**
	Rachis	"	2.09	- 100.22	- 0.43^{NS}
	Seed	"	1.60	- 165.45	-0.23^{NS}
	Leaf sap	m mol kg^{-1}	2.72	- 0.00	- 0.79*
Calcium	Glume	m mol g^{-1}	0.68	13.29	+ 0.63^{NS}
	Rachis	"	0.42	17.66	+ 0.60^{NS}
	Seed	"	1.00	26.64	+ 0.61^{NS}
	Leaf sap	m mol kg^{-1}	0.71	0.08	+ 0.81*
Magnesium	Glume	m mol g^{-1}	3.23	- 25.50	- 0.82**
	Rachis	"	0.81	29.25	+ 0.60^{NS}
	Seed	"	2.85	- 16.53	- 0.62^{NS}
	Leaf sap	m mol kg^{-1}	1.73	- 0.01	- 0.09^{NS}
K_+/Na_+	Glume	m mol g^{-1}	0.93	0.68	+ 0.89**
	Rachis	"	1.00	1.31	+ 0.81**
	Seed	"	0.79	0.35	+ 0.79*
	Leaf sap	m mol kg^{-1}	0.93	0.97	+ 0.76*

* = Significant at P = 0.05
** = Highly significant at P = 0.01
NS = Non-significant

Grain yield and yield components: All the yield components i.e., number of tillers, shoot and root dry weights and grain yield except straw yield improved significantly in the case of selected as compared to non-selected population of LU 26S (Table 3) at EC 15 dS m^{-1}. Correlation between the grain yield and, number of tillers, root and shoot dry weights was found positive and significant but non-significant with straw yield and shoot/root ratio. Similar results were reported by Asseed *et al.* (1975).

Ionic variation in different parts of plant: Ionic composition of the flag leaf sap showed significant differences for Na^+, Ca^{+2}, K^+ and Cl^- concentrations as well as K^+/Na^+ ratio between the two populations of LU 26S. Selected population of LU 26S had much lower concentration of Na^+ and Cl^- while better Ca^{+2}, K^+ and K^+/Na^+ in its flag leaf (Table 3). Further detailed analyses for the concentration of various ions (Na^+, K^+, Ca^{+2}, Mg^{+2}, K^+/Na^+ ratio and Cl^-) at 15 dS m^{-1} in different parts of spike (glume, rachis and seed) clearly showed the differences between selected and non-selected population (Table 4). All the parts of spike of selected population of LU 26S maintained lower concentrations of Na^+ and Cl^- while higher concentrations of K^+, Ca^{+2} and K^+/Na^+ ratio. The glume analysis was found more representative as compared to flag leaf cell sap and rachis (Table 4 and 5). Significant differences between selected and non-selected population of LU 26S elucidated the better ability of selected material to exclude Na^+ and Cl^-, furthermore, this mechanism was much pronounced in glumes. Perhaps this ability of glume made the selected population of LU 26S more tolerant against salinity.

CONCLUSIONS

In order to screen material for salt tolerance (with regard to maturity) one may prefer to analyse glume over flag leaf. However, later too had good correlation with salt tolerance.

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