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SCREENING FOR SALT TOLERANCE IN WHEAT GENTOYPES AT AN EARLY SEEDLING STAGE

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Abstract

Twenty-four wheat genotypes were screened for salt tolerance at an early seedling growth stages at 0, 100, 150 and 200 m*M* NaCl levels. Seedlings of each genotype were compared for their growth under saline conditions as a percentage of the control value. Experiments were conducted in plastic bowls with nylon net over which seed were placed for germination. The bowls were kept in an incubator at 25 ± 5^{o}C in dark for 72 hours then they were exposed to 4000-lux light intensity for photosynthetic activity. Seedlings were harvested after 192 hours and their shoot and root lengths and dry weights were recorded. Results indicated that the wheat genotypes V-8001, LU26s, Bhittai, C-228, KTDH, KTDH-22, DS-17 are tolerant at germination and seedling stage in most of the growth parameters studied.

Introduction

High concentration of complex inorganic salts present in the growing medium, retard the growth in most of the crop plants depending on the nature of the salts present, the growth stages and the salt tolerance or avoidable mechanism of the plant tissues (Ashraf *et al.,* 2002). Most of the crops tolerate salinity to a threshold level and above, where yield decreases as the salinity increases (Khan *et al.,* 2006). Plant scientists to overcome the salinity have adopted various strategies. One of the important of them is to exploit genetic variability of the available germplasm to identify a tolerant genotype that may sustain a reasonable yield on salt affected soils (Ashraf *et al.,* 2006). Characters such as germination, survival and seedling growth or biomass accumulation, have been the most commonly used criteria for identifying salinity tolerance in plants (Khan *et al.,* 2006). Salt tolerance, however, is usually assayed in terms of absolute or relative growth or yield (accumulation of biomass or grain yield) (Sarwar & Ashraf 2003). This is due to ease of measurement, and because biomass production under saline conditions is usually the ultimate goal. Therefore, comparison of large number of genotypes for seedling growth can provide useful information about the salt tolerance potential of screened material which will be useful for breeding salt tolerant cultivar or introducing the screened material for cultivation on salt-affected soils.

Screening of large numbers of genotypes of a crop is necessary to identify the salt tolerant germplasm for breeding programs to evolve the salt tolerant and high yielding crop varieties. Screening for salinity tolerance in the field is difficult, due to spatial heterogeneity of soil physico-chemical properties, and seasonal fluctuations in rainfall. However, field screening of different barley, wheat and *Brassica* genotypes at Biosaline Research Station-II (Pacca Anna) of NIAB, Pakistan, showed that considerable genetic variation for salt tolerance exists among the species of *Brassica*, barley and wheat (Ashraf *et al.,* 2005 b). Screening under controlled environments has, therefore, often been carried out. Large numbers of modern bread and primitive wheat genotypes were screened for salt tolerance in glasshouses, the criteria being germination and biomass production at high salinity (up to 200 m*M* NaCl) relative to that in non-saline conditions. From the data on germination and shoot dry biomass, tolerant genotypes can be identified and germplasm so screened can be used in the breeding programs for stress tolerance (Sarwar & Ashraf, 2003). Sayed (1985) also screened 5000 wheat lines using plant survival at high salinity and showed considerable genetic diversity amongst hexaploid and tetraploid lines. However, little has come up from such work, presumably due to a lack of correlation between performance of genotypes under glasshouse conditions and that under field conditions. Possibly, application of the glasshouse based on screening methods would have been very effective if genetic differences at moderate salinity levels i.e., 50-100 m*M* NaCl, had been found.

Keeping in view this idea, present investigation was planned for screening 24 wheat genotypes in a solution culture experiment at 100 to 200 m*M* NaCl. This research describes the effect of soil salinity on the germination and seedling growth of these wheat genotypes. The screened material may be used in the breeding programme of NIA Tandojam, Pakistan or can be recommended for cultivation on salinity-hit areas.

Materials and Methods

The seeds of 24 wheat genotypes were obtained from Plant Genetics Division, NIA, Tandojam. Healthy caryopses of each genotype were surface sterilized with 5% Sodium hypochlorite solution for five minutes to avoid any fungal infection. These seeds were then thoroughly washed with distilled water thrice. Counted number of seeds of each wheat genotype were planted over nylon net placed in a plastic bowls (AEARC, Annual Report, 1984), having $1/4^{th}$ Hoagland Nutrient Solution (Hoagland & Arnon, 1950) salinized with different concentrations of Sodium chloride (NaCl) i.e., control, 100, 150 and 200mM. These bowls were then covered with perforated plastic bags to maintain constant humidity. The bowls were then kept in an incubator at $25 \pm 5^{o}C$ in dark for germination for 72 hours. Each treatment was replicated thrice. These bowls were then exposed to 4000 lux light intensity for photosynthetic activity for further 5 days. After the completion of total 8 days, the experiments were terminated and their germination percentage, shoot and root lengths were measured and fresh and dry weights were also recorded. All the collected data were statistically analyzed (Steel & Torrie, 1997).

Results

Germination of all 24 wheat genotypes decreased gradually with increasing salinity levels of the media. Variations in seed germination were recorded in all the tested wheat genotypes (Table 1). The maximum reduction in germination was found at the highest salinity level (200 m*M* NaCl). Significant ($p \leq 0.05$) reduction was observed in Margla (51%) followed by Bakhtawar (36.5%) at the highest salinity level; however, the other wheat genotypes were successful in maintaining seed germination above 85% (Table 1). Shoot length was affected significantly with the increase in salinity (Table 2). Under control condition, maximum shoot length was observed in genotypes V-8319, KTDH, KTDH-22 and Sarsabz. On exposing wheat genotypes to 200 m*M* NaCl salinity, the genotypes V-8001, KTDH, KTDH-22, Lu-26s, Marvi, Bhittai, DS-17, Abadgar and Sarsabz performed better by maintaining less than 50% reduction in shoot length as compared to others. These varieties also performed significantly better at 100 and 150 m*M* NaCl levels than 200 m*M* (Table 2).

Table 1. Effect of different levels of NaCl on seed germination (%) of wheat genotypes.

Genotypes	Control	100 m*M*	% Red.	150 m*M*	% Red.	200 m*M*	% Red.	Mean	
V-7015	97.77	96.63	(1.17)	94.40	(3.45)	88.85	(9.12)	94.41	A
V-7012	98.87	96.63	(2.27)	91.10	(7.86)	88.63	(10.36)	93.81	A
V-7004	97.73	96.67	(1.08)	95.50	(2.28)	93.30	(4.53)	95.80	A
V-7003	100.00	98.87	(1.13)	98.87	(1.13)	97.73	(2.27)	98.87	A
V-8001	96.67	94.67	(2.07)	93.33	(3.46)	91.00	(5.87)	93.92	A
V-8319	100.00	98.57	(1.43)	97.33	(2.67)	96.67	(3.33)	98.14	A
KTDH	100.0	99.00	(1.00)	96.67	(3.33)	87.67	(12.33)	95.84	A
KTDH-22	100.0	99.00	(1.00)	97.77	(2.23)	97.67	(2.33)	98.61	A
Margla	95.5	91.10	(4.64)	89.97	(5.82)	46.60	(51.22)	80.80	B
Inquilab	96.7	94.43	(2.38)	83.33	(13.85)	81.10	(16.16)	88.90	AB
Lu-26s	100.0	100.00	(0.00)	99.00	(1.00)	97.00	(3.00)	99.00	A
C-228	99.0	97.67	(1.34)	97.00	(2.02)	96.67	(2.35)	97.59	A
Marvi	98.7	98.50	(0.17)	98.00	(0.68)	96.83	(1.86)	98.00	A
Bhittai	99.3	98.67	(0.66)	97.50	(1.84)	95.47	(3.89)	97.74	A
Zardana	98.9	97.70	(1.18)	94.40	(4.52)	87.73	(11.27)	94.68	A
Chakwal	100.0	100.00	(0.00)	95.67	(4.33)	92.33	(7.67)	97.00	A
RWM-9313	97.8	97.73	(0.04)	96.63	(1.17)	95.53	(2.29)	96.92	A
ESW-9525	99.0	98.97	(0.06)	97.90	(1.14)	96.03	(3.03)	97.98	A
Khirman	97.0	96.67	(0.31)	94.27	(2.78)	90.67	(6.50)	94.65	A
DS-17	99.0	99.00	(0.00)	98.03	(0.98)	96.67	(2.35)	98.18	A
Abadgar	96.6	95.53	(1.14)	95.53	(1.14)	93.07	(3.68)	95.19	A
Sarsabz	100.0	99.00	(1.00)	99.00	(1.00)	98.00	(2.00)	99.00	A
Bakhtawar	97.7	82.20	(15.8)	82.13	(15.96)	62.10	(36.46)	81.04	B
Iqbal	100.0	97.77	(2.23)	95.40	(4.60)	89.43	(10.57)	95.65	A
Mean	**98.60**	**96.87**		**94.95**		**89.86**		**95.07**	

Values in parenthesis indicate percent decrease (-) over control

Means in the same columns and same rows sharing the same letters did not differ significantly (p≥0.05).

Table 2. Effect of different levels of NaCl on shoot length (cm) of wheat genotypes.

Genotypes	Control	100 m*M*	% Red.	150 m*M*	% Red.	200 m*M*	% Red.	Mean	
V-7015	15.3	14.23	(6.7)	11.74	(23.0)	2.63	(82.75)	11.0	DEF
V-7012	16.6	15.27	(7.8)	11.32	(31.7)	4.91	(70.37)	12.02	CDEF
V-7004	14.2	13.78	(3.2)	11.77	(17.3)	3.73	(73.79)	10.88	DEF
V-7003	15.6	14.67	(6.0)	11.27	(27.8)	5.13	(67.12)	11.67	CDEF
V-8001	16.1	14.17	(12.2)	11.63	(27.9)	8.87	(45.01)	12.70	BCD
V-8319	19.9	17.93	(9.9)	12.30	(38.2)	7.93	(60.15)	14.52	AB
KTDH	20.4	18.97	(7.2)	15.90	(22.2)	10.13	(50.42)	16.36	A
KTDH-22	20.1	18.73	(7.0)	15.27	(24.1)	11.03	(45.21)	16.29	A
Margla	17.6	12.57	(28.7)	10.53	(40.3)	4.20	(76.18)	11.23	DEF
Inquilab	14.2	13.00	(8.3)	11.67	(17.6)	6.23	(56.03)	11.27	DEF
Lu-26s	15.4	15.13	(1.6)	12.37	(19.5)	8.83	(42.55)	12.93	BCD
C-228	20.4	19.63	(3.8)	15.30	(25.0)	9.47	(53.58)	16.20	A
Marvi	15.7	14.60	(7.2)	11.90	(24.4)	8.40	(46.60)	12.66	BCDE
Bhittai	12.0	10.57	(11.9)	10.50	(12.5)	8.70	(27.50)	10.44	EF
Zardana	15.6	15.27	(2.1)	13.57	(13.0)	3.58	(77.05)	12.01	CDEF
Chakwal	15.0	13.77	(8.0)	11.50	(23.2)	7.07	(52.77)	11.83	CDEF
RWM-9313	17.4	16.90	(2.9)	15.90	(8.6)	4.40	(74.71)	13.65	BC
ESW-9525	14.4	10.77	(25.4)	10.0	(30.5)	6.10	(57.73)	10.33	F
Khirman	15.9	13.37	(16.1)	10.5	(34.1)	6.72	(57.82)	11.63	CDEF
DS-17	14.5	14.21	(2.2)	13.2	(9.4)	9.67	(33.45)	12.90	BCD
Abadgar	14.4	12.49	(13.6)	9.5	(34.1)	8.43	(41.66)	11.22	DEF
Sarsabz	20.1	18.73	(7.0)	15.3	(24.1)	11.03	(45.21)	16.29	A
Bakhtawar	16.6	12.38	(25.4)	7.3	(55.9)	3.73	(77.53)	10.01	F
Iqbal	17.3	16.03	(7.1)	13.6	(21.3)	5.13	(70.26)	13.00	BCD
Mean	**16.5**	**14.88**		**12.2**		**6.92**		**12.63**	

Values in parenthesis indicate percent decrease (-) over control

Means in the same columns and same rows sharing the same letters did not differ significantly (p≥0.05).

Table 3. Effect of different levels of NaCl on root length (cm) of wheat genotypes.

Genotypes	Control	100 m*M*	% Red.	150 m*M*	% Red.	200 m*M*	% Red.	Mean	
V-7015	14.26	11.32	(20.62)	10.10	(29.17)	4.93	(65.43)	10.15	ABCDEF
V-7012	11.53	9.81	(14.92)	5.46	(52.65)	3.60	(68.78)	7.60	GHI
V-7004	10.87	10.70	(1.56)	8.90	(18.12)	4.07	(62.56)	8.64	DEFGH
V-7003	16.60	14.83	(10.66)	10.63	(35.96)	4.77	(71.27)	11.71	AB
V-8001	12.47	11.43	(8.34)	7.75	(37.85)	6.23	(50.04)	9.47	CDEFG
V-8319	13.23	9.90	(25.17)	7.40	(44.07)	4.43	(66.52)	8.74	DEFGH
KTDH	10.80	10.73	(0.65)	10.50	(2.78)	6.20	(42.59)	9.56	BCDEFG
KTDH-22	11.73	10.53	(10.23)	10.40	(11.34)	6.63	(43.48)	9.82	BCDEFG
Margla	9.63	7.90	(17.96)	5.33	(44.65)	2.93	(69.57)	6.45	I
Inquilab	8.53	8.47	(0.70)	6.43	(24.62)	3.07	(64.01)	6.63	HI
Lu-26s	9.70	9.63	(0.72)	9.03	(6.91)	5.57	(42.58)	8.48	EFGHI
C-228	13.17	12.57	(4.56)	10.17	(22.78)	7.00	(46.85)	10.73	ABCDEF
Marvi	15.07	12.47	(17.25)	9.87	(34.51)	6.47	(57.07)	10.97	ABC
Bhittai	17.73	13.93	(21.43)	9.47	(46.59)	7.50	(57.70)	12.16	A
Zardana	11.77	11.60	(1.44)	9.53	(19.03)	3.38	(71.28)	9.07	CDEFG
Chakwal	10.93	10.10	(7.59)	9.00	(17.66)	4.57	(58.19)	8.65	DEFGH
RWM-9313	14.97	12.97	(13.36)	11.63	(22.31)	4.97	(66.80)	11.14	ABC
ESW-9525	11.73	8.30	(29.24)	7.93	(32.40)	5.77	(50.81)	8.43	EFGHI
Khirman	14.03	11.67	(16.82)	10.62	(24.31)	5.48	(60.94)	10.45	ABCDEF
DS-17	14.43	13.83	(4.16)	12.17	(15.66)	8.00	(44.56)	12.11	A
Abadgar	10.90	8.03	(26.33)	5.70	(47.71)	5.27	(51.65)	7.48	GHI
Sarsabz	10.80	10.73	(0.65)	10.50	(2.78)	6.20	(42.59)	9.56	BCDEFG
Bakhtawar	12.32	6.70	(45.62)	4.29	(65.18)	4.25	(65.50)	6.89	HI
Iqbal	10.40	9.57	(7.98)	9.10	(12.50)	3.60	(65.38)	8.17	FGHI
Mean	**12.40**	**10.74**		**8.83**		**5.20**		**9.29**	

Values in parenthesis indicate percent decrease (-) over control

Means in the same columns and same rows sharing the same letters did not differ significantly (p≥0.05).

Root length at 200 m*M* NaCl showed maximum reduction as compared to 100 and 150 m*M* NaCl levels. Out of 24 genotypes, 16 showed more than 50% reduction in their root length whereas 8 genotypes performed better. Maximum reduction in root length was observed in V-7003 and Zardana (> 71%) and minimum in Lu-26s, Sarsabz, KTDH and KTDH-22 (about 43 %).

Due to increase in salinity, shoot and root emergence was delayed, as a result of which biomass accumulation was severely affected consequently; fresh and dry weights were reduced. Under non-saline condition maximum shoot weight was observed in Marvi, KTDH and KTDH-22, whereas maximum decrease in fresh weight of shoot was observed in Iqbal and Inquilab. At 200 m*M* NaCl, only one genotype (Sarsabz) has less than 50% reduction in fresh weight. Genotypic variations for root fresh weight of all the 24 genotypes were found when grown under normal and saline conditions. Under controlled conditions, the genotypes Marvi and Chakwal have the highest root fresh weight as compared to other genotypes. In all the genotypes root fresh weight was recorded more than 50% at 200 m*M* NaCl level except Abadgar (16%), Bhittai (42 %), RWM-9313 (45%), Sarsabz (49 %), and V-8001 (49%). Similarly maximum reduction in shoot dry weight was recorded at 200 m*M* NaCl in all wheat genotypes. The minimum reduction was observed in Sarsabz (28%) followed by Lu-26s (39%) and V-7003 (39.8%) whereas 14 genotypes showed more than 50% reduction in their shoot dry weight.

Root dry weight showed the same pattern as in fresh weight. Maximum root dry weight was observed in V-7004 followed by Bhittai under control. At 200 m*M* NaCl, 17 genotypes exhibited more than 50% reduction in their dry weight while only 7 genotypes maintained less than 50%. The maximum decrease in root dry weight was observed in V-7004 and minimum in Sarsabz.

Table 4. Effect of different levels of NaCl on shoot fresh biomass (g plant^{-1}) of wheat genotypes.

Genotypes	Control	100 m*M*	% Red.	150 m*M*	% Red.	200 m*M*	% Red.	Mean	
V-7015	3.687	3.100	(15.921)	2.383	(35.368)	0.389	(89.44)	2.390	ABCD
V-7012	3.340	2.640	(20.958)	1.650	(50.599)	0.307	(90.80)	1.984	DEF
V-7004	3.527	3.137	(11.058)	2.417	(31.472)	0.585	(83.41)	2.417	ABCD
V-7003	3.040	2.800	(7.895)	1.969	(35.230)	0.833	(72.59)	2.161	BCDE
V-8001	3.343	2.473	(26.025)	2.033	(39.186)	1.573	(52.94)	2.356	ABCDE
V-8319	4.052	2.910	(28.184)	1.526	(62.340)	1.171	(71.10)	2.415	ABCD
KTDH	4.076	3.254	(20.167)	2.568	(36.997)	1.548	(62.02)	2.862	A
KTDH-22	4.091	2.938	(28.184)	2.210	(45.979)	1.649	(59.692)	2.722	AB
Margla	3.389	2.228	(34.258)	1.688	(50.192)	0.267	(92.122)	1.893	DEF
Inquilab	2.660	2.525	(5.075)	1.933	(27.331)	0.749	(71.842)	1.967	DEF
Lu-26s	3.395	2.700	(20.471)	2.049	(39.647)	1.217	(64.153)	2.340	ABCDE
C-228	3.756	3.724	(0.852)	2.277	(39.377)	1.580	(57.934)	2.834	A
Marvi	4.120	2.667	(35.267)	2.200	(46.602)	1.567	(61.966)	2.639	ABC
Bhittai	3.463	2.012	(41.900)	2.083	(39.850)	1.353	(60.930)	2.228	BCDE
Zardana	3.713	3.640	(1.966)	2.937	(20.900)	0.281	(92.432)	2.643	ABC
Chakwal	3.624	2.649	(26.904)	2.088	(42.384)	1.255	(65.370)	2.404	ABCD
RWM-9313	2.727	2.270	(16.758)	1.603	(41.217)	0.693	(74.587)	1.823	EF
ESW-9525	2.990	2.323	(22.308)	1.670	(44.147)	1.290	(56.856)	2.068	DEF
Khirman	3.712	2.837	(23.572)	2.166	(41.649)	1.114	(69.989)	2.457	ABCD
DS-17	2.898	2.413	(16.736)	2.080	(28.226)	1.270	(56.177)	2.165	BCDE
Abadgar	3.557	2.778	(21.900)	1.730	(51.364)	1.210	(65.983)	2.319	ABCDE
Sarsabz	3.303	2.388	(27.702)	1.883	(42.991)	1.640	(50.348)	2.304	ABCDE
Bakhtawar	3.213	1.817	(43.44)	0.823	(74.385)	0.253	(92.126)	1.527	F
Iqbal	2.688	2.653	(1.30)	2.287	(14.918)	0.850	(68.378)	2.120	CDE
Mean	**3.432**	**2.703**		**2.011**		**1.027**		**2.293**	

Values in parenthesis indicate percent decrease (-) over control

Means in the same columns and same rows sharing the same letters did not differ significantly (p≥0.05).

From these studies it can be concluded that the genotypes Sarsabz, V-8001, Lu-26s, KTDH, KTDH-22, Bhittai and DS-17 are more tolerant to salinity upto 200 m*M* NaCl. The genotypes RWM-9313, Marvi, Abadgar, V-7015, V-7012, V-7004, V-7003, V-8319, Margla, Inquilab, C-228, Zardana, ESW-9525, Khirman, Chakwal-86, Bakhtawar and Iqbal can be categorized as sensitive to high salinity i.e., 200 m*M* NaCl stress.

Discussion

As the experiments were conducted in plastic bowls containing test solutions and seeds were sown on the net just above the solution which have no direct contact with solution that is why reasonable germination was recorded upto 200 m*M* NaCl in all the varieties except Margla and Bakhtawar. Literature (Ashraf *et al.*, 1996; 2002) also indicated that germination is not a good criteria to determine salt tolerance potential of crop plants because germination depends upon many factors, including conditions at the time of harvesting, storing temperatures etc. Survival of seedlings is the criteria on the basis of which large number of genotypes can be screened for salt tolerance.

Root is the plant organ which supplies all the nutrients from growth medium to growing plant and has direct contact with the medium so rooting behaviour provides the useful information regarding the salt tolerance potential of plants. In the present investigation, root growth was severely affected due to salinity (Table 3). It is reported that root growth is sensitive to increase in salt concentration of medium that's why roots are rapidly reduced or prevented by salinity (Cramer, *et al.*, 1988; Ashraf *et al.*, 2005). Under saline conditions, depletion of O_2 deprives the plants of its primary energy source and accumulation of internal ethylene causes the inhibition of root elongation (Ashraf *et al.*, 2005) by reducing root growth, which consequently reduce root fresh and dry biomass. Present results also indicated that when the seeds exposed to high salinity severe reduction in root length (Table 3), root fresh (Table 5) and dry biomass (Table 7) appeared in all the wheat genotypes. However, the genotypes having genetic potential for salt tolerant showed different behavior as in case of V-7004 and Sarsabz in the present study (Tables 3, 5, 7). It was reported that high salt concentration in the nutrient medium causes stunted growth in plants (Ashraf *et al.*, 1999; Cherian *et al.*, 1999; Takemura *et al.*, 2000). The immediate response of salt stress is reduction in rate of leaf surface expansion (Wang & Nil, 2000), this results in a considerable decrease in the fresh and dry weights of shoot, leaves and roots (Ali Denar *et al.*, 1999; Chartzoulakis & Klapaki, 2000; Ashraf *et al.*, 2005). Salinity reduced plant growth either by decreasing plant osmotic potential or due to specific ion toxicity (Dionisio-Sese & Tobita, 2000; Ashraf & Sawar, 2002). In present study, a significant decrease in shoot length (Table 2), fresh and dry weights of shoot (Table 4, 6) of all the genotypes was noted with the increase in salt concentration of medium, however, genotypes V-8001, KTDH, KTDH-22, Lu-26s, Marvi, Bhittai, DS-17, Abadgar and Sarsabz performed better than others by maintaining reduction in shoot growth less than 50 %. Reduction in plant growth as a result of salt stress has also been reported in several other plant species (Ashraf & McNeilly, 1990; Mishra *et al.*, 1991; Ashraf & O'leary, 1997).

NaCl stress significantly reduced total dry biomass (shoot+ root dry; biomass) for all the wheat cultivars but genotype Marvi, KTDH and KTDH-22 was the least affected at both salinity levels (Tables 6, 7). The degree of reduction in dry biomass increased with increasing salt stress. Reduction in dry biomass has also been reported in many other crops (Pessarakli & Huber, 1991; Al-Rawahy *et al.*, 1992; Ashraf *et al.*, 2002). The negative response of dry biomass with increasing salinity stress may be attributed to decreased rate of photosynthesis. The results are in accordance with Ashraf *et al*., (1991), Ullah *et al*., (1993) and Cachorro *et al*., (1994).

Increasing salinity is accompanied by significant reductions in shoot fresh and dry biomass, shoot and root length (Tables 2-7) similar results were reported by Mohammad *et al*., (1998) in tomato. In the present study, almost all the wheat genotypes responded varyingly to imposition of different salinity levels. Wheat genotypes Sarsabz, V-8001, Lu-26s, KTDH, KTDH-22, Bhittai and DS-17 showed better performance in terms of shoot and root growth and proved to be tolerant to lower as well as high level of salinity. Similar, results were also reported by Meloni *et al*., (2001) for cotton, Ashraf & Sarwar (2002) for Brassica and Sarwar & Ashraf (2003) and Iqbal *et al*., (2006) for Wheat.

From the results it can be concluded that screening of a large germplasm can be done through laboratory experiments using accumulation of shoot and root biomass accumulation or their vigour under saline conditions. The screen material can be used to evolve high yielding salt tolerant wheat cultivars or can directly be introduced for cultivation on salt-affected areas.

Table 5. Effect of different levels of NaCl on root fresh biomass (g plant^{-1}) of wheat genotypes.

Genotypes	Control	100 m*M*	% Red.	150 m*M*	% Red.	200 m*M*	% Red.	Mean	
V-7015	2.540	2.320	(8.7)	2.212	(12.9)	0.460	(81.9)	1.883	ABCD
V-7012	1.947	1.627	(16.4)	1.322	(32.1)	0.590	(69.7)	1.372	DEFG
V-7004	2.080	1.943	(6.6)	1.763	(15.2)	0.577	(72.3)	1.591	CDEFG
V-7003	2.894	2.257	(22.0)	2.000	(30.9)	0.639	(77.9)	1.948	ABC
V-8001	3.053	2.643	(13.4)	1.790	(41.4)	1.553	(49.1)	2.260	A
V-8319	2.860	1.590	(44.4)	1.507	(47.3)	1.016	(64.5)	1.743	ABCDE
KTDH	2.750	2.157	(21.6)	1.916	(30.3)	0.952	(65.4)	1.944	ABC
KTDH-22	2.377	1.784	(24.9)	1.302	(45.2)	0.952	(59.9)	1.604	CDEFG
Margla	1.358	1.329	(2.1)	1.249	(8.0)	0.356	(73.8)	1.073	GH
Inquilab	1.525	1.288	(15.5)	1.134	(25.6)	0.479	(68.6)	1.107	GH
Lu-26s	2.577	1.869	(27.5)	1.579	(38.7)	1.117	(56.7)	1.786	ABCDE
C-228	2.307	1.317	(42.9)	1.134	(50.8)	1.087	(52.9)	1.461	CDEFG
Marvi	3.600	2.033	(43.5)	1.717	(52.3)	1.217	(66.2)	2.142	AB
Bhittai	1.517	1.330	(12.3)	1.315	(13.3)	0.885	(41.7)	1.262	EFG
Zardana	2.361	2.328	(1.4)	1.877	(20.5)	0.216	(90.8)	1.696	BCDEF
Chakwal	3.092	2.074	(32.9)	1.805	(41.6)	0.977	(68.4)	1.987	ABC
RWM-9313	1.717	1.622	(5.5)	1.123	(34.6)	0.950	(44.7)	1.353	DEFG
ESW-9525	1.967	1.263	(35.8)	1.227	(37.6)	0.717	(63.5)	1.294	EFG
Khirman	2.776	2.101	(24.3)	1.667	(39.9)	0.957	(65.5)	1.875	ABCD
DS-17	2.255	1.896	(15.9)	1.480	(34.4)	0.746	(66.9)	1.594	CDEFG
Abadgar	1.428	1.403	(1.7)	1.302	(8.8)	1.200	(16.0)	1.333	EFG
Sarsabz	3.053	2.643	(13.4)	1.790	(41.4)	1.553	(49.1)	2.260	A
Bakhtawar	1.244	0.980	(21.2)	0.520	(58.2)	0.245	(80.3)	0.747	H
Iqbal	1.533	1.331	(13.2)	1.221	(20.4)	0.675	(56.0)	1.190	FGH
Mean	**2.284**	**1.797**		**1.498**		**0.838**		**1.604**	

Values in parenthesis indicate percent decrease (-) over control

Means in the same columns and same rows sharing the same letters did not differ significantly (p≥0.05).

Table 6. Effect of different levels of NaCl on shoot dry biomass (g plant^{-1}) of wheat genotypes.

Genotypes	Control	100 m*M*	% Red.	150 m*M*	% Red.	200 m*M*	% Red.	Mean
V-7015	0.4260	0.3923	(7.9)	0.3257	(23.5)	0.0590	(86.1)	0.3008
V-7012	0.3367	0.3137	(6.8)	0.1663	(50.6)	0.0347	(89.7)	0.2129
V-7004	0.2620	0.2440	(6.9)	0.2153	(17.8)	0.0447	(82.9)	0.1915
V-7003	0.2760	0.2507	(9.2)	0.2060	(25.4)	0.0753	(72.7)	0.2020
V-8001	0.3477	0.3293	(5.3)	0.2913	(16.2)	0.2093	(39.8)	0.2944
V-8319	0.3961	0.3557	(10.2)	0.2247	(43.3)	0.1583	(60.0)	0.2837
KTDH	0.3360	0.2867	(14.7)	0.2840	(15.5)	0.1740	(48.2)	0.2702
KTDH-22	0.3793	0.3253	(14.2)	0.2588	(31.8)	0.2027	(46.6)	0.2915
Margla	0.3640	0.4747	(+30.4)	0.2830	(22.2)	0.0238	(93.5)	0.2864
Inquilab	0.2660	0.2620	(1.5)	0.2257	(15.1)	0.0657	(75.3)	0.2049
Lu-26s	0.3477	0.3293	(5.3)	0.2913	(16.2)	0.2093	(39.8)	0.2944
C-228	0.3860	0.3190	(17.4)	0.2417	(37.4)	0.1703	(55.9)	0.2793
Marvi	0.4133	0.3100	(25.0)	0.3100	(25.0)	0.2200	(46.8)	0.3133
Bhittai	0.3177	0.2480	(21.9)	0.1743	(45.1)	0.1740	(45.2)	0.2285
Zardana	0.3783	0.3660	(3.2)	0.2897	(23.4)	0.1400	(63.0)	0.2935
Chakwal	0.3790	0.2830	(25.3)	0.2780	(26.6)	0.1977	(47.8)	0.2844
RWM-9313	0.2907	0.2450	(15.7)	0.2083	(28.3)	0.1370	(52.9)	0.2203
ESW-9525	0.3317	0.2487	(25.0)	0.1447	(56.4)	0.0840	(74.7)	0.2023
Khirman	0.3063	0.3010	(1.7)	0.2516	(17.8)	0.1600	(47.8)	0.2547
DS-17	0.2500	0.2333	(6.7)	0.2183	(12.7)	0.1430	(42.8)	0.2112
Abadgar	0.4090	0.3790	(7.3)	0.2667	(34.8)	0.1863	(54.5)	0.3103
Sarsabz	0.3197	0.3087	(3.4)	0.2693	(15.8)	0.2294	(28.2)	0.2818
Bakhtawar	0.4243	0.3357	(20.9)	0.0950	(77.6)	0.0067	(98.4)	0.2154
Iqbal	0.3113	0.2973	(4.5)	0.2843	(8.7)	0.0940	(69.8)	0.2467
Mean	**0.3440**	**0.3099**		**0.2418**		**0.1333**		**0.2573**

Values in parenthesis indicate percent decrease (-) over control

Means in the same columns and same rows sharing the same letters did not differ significantly (p≥0.05).

Table 7. Effect of different levels of NaCl on root dry biomass (g plant^{-1}) of wheat genotypes.

Genotypes	Control	100 m*M*	% Red.	150 m*M*	% Red.	200 m*M*	% Red.	Mean
V-7015	0.1990	0.1960	(1.6)	0.1837	(7.7)	0.0500	(74.9)	0.1572
V-7012	0.1410	0.1067	(24.3)	0.1313	(6.9)	0.0330	(76.6)	0.1030
V-7004	0.6917	0.1000	(85.5)	0.0870	(87.4)	0.0210	(97.0)	0.2249
V-7003	0.1250	0.1003	(19.8)	0.0970	(22.4)	0.0333	(73.4)	0.0889
V-8001	0.2267	0.1560	(31.2)	0.1340	(40.9)	0.1242	(45.2)	0.1602
V-8319	0.1492	0.1433	(4.0)	0.1035	(30.6)	0.0730	(51.1)	0.1173
KTDH	0.1390	0.1193	(14.2)	0.1070	(23.0)	0.0607	(56.3)	0.1065
KTDH-22	0.1150	0.0863	(25.0)	0.0833	(27.6)	0.0510	(55.7)	0.0839
Margla	0.1167	0.1004	(14.0)	0.0825	(29.3)	0.0148	(87.3)	0.0786
Inquilab	0.1067	0.0866	(18.8)	0.0787	(26.2)	0.0267	(75.0)	0.0747
Lu-26s	0.2000	0.1793	(13.7)	0.1500	(27.8)	0.100	(50.0)	0.1573
C-228	0.1373	0.1020	(25.7)	0.0757	(44.9)	0.0513	(62.6)	0.0916
Marvi	0.2613	0.1233	(52.8)	0.1167	(55.3)	0.0863	(67.0)	0.1469
Bhittai	0.3837	0.0780	(79.7)	0.0733	(80.9)	0.0677	(82.4)	0.1507
Zardana	0.1600	0.1560	(2.5)	0.1133	(29.2)	0.1040	(35.0)	0.1333
Chakwal	0.1977	0.1450	(26.7)	0.1013	(48.8)	0.0970	(51.0)	0.1353
RWM-9313	0.1103	0.1096	(0.6)	0.0720	(34.7)	0.0687	(37.7)	0.0902
ESW-9525	0.1067	0.0797	(25.3)	0.0610	(42.8)	0.0507	(52.5)	0.0745
Khirman	0.1493	0.1347	(9.8)	0.0997	(33.2)	0.0597	(60.0)	0.1109
DS-17	0.1230	0.0773	(37.2)	0.0743	(39.6)	0.0506	(58.9)	0.0813
Abadgar	0.2110	0.1833	(13.1)	0.1097	(48.0)	0.0887	(58.0)	0.1482
Sarsabz	0.1253	0.1133	(9.6)	0.1003	(20.0)	0.0847	(32.4)	0.1059
Bakhtawar	0.1780	0.0983	(44.8)	0.0323	(81.8)	0.0101	(94.3)	0.0797
Iqbal	0.1070	0.1067	(0.3)	0.0923	(13.7)	0.0537	(49.8)	0.0899
Mean	**0.1859**	**0.1201**		**0.0983**		**0.0609**		**0.1163**

Values in parenthesis indicate percent decrease (-) over control

Means in the same columns and same rows sharing the same letters did not differ significantly ($p \geq 0.05$).

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