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Screening of 20 Wheat Lines Against Salinity in Hydroponics

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Abstract
A hydroponic study was conducted to categorize 20 wheat genotypes in salt tolerance groups i.e. tolerant, moderately tolerant and sensitive on the basis of growth and chemical parameters for rapid screening against salinity. Genotypes 8717, 8247, and 8670-2 were found to be more tolerant than other genotypes on the basis of growth parameters (Shoot fresh weight, shoot dry weight and root fresh weight). No correlation was found between salt tolerance and chemical parameters (Na^+, K^+ and Cl^- in the expressed leaf sap) in this study.

Key words: Screening, Wheat, Salinity

Introduction
Among different environmental stresses faced by plants, one major stress is the soil salinity which is associated with arid and semi-arid areas of the world (Ashraf, 1994). Salinity is a worldwide problem and total salt affected area in the world is about 955 mha. This problem is also very serious in Pakistan because 6.67 mha of arable land in Pakistan are affected by various degrees of soil salinity (Khan, 1998).

An important approach to cope with soil salinity is to exploit the genetic potential of crop plants for their adaptability to adverse soil conditions. This approach is a short term strategy and induces the crop cultivation on the salt affected fields. To employ this approach, the screening of salt tolerant genotypes is necessary because considerable variability for tolerance has been observed among and even within the species (Noryln and Epstein, 1984). Ehsan and Wright (1998) suggested that improvement for salt tolerance might be achieved through selection from already existing wheat varieties. Screening of large number of genotypes in saline field conditions is not feasible due to extreme spatial and temporal variability in soil salinity under field conditions (Richards, 1983). Therefore the crop gene stocks are often screened in nutrient solution by adding appropriate amount of salt to develop the desired salinity levels. This method is relatively quick and reliable for screening the crop genotypes against salinity (Qureshi *et al.*, 1990).The objective of this paper is to screen 20 wheat genotypes on the basis of some growth and chemical parameters against salinity.

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Materials and Methods
This study was carried out at Saline Agriculture Research Center, University of Agriculture, Faisalabad during the year 2000-2001. The healthy seeds of 20 wheat genotypes were sown in trays having 2 inch layer of gravels. At two leaf stage, the seedlings were wrapped with foam at root shoot junction, transplanted in thermopole sheets with holes in them floating on 200 L capacity iron tubs, lined with polythene sheet containing ½ strength Hoagland's solution (Hoagland & Arnon, 1950). Aeration was supplied by bubbling air through the nutrient solution 8 h daily (Haq *et al.*, 2003). The solution was changed every week. The design of the experiment was completely randomized with five replicates. After one week of transplanting, salinity of 100 and 200 mol m^{-3} was developed step-wise with NaCl, whereas in control no salt was added. The pH was maintained between 6.0 – 6.5 throughout the experiment. Plants were harvested after 40 days of imposition of salinity and data about shoot fresh weight, shoot dry weight and root fresh weight were recorded. The fully expanded flag leaves were sampled and stored at -20°C for the determination of Na^+, K^+ and Cl^- in the leaf sap. The leaf sap was extracted using the method of Gorham *et al.*, (1984). Na^+ and K^+ were determined using a flame photometer (PFP7 Jenway) and Cl^- using a chloride analyzer (Corning 925).The data were analyzed following Steel and Torrie (1980).

Criteria of classification of wheat genotypes for salt tolerance

The genotypes can be grouped into tolerant, moderately tolerant and sensitive categories mainly on the basis of some important growth i.e. shoot fresh and dry weights, and root fresh weight (Murillo *et al.*, 2000) and chemical (leaf Na^+, K^+ and Cl^- of leaf sap) characters (Gorham *et al.*, 1984). The values in the parameters (% of control) at two salinity levels were averaged (see

Tables) and used for the classification (Murillo *et al.,* 2001) as given below.

On the basis of shoot fresh weight the genotypes which have values of average of % of control at two salinity levels more than or equal to 50 % are placed in tolerant group. Those having values 40-49.9 % are considered as moderately tolerant, whereas those which have values less than 40 % average of % of control at two salinity levels were considered as sensitive group. On the basis of shoot dry weight and root fresh weight, the genotypes having average values of % of control at two salinity levels more than or equal to 70 %, 55-69.9 % and less than 55 % are categorized into tolerant, moderately tolerant and sensitive groups, respectively. The genotypes hence classified in salt tolerance groups were looked for in chemical parameters and efficacy of these parameters for categorization was compared.

Results and Discussion

The growth and chemical growth parameters such as shoot fresh weight, shoot dry weight, root fresh weight, root dry weight as well as leaf Na^+, K^+ and Cl^- are measured for the determination of crop salt tolerance at early growth stages and can be used as selection/screening criteria for salinity tolerance (Qureshi *et al.,* 1990). However, direct measure of plant salt tolerance is the total bio-mass production or its components. Shoot elongation or height is dependent more upon plant genetic makeup and is not a good parameter for measuring salt tolerance (Ashraf *et al.,* 1999). So we emphasized more upon shoot/root fresh and dry weights as well as chemical parameters for screening.

Genotypes were classified in salt tolerance groups according to selection criteria on the basis of shoot fresh weight (Table 1) The most tolerant genotype was 8717 followed by 8670-2, 8247, 8707, 8271 and SQ 26, respectively. The genotypes 8721, 8715, 8670-3, 8250, 8272, 8714, SQ 78 and 8636 were categorized as moderately tolerant in descending order of salt tolerance within this group. The most sensitive genotype was 8767 followed by SQ 133, 8670-1, 8706-2, SQ 77 and B2-156. On the basis of shoot dry weight (Table 2), the most tolerant genotype was 8717 followed by 8670-2, 8247, 8271, 8707 and SQ 26, respectively. Moderately tolerant group included 8721, 8715, 8706-2, 8670-3, 8272, 8636, SQ 78, 8250 and 8714 in descending order of salt tolerance. The most sensitive genotype was SQ 133 followed by 8767, B2-156, SQ 77 and 8670-1, respectively in case of shoot dry weight. The overall grouping of genotypes was same as given in shoot fresh weight with only one change that the genotype 8706-2 was included in moderately tolerant group. This change was due to the fact that this genotype falls on the margin on the sensitive group in shoot fresh weight case.

The low shoot fresh weight of the wheat genotypes was attributed to decreased water potential of rooting medium and growth inhibition related to osmotic effects under saline conditions (Munns *et al.,* 1995). Under salinity, plant cell turgor pressure decreased and stomatal closure took place resulting in decreased photosynthesis (Gale & Zeroni, 1984). The reduction in shoot weight under saline conditions was also reported by Qureshi *et al.,* (1991), Steppuhn & Wall (1997), Shafqat *et al.,* (1998), Akhtar *et al.,* (1998) and Rashid *et al.,* (1999) in wheat. According to Cheeseman (1988) osmotica synthesis to withstand salinity stress utilizes much of carbon and reduces metabolite synthesis and thus ultimately biomass production was decreased.

On the basis of root fresh weight (Table 3), the most tolerant genotype was 8717 followed by 8721, 8247 and 8670-2, respectively. Moderately tolerant group included SQ 78, 8670-3, 8636, 8715, 8707, 8272, SQ 26 and 8271, respectively. The most salt sensitive genotype was SQ 133 followed by 8767, B2-156, SQ 77, 8250, 8706-2, 8670-1 and 8714, respectively. There was a trend of narrowing down of tolerant group in case of root fresh weight. The genotypes 8707,SQ 26 and 8271 which were declared tolerant in case of shoot fresh/dry weight shifted to moderately tolerant group in case of root fresh weight. The same trend persisted in case of moderately tolerant group. The genotypes 8250 and 8714 shifted to sensitive group which were declared moderately tolerant genotypes in case of shoot fresh/dry weight. There was also a shift from moderately tolerant to tolerant group i.e. genotype 8721.

The sensitive group in case of root fresh weight was the largest sensitive group in all the parameters discussed. The less root fresh weight under saline conditions might be due to decrease in water availability to plants by decreased osmotic potential at root surface (Tarry & Waldrow, 1984) and also due to specific ion toxicity and nutritional imbalance (Levitt, 1980). The decreased root fresh weight with increase in salinity has also been reported by Qureshi *et al.,* (1991) and Akhtar *et al.,* (1998) in wheat.

Regarding data of Na^+, K^+ and Cl^- in expressed leaf sap (Table 4) the values at 200 mol m^{-3} salinity level became non significant with respect to each other. However, at control and 100 mol m^{-3} salinity levels, there was a small difference between genotypes with respect to Na^+, K^+ and Cl^- content of expressed leaf sap. The genotypes 8717, 8247 and 8670-2 declared tolerant in consensus with the three growth parameters have taken up Na^+, K^+ and Cl^- in lesser amount with respect to others in control. At 100 mol m^{-3} salinity level the same pattern continued.

Table 1: Shoot fresh weight response of different wheat genotypes at different salinity levels

Genotypes	Control	100 mol $^{m-3}$	200 mol m^{-3}	Mean per cent *	Tolerance group
SQ 26	23.8	17.73 (74.5)	6.069 (25.5)	50.0	T
SQ 78	9.40	6.18 (65.8)	1.496 (15.9)	40.9	M T
B2-156	21.91	12.1 (55.2)	4.450 (21.0)	38.1	S
SQ 77	24.66	14.9 (60.4)	3.564 (14.5)	37.5	S
SQ 133	31.77	17.11 (53.9)	3.956 (12.5)	33.2	S
8707	13.77	9.88 (71.8)	3.900 (28.3)	50.1	T
8706-2	15.49	7.724(49.9)	3.878 (25.0)	37.5	S
8714	21.12	12.63 (59.8)	4.852 (23.0)	41.4	M T
8767	19.41	10.11 (52.1)	2.582 (13.3)	32.7	S
8636	18.92	11.03 (58.3)	4.260 (22.5)	40.4	M T
8715	18.8	12.76 (67.9)	4.902 (26.1)	47.0	M T
8717	10.09	6.962 (69.0)	3.572 (35.4)	52.2	T
8670-2	17.11	12.83 (75.0)	4.502 (26.3)	50.7	T
8670-3	17.01	9.478 (55.7)	5.156 (30.3)	43.0	M T
8271	14.89	10.64 (71.5)	4.274 (28.7)	50.1	T
8721	15.1	10.51 (69.6)	4.396 (29.1)	49.4	M T
8247	19.31	13.78 (71.4)	5.612 (29.1)	50.3	T
8250	19.42	11.11 (57.2)	5.160 (26.6)	41.9	M T
8670-1	24.27	11.08 (45.7)	5.796 (23.9)	34.8	S
8272	19.57	11.12 (56.8)	5.084 (26.0)	41.4	M T

( ) = % of control, T= Salt tolerant, M T= Moderately salt tolerant, S= Salt sensitive
* = Mean per cent values of both salt treatments

Table 2. Shoot dry weight response of different wheat genotypes at different salinity levels

Genotypes	Control	100 mol m^{-3}	200 mol m^{-3}	Mean per cent *	Tolerance group
SQ 26	2.478	2.416 (97.5)	1.044 (42.1)	70.0	T
SQ 78	0.904	0.870 (89.6)	0.248 (27.4)	58.5	MT
B2-156	2.242	1.620 (71.5)	0.724 (32.3)	51.9	S
SQ 77	2.580	2.054 (79.6)	0.638 (24.7)	52.2	S
SQ 133	3.680	2.528 (68.7)	0.742 (20.2)	44.5	S
8707	1.574	1.534 (97.5)	0.713 (45.3)	71.4	T
8706-2	1.542	1.042 (67.6)	0.684 (44.4)	65.7	MT
8714	2.174	1.644 (75.6)	0.796 (36.6)	56.1	MT
8767	2.364	1.614 (68.3)	0.500 (21.2)	44.8	S
8636	1.862	1.518 (81.5)	0.728 (39.1)	60.2	MT
8715	1.976	1.792 (90.7)	0.814 (41.2)	66.0	MT
8717	0.940	0.918 (97.7)	0.578 (61.5)	79.6	T
8670-2	1.714	1.772 (103.4)	0.754 (44.0)	73.7	T
8670-3	1.610	1.204 (74.8)	0.832 (51.7)	63.3	MT
8271	1.468	1.402 (95.5)	0.712 (48.5)	72.0	T
8721	1.624	1.499 (89.2)	0.796 (49.0)	69.1	MT
8247	1.966	1.898 (96.5)	0.954 (48.5)	72.5	T
8250	2.125	1.570 (73.9)	0.862 (40.6)	57.3	MT
8670-1	2.416	1.564 (64.7)	1.028 (42.6)	53.7	S
8272	2.062	1.644 (79.7)	0.854 (41.4)	60.6	MT

( ) = % of control, T= Salt tolerant, M T= Moderately salt tolerant, S= Salt sensitive
* = Mean per cent values of both salt treatments

Table 3. Root fresh weight response of different wheat genotypes at different salinity levels

Genotypes	Control	100 mol $^{m-3}$	200 mol m^{-3}	Mean per cent *	Tolerance group
SQ 26	9.11	6.746 (74.1)	3.800 (41.7)	57.9	MT
SQ 78	2.708	2.710 (100.1)	0.960 (35.5)	67.8	MT
B2-156	8.25	4.460 (54.1)	2.428 (29.4)	41.8	S
SQ 77	9.818	5.922 (60.3)	2.082 (21.2)	46.8	S
SQ 133	13.29	6.098 (45.9)	2.532 (19.1)	32.5	S
8707	5.158	4.990 (96.7)	1.624 (31.5)	64.1	MT
8706-2	6.962	4.448 (63.8)	2.459 (35.3)	49.6	S
8714	9.385	6.276 (66.9)	3.112 (33.2)	50.1	S
8767	9.548	4.948 (51.8)	2.452 (25.7)	38.8	S
8636	6.764	6.038 (89.3)	2.774 (41.0)	65.2	MT
8715	7.216	5.744 (79.6)	3.452 (47.8)	63.7	MT
8717	5.07	4.416 (87.1)	3.480 (68.6)	77.4	T
8670-2	6.658	6.358 (95.5)	2.962 (44.5)	70.0	T
8670-3	5.904	4.586 (77.7)	3.212 (54.4)	66.1	MT
8271	6.812	4.946 (72.6)	2.845 (41.4)	57.0	MT
8721	4.99	4.668 (93.5)	2.896 (58.0)	75.8	T
8247	7.038	6.440 (91.5)	3.708 (52.7)	72.1	T
8250	8.558	5.318 (62.1)	3.126 (36.5)	49.3	S
8670-1	9.601	4.966 (51.7)	4.575 (47.7)	49.7	S
8272	6.688	4.933 (73.8)	3.542 (53.0)	63.4	MT

( ) = % of control, T= Salt tolerant, M T= Moderately salt tolerant, S= Salt sensitive

*= Mean per cent values of both salt treatments

Table.4. The ionic concentration of expressed leaf sap of different wheat genotypes at different salinity levels

Genotypes	Na^+ concentration (mol m^{-3})			K^+ concentration (mol m^{-3})			Cl^- concentration (mol m^{-3})		
	Salinity Levels (NaCl)								
	Control	100 mol m^{-3}	200 mol m^{-3}	Control	100 mol m^{-3}	200 mol m^{-3}	Control	100 mol m^{-3}	200 mol m^{-3}
SQ 26	60.0 a-d	63.3 g-h	75.0	155.8 e-g	174.2 a-e	112.5	54.9 c-g	67.9 c-e	232.3
SQ 78	65.8 a-c	88.3 a-f	106.2	185.0 a-f	215.0 a-e	225.0	46.9 d-g	86.8 b-e	278.0
B2-156	50.0 a-g	92.5 a-e	125.0	150.0 e-g	232.5 ab	175.0	35.2 fg	75.5 c-e	221.7
SQ 77	49.1 a-g	86.0 a-g	118.7	174.2 a-g	219.5 a-d	125.0	50.6 d-g	81.1 c-e	232.3
SQ 133	53.3 a-g	65.8 f-h	100.0	163.3 c-g	147.5 c-e	150.0	34.7 fg	90.5 a-e	330.8
8707	45.0 c-g	96.6 a	125.0	185.0 a-f	240.4 ab	112.5	43.1 d-g	119.0 a-e	366.0
8706-2	52.5 a-g	78.3 a-h	118.7	153.3 e-g	215.8 a-d	150.0	35.2 fg	104.4 a-e	228.8
8714	44.1 c-g	91.6 a-e	125.0	153.3 a-f	215.4 a-e	175.0	58.6 c-g	129.5 a-d	411.8
8767	55.8 a-g	81.6 a-h	125.0	180.8 fg	193.8 a-e	218.7	67.5 a-f	99.0 a-e	435.6
8636	53.3 a-g	80.8 a-h	118.7	139.2 b-g	183.8 a-e	112.5	45.4 d-g	97.3 a-e	366.2
8715	48.3 b-g	70.8 c-h	85.0	167.5 bg	177.5 a-e	175.0	39.4 e-g	91.0 a-e	348.4
8717	43.3 d-g	83.3 a-g	106.2	137.5 fg	202.5 a-e	112.5	38.4 e-g	104.9 a-e	371.1
8670-2	50.8 a-g	87.5 a-g	112.5	165.8 b-g	209.6 a-e	112.5	39.8 d-g	105.1 a-e	380.2
8670-3	35.0 g	75.0 a-h	125.0	180.8 a-f	201.7 a-e	150.0	32.3 fg	86.3 b-e	344.9
8271	49.1 a-g	58.3 h	100.0	192.5 a-f	151.7 c-e	187.5	35.6 fg	90.1 a-e	489.2
8721	38.3 d-g	83.3 a-g	125.0	162.5 d-g	206.1 a-e	168.7	61.7 b-g	123.2 a-e	383.6
8247	37.5 e-g	64.1 f-h	137.5	165.0 c-g	145.0 de	156.2	36.6 fg	99.2 a-e	373.1
8250	51.6a-g	92.5 a-e	125.0	232.9 a	215.0 a-e	143.7	85.6 a-c	122.5 a-e	253.4
8670-1	41.6d-g	79.1 a-h	143.7	190.0 a-f	185.8 a-e	218.7	72.0 a-e	73.6 de	447.0
8272	70..0 ab	86.6 a-g	118.7	222.0 a-d	215.0 a-e	137.5	74.8 a-d	143.6 ab	492.8

The values sharing the same letters in the columns are statistically non-significant at P= 0.05

As reported in literature there must be a positive correlation between K^+ uptake and growth parameters and/or a negative correlation between Na^+ uptake and growth parameters. As regards the data being reported here there seems to be no correlation between chemical parameters and salt tolerance.

Exclusion of Na^+ at leaf or cellular level is an important salt tolerance mechanism in wheat (Schachtman and Munns, 1992 and Rashid *et al.,* 1999). Tolerant wheat plants maintain less Na^+ concentration in leaves at high stress level. They maintain this leaf Na^+ concentration mainly by efficient exclusion of Na^+ at root or leaf level. Gorham *et al.,* (1986) reported that amphiploids of Tricitum and Aegilops tolerate salt stress better than wheat due to efficient exclusion of Na^+ and Cl^- from the younger leaves. Increased K^+/Na^+ ratio with increased salinity in tolerant wheat genotypes with respect to sensitive genotypes were earlier reported in different studies (Akhtar *et al.,*1998, Shafqat *et al.,*1998, Rashid *et al.,*1999).

Conclusion

Growth parameters like shoot fresh and dry weights and root fresh weight were found to be more important for screening of germplasm against salinity at early growth stages. No correlation of chemical parameters with salt tolerance was found. Genotypes 8717, 8247 and 8670-2 were found to be salt tolerant. Genotypes SQ-78, 8636, 8715, 8670-3 and 8272 were found to be moderately tolerant and B2-156, SQ-77, SQ-133, 8767 and 8670-1 were declared sensitive wheat genotypes.

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