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Classification of Different Wheat Genotypes in Salt Tolerance Categories on the Basis of Biomass Production

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ABSTRACT

A hydroponics study was conducted in 2000-2001 at Saline Agriculture Research Center, University of Agriculture, Faisalabad to screen out wheat germplasm against salinity. There were 20 wheat genotypes and three EC levels (Control, 100 and 200 mol m^{-3} NaCl) with five repeats. Seven day old wheat seedlings were transplanted in thermopole sheets with holes floating on ½ strength Hoaglands solution (200 L). The experiment was arranged in complete randomized design. After 40 days of the imposition of the salinity stress @ 100 and 200 mol m^{-3}, the plants were harvested and data about shoot fresh weight, shoot dry weight and root fresh weight were recorded and analyzed statistically to interpret the results. Classification criteria was made according to which wheat genotypes were categorized in salt tolerance categories on the basis of biomass production. The genotypes in salt tolerant group were 8244, 8730, 8659, B2-57 and B2-5711; whereas, moderately salt tolerant group included 8602-1, B4-5711, 8784, 8670, 8706-1, 8638 and the sensitive group comprised of 8699, 8757, B4-92, B2-5713, 8290, 5039, 8750, 8284 and B2-5734 in descending order of salt tolerance within each group.

Key Words: Screening; Wheat; Salt tolerance; Hydroponics

INTRODUCTION

Wheat has been ranked as moderately salt tolerant crop (Qureshi & Barrett-Lenard, 1998), but increasing concentration of salts in growth medium resulted in less height and tillering capacity compared to non-saline control (Shafqat *et al*., 1998). The increasing demand of the increasing population necessitates the use of poor quality soils and waters to increase the wheat production. The problem of salinity is very serious in Pakistan as 6.67 Mha area in Pakistan is salt affected (Khan, 1998).

Salinity is inimical to plant growth through specific ion effects, osmotic effects and induced nutrient deficiency (Wyn Jones, 1981). One easy way to cope with the problem of salinity is to exploit the genetic potential of plants for their adaptability to adverse soil conditions. This approach induced the crop cultivation on the salt affected fields but considerable variability for salt tolerance has been observed among and even within the plant species (Norlyn & Epstein, 1984). Ehsan & 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 salts 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 study was to pre screen 20 newly bred wheat genotypes against salinity @ 100 and 200 mol m^{-3} NaCl and to categorize these in salt tolerance categories on the basis of biomass production.

MATERIALS AND METHODS

This study was carried out at Saline Agriculture Research Center, University of Agriculture, Faisalabad. Healthy seeds of 20 wheat genotypes were sown in trays having two inches layer of gravels. At two leaf stage, seedlings were transplanted in thermopole sheets having holes and floating on ½ strength Hoagland's solution (Hoagland & Arnon, 1950). The solution was changed every week. The design of the experiment was CRD with five replicates. After one week of transplanting, EC of 100 and 200 mol m^{-3} was developed stepwise with NaCl in three increments whereas in control no salt was added. The pH was maintained between 6.0 – 6.5 daily throughout the experiment. Plants were harvested after 40 days of the imposition of EC and data about shoot fresh weight, shoot dry weight and root fresh weight were recorded.

Criteria of classification of wheat genotypes for salt tolerance. The genotypes were categorized into three groups i.e. tolerant, moderately tolerant and sensitive mainly on the basis of their shoot fresh weight, shoot dry weight and root fresh weight at two EC levels (Murillo *et al*., 2001). The values in the parenthesis (per cent of control) at two EC levels were averaged (see Tables) and used for the classification as given below.

On the basis of shoot fresh weight the genotypes which have values of average of the percent 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 per cent of control at two EC levels were considered as sensitive group.

On the basis of shoot dry weight, the genotypes having average values of percent of control at two EC levels more than or equal to 70%, 60-69.9% and less than 60% are categorized into tolerant, moderately tolerant and sensitive groups, respectively.

Similarly, on the basis of root fresh weight, the genotypes which have values of average of percent of control at two EC levels more than or equal to 70% are placed in tolerant group. Those having values 50-69.9% are considered as moderately tolerant and those which are less than 50% fall in sensitive group.

RESULTS AND DISCUSSION

The physical growth parameters such as shoot fresh weight, shoot dry weight, root fresh weight and root dry weight are more correlated with crop salt tolerance at early growth stages and can be used as selection/screening criteria for salt tolerance (Ashraf *et al*., 1999).

Shoot fresh and dry weights. The categorization of wheat genotypes on the basis of shoot fresh weight (Table I) indicated that the genotypes in tolerant category were 8244, 8730 and 8659 whereas moderately tolerant group included B2-57, 8602-1, B4-5711, 8784, 8670, B2-5711 and 8706-1 and the sensitive group included 8638, 8699, 8757, B4-92, B2-5713, 8290, 5039, 8750, 8284 and B2-5734 in descending order of salt tolerance within these groups. 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 Rashid *et al.* (1999) in wheat. According to Cheesman (1998) osmotica synthesis to withstand salinity stress utilizes much of carbon and reduces metabolite synthesis and thus ultimately biomass production was decreased.

The above classification was also true for shoot dry weight (Table II) except that the genotype B2-57 has shifted from moderately tolerant to tolerant and genotype 8659 has shifted from tolerant to moderately tolerant group. Similarly the genotypes 8670 and 8638 also shifted between moderately tolerant and sensitive groups. These changes could be due to the fact that these genotypes were falling at the margins of moderately tolerant and sensitive groups. The increased shoot dry weight of some tolerant wheat genotypes at 100 mol m^{-3} compared with control may be due to more tiller production, high K^+ absorption and better Na^+ management of these genotypes at this salinity level. Similar results in case of Lyp.90, LU-26s and Amphiploids of *Triticum* and *Agelopes* were reported by Akhtar *et al.* (1994).

Root fresh weight. Classification of wheat genotypes done on the basis of shoot fresh weight was also true for root fresh weight except that in this case the genotypes 8244 and B2-5711 were mutually shifted between tolerant and moderately tolerant groups (Table III). Similarly 8750 and 8638 come under moderately tolerant group from the sensitive group and the 8670 shifted to sensitive group from

Table I. Shoot fresh weight response of different wheat genotypes at different salinity levels

Genotypes	Control	100 mol m^{-3}	200 mol m^{-3}	Average*	Tolerance group
8244	12.35	10.48 (85)[a]	4.53 (37)[b]	61.0	T
8730	17.24	12.83 (74)	5.32 (31)	52.5	T
8659	21.37	14.68 (70)	6.50 (30)	50.0	T
B2-57	16.56	11.57 (70)	4.44 (27)	48.5	M T
8602-1	19.77	13.88 (70)	5.41 (27)	48.5	M T
B4-5711	23.13	15.27 (66)	5.57 (24)	45.0	M T
8784	20.56	13.13 (64)	5.05 (25)	44.5	M T
8670	17.00	10.04 (59)	4.07 (24)	41.5	M T
B2-5711	24.13	16.74 (69)	5.91 (24)	40.5	M T
8706-1	15.63	9.85 (61)	3.09 (20)	40.5	M T
8638	18.72	10.44 (56)	4.16 (22)	39.0	S
8699	19.58	11.90 (61)	2.48 (13)	37.0	S
8757	20.60	10.47 (51)	4.41 (21)	36.0	S
B4-92	16.92	8.49 (50)	3.63 (21)	35.5	S
B2-5713	21.26	9.11 (43)	5.62 (26)	34.5	S
8290	22.08	11.45 (52)	3.27 (15)	33.5	S
5039	32.70	15.97 (49)	5.61 (17)	33.0	S
8750	11.14	4.28 (38)	2.64 (24)	31.0	S
8284	20.81	9.39 (45)	3.05 (15)	30.0	S
B2-5734	11.71	5.10 (44)	1.69 (14)	29.0	S

( ) =% of control; T= Salt tolerant; M T= Moderately salt tolerant; S= Salt sensitive; * = (a + b) / 2

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

Genotypes	Control	100 mol m^{-3}	200 mol m^{-3}	Average*	Tolerance group
8244	1.594	1.688 (106)[a]	0.804 (50)[b]	78.0	T
8730	1.928	1.804 (94)	0.942 (49)	71.5	T
8659	2.506	2.146 (86)	1.144 (46)	66.0	M T
B2-57	1.674	1.650 (99)	1.002 (60)	79.5	T
8602-1	2.094	1.962 (94)	0.864 (41)	67.5	M T
B4-5711	2.538	2.234 (88)	1.046 (41)	64.5	M T
8784	2.188	1.974 (90)	0.890 (41)	65.5	M T
8670	2.008	1.380 (69)	0.694 (35)	52.0	S
B2-5711	2.556	2.410 (94)	1.068 (42)	68.0	M T
8706-1	1.708	1.766 (103)	0.516 (30)	66.5	M T
8638	1.858	1.510 (81)	0.730 (39)	60.0	M T
8699	2.502	2.042 (82)	0.496 (20)	51.0	S
8757	2.160	1.550 (72)	0.780 (36)	54.0	S
B4-92	1.726	1.250 (72)	0.688 (40)	56.0	S
B2-5713	2.254	1.340 (59)	1.018 (45)	52.0	S
8290	2.492	1.874 (75)	0.562 (23)	49.0	S
5039	3.818	2.132 (56)	0.890 (23)	39.5	S
8750	1.326	0.584 (44)	0.450 (34)	39.0	S
8284	2.296	1.294 (65)	0.502 (22)	43.5	S
B2-5734	1.206	0.708 (59)	0.320 (27)	43.0	S

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

Genotypes	Control	100 mol m^{-3}	200 mol m^{-3}	Average*	Tolerance group
8244	5.59	4.49 (80)[a]	2.69 (48)[b]	64.0	M T
8730	6.39	6.14 (96)	3.45 (54)	75.0	T
8659	9.17	8.10 (88)	4.80 (52)	70.0	T
B2-57	5.94	4.94 (83)	2.22 (37)	60.0	M T
8602-1	7.06	5.37 (76)	3.62 (51)	63.5	M T
B4-5711	9.76	7.53 (77)	3.35 (34)	55.5	M T
8784	8.18	5.96 (73)	3.28 (40)	56.5	M T
8670	8.24	4.05 (49)	3.27 (40)	44.5	S
B2-5711	7.85	7.75 (99)	3.37 (43)	71.0	T
8706-1	6.08	4.23 (70)	1.80 (30)	50.0	M T
8638	5.99	5.05 (84)	2.42 (40)	62.0	M T
8699	7.70	5.21 (68)	1.84 (24)	46.0	S
8757	7.49	4.82 (64)	2.00 (27)	45.5	S
B4-92	6.91	3.87 (56)	1.87 (27)	41.5	S
B2-5713	7.21	3.57 (50)	2.78 (39)	44.5	S
8290	8.34	4.66 (56)	2.36 (28)	42.0	S
5039	14.6	8.46 (58)	3.59 (25)	41.5	S
8750	3.25	1.83 (56)	1.66 (51)	53.5	M T
8284	9.07	4.59 (51)	2.25 (25)	38.0	S
B2-5734	5.04	2.63 (52)	1.50 (30)	41.0	S

( ) =% of control, T= Salt tolerant, M T= Moderately salt tolerant, S= Salt sensitive; * = (a + b) / 2

moderately tolerant group. 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 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 Akhtar *et al.* (1998) in wheat.

In screening experiments it is difficult to express the response of large number of genotypes individually. A simple and rigorous method for quick screening and categorization of genotypes into salt tolerance group was developed. It was noted that the genotypes declared tolerant in case of shoot fresh weight (8244, 8730 and 8659) were not the same in case of shoot dry weight (8244, 8730 and B2-57) and root fresh weight (8730, 8659 and B2-5711). The genotype 8730 was common in all groups. Common genotypes declared moderately tolerant in all the parameters studied were 8602-1, B4-5711, 8784 and 8706-1 and common sensitive genotypes were 8699, 8757, B4-92, B2-5713, 8290, 5039, 8284 and B2-5734.

CONCLUSION

A simple and rigorous method for quick screening and categorization of genotypes into salt tolerance groups was developed. Genotype 8730 was declared tolerant whereas genotypes 8602-1, B4-5711, 8784 and 8706-1 were declared moderately tolerant and sensitive genotypes were 8699,

8757, B4-92, B2-5713, 8290, 5039, 8284 and B2-5734.

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