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EFFECT OF NaCl SALINITY ON THE GERMINATION AND SEEDLING GROWTH OF SEVEN WHEAT GENOTYPES

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Abstract

Seeds of seven wheat genotypes were subjected to 0.02 (control), 2, 4, 6 and 8 dS/m NaCl salinity under laboratory conditions. Germination percentage varied significantly among various genotypes, while non-significant differences were found between different concentrations of salt. However, seedling growth characters studied varied significantly among various genotypes as well as under different levels of salt. Interaction between genotypes and salt concentrations was also significant.

Introduction

Increased salinity is a stringent problem and a major limiting factor for crop production around the globe (Wahid *et al.*, 2007). High levels of soil salinity can significantly inhibit seed germination and seedling growth, due to the combined effects of high osmotic potential and specific ion toxicity. Seed germination and early seedling growth are the most sensitive stages to salinity stress (Muhammad & Hussain, 2010), critical factors to crop production under salt-stress conditions and important traits used to screen germplasm for salt tolerance to sustain food production under salt stress (Ashraf *et al*., 2007).

The identification of genotypes having potential salt tolerance is an effective approach to solve the problems of saline soils (Pervaiz *et al.*, 2007). Screening for salt-tolerant wheat germplasm is important to determine whether there is a genetic basis for selection and breeding purposes and to whether there are useful genotypes or new genes for tolerance to salt stress. Differences in salt tolerance exist not only between species but also amongst genotypes within species (Khan, *et al.*, 2008). In order to improve salt tolerance, it is important to explore inter-cultivar genetic variation for salt tolerance (Noreen *et al.*, 2007). Inter-cultivar variation for salt tolerance at different levels of NaCl salinity at the germination and/or seedling stages has been assessed in *Hordeum vulgare* L. (Ahmad *et al.*, 2006; Anwar *et al.*, 2011), *Zea mays* L. (Sadat-Noori *et al.*, 2008), *Triticum aestivum* L. (Ikramullah *et al.*, 2005; Khan *et al.*, 2005; Saboora *et al.*, 2006; Shalaby *et al.*, 2008; Abdel-Ghani, 2009; Jamal *et al.*, 2011; Kanwal *et al.*, 2011; Shafi *et al.*, 2010; 2011). The present study was conducted to screen 7 wheat genotypes at different levels of NaCl salinity under laboratory condition and to determine the genotypic variability in their tolerance to salinity both at the germination and seedling stage.

Materials and Method

Seeds of 7 wheat genotypes viz., *Bakhtawar-92*, *Bhakar-2002*, *Fakhar-e-Sarhad*, *Khyber-87*, *Nasir-2000*, *Pirsabak-2005*, and *Uqab-2000* were obtained from Cearl Crop Research Institute (CCRI) Pirsabak, Nowshera. They were grown in 0.02 (control), 2, 4, 6 and 8 dS/m saline solution of NaCl. Seeds were placed on twice folded Whatman # 1 filter paper as seed beds in petri dishes. Each petri dish was provided with 8ml of the respective salt concentration. There were 10 replicates, each with 10 seeds. The glassware was thoroughly washed with tap water followed by a rinsing with distilled water. Dried glassware was then sterilized at 170^{o}C for 4 hours prior to use. The dishes were incubated at 25^{o}C in a Completely Randomized (CR) Design. Germination, radicle and plumule length was determined after 72 hours. Fresh and dry weights of all the seedlings in all replicates of each treatment were recorded to determine average fresh and dry weight per seedling. Seedlings were dried at 65^{o}C for 72 hours. The moisture contents of seedling were determined on oven dry basis following (Hussain, 1989). The results were subjected to ANOVA (Steel & Torie, 1980).

Results and Discussion

Effect on germination: Analysis of variance (ANOVA) revealed that the effect of different concentrations of NaCl salinity on the seed germination of various genotypes was significant. Interaction between genotypes and concentrations was also significant. However, differences between different concentrations were non-significant (Table 1). Among various genotypes maximum mean germination (96.00%) was recorded in *Nasir-2000*, followed by *Khyber-87* (86.00%), *Pirsabak-2005* (78.80%), *Uqab-2000* (74.00%), *Fakhar-e-Sarhad* (73.20%) and *Bakhtawar-92* (69.60%). Concentration means showed that maximum germination (75.71 %) was recorded under 2, 4 and 8 dS/m levels of salt followed by 6 dS/m concentration of salt (74.86%) and control (73.43%). Interaction of genotypes and concentrations reveal that maximum germination percentage (100%) was recorded in the genotype *Nasir-2000* at 2 and 4 dS/m salinity levels which decreased at the subsequent levels. The minimum germination % age (32.00%) was recorded in genotype *Bhakkar-2002* under control condition, which increased smoothly with increasing level of salt, reaching to 68.00% at the highest concentration of salt applied (Table 2).

Table 1. Means squares of the analysis of variance for germination (%), plumule and radicle growth (mm), seedling fresh and dry weight (mg) and moisture contents (%).

Source	d.f	Germination (%)	Plumule growth (mm)	Radicle growth (mm)	Fresh weight (mg)	Dry weight (mg)	Moisture contents (%)
Genotypes (G)	6	5903.619*	337.623*	825.696*	3626.307*	771.090*	213626.205*
Concentration (C)	4	34.857NS	208.177*	249.604*	4242.134*	67.009*	48054.563*
G X C	24	333.857*	69.135*	119.390*	506.638*	53.292*	26682.669*
Error	140	181.429	13.512	51.824	282.863	21.611	8136.028
Coefficient of Variation (%)		17.94	20.19	20.89	13.58	15.99	25.77

d.f = Degree of freedom

Table 2. Effect of different concentrations (dS/m) of NaCl on the germination (%).

Wheat genotypes	Concentration (dS/m)					Genotypic means
	Control	2 dS/m	4 dS/m	6 dS/m	8 dS/m	
Bakhtawar-92	82.0 bcdefg -	64.0 hij (78.05)	66.0 ghij (80.49)	62.0 ij (75.61)	74.0 defghi (90.24)	69.60 d
Bhakkar-2002	32.0 l -	40.0 kl (125.00)	42.0 kl (131.25)	54.0 jk (168.75)	68.0 fghij (212.50)	47.20 e
Fakhar-e-Sarhad	62.0 ij -	74.0 defghi (119.35)	78.0 defghi 125.81	80.0 cdefgh (129.03)	72.0 efghi (116.13)	73.20 cd
Khyber-87	82.0 bcdefg -	90.0 abcd (109.76)	88.0 abcde (107.32)	90.0 abcd (109.76)	80.0 cdefgh (97.56)	86.00 b
Nasir-2000	98.0 ab -	100.0 a (98.00)	100.0 a (98.00)	96.0 abc (97.96)	90.0 abcd (91.84)	96.80 a
Pirsabak-2005	84.0 abcdef -	86.0 abcde (102.38)	76.0 defghi (90.48)	74.0 defghi (88.10)	74.0 defghi (88.10)	78.80 bc
Uqab-2000	74.0 defghi -	76.0 defghi (102.70)	80.0 cdefgh (108.11)	68.0 fghij (91.89)	72.0 efghi (97.30)	74.00 cd
Concentration Means	73.43 -	75.71 (103.10)	75.71 (103.10)	74.86 (101.95)	75.71 (103.10)	

LSD value at 0.05 alpha level for genotype means = 7.532 and interaction = 16.84
Means in the last column/ rows sharing the same letter do not differ significantly from each other at 5% level of probability
Figures in parenthesis represent % of control

Soil salinity can significantly inhibit seed germination and seedling growth, due to the combined effects of high osmotic potential and specific ion toxicity. In the present study, germination % age among various wheat genotypes varied ranging from 47.20% in *Bhakkar-2002* to 96.00% in *Nasir-2000*. *Bhakkar-2002* was the only genotype with less than 50% germination. Germination % age under each test condition was better than control. As compared to control, germination under salt stress increased in all the genotypes, except *Bakhtawar-92* where it decreased under different salt concentration. Low doses of salt were more effective in boosting germination % age of most of the genotypes except *Bhakkar-2002* where germination enhanced under high salt concentration. Seed germination is particularly sensitive to salinity. Retardation and reduction in seed germination of wheat genotypes under NaCl treatments have been reported by (Khan *et al.*, 2005; Khan *et al.*, 2006; Saboora *et al.*, 2006; Akbari *et al.*, 2007; Abdel-Ghani, 2009). Reduced and delayed seed germination under NaCl stress in barley (Ahmad *et al.*, 2006) and *Zea mays* (Khatoon *et al.*, 2010) have also been reported. The present study negates all the above mentioned reports.

Effect on plumule growth: ANOVA showed significant variation for plumule growth among various genotypes and different salinity concentrations. The interaction between genotypes and concentrations was also significant (Table 1). Genotypic means reveal that plumule growth was maximum (24.9 mm) in the genotype *Khyber-87*, followed by *Nasir-2000* (20.7 mm), *Bakhtawar-92* (18.9 mm), *Fakhar-e-Sarhad* (17.3 mm), *Bhakkar-2002* (16.5 mm), *Pirsabak-2005* (15.1 mm) and *Uqab-2000* (14.1 mm). Concentration means showed that plumule growth was retarded under increasing concentrations of NaCl salinity. It was maximum (20.4 mm) in control and statistically at par with 2 dS/m salt level (20.3 mm). Plumule growth at 4 dS/m concentration (19.3 mm) was significantly less than control and greater than the subsequent higher salt levels. As regard the interaction of genotypes and concentrations, *Khyber-87* at 2 dS/m NaCl concentration generated the maximum (32.4 mm) plumule growth, which was statistically significant from the rest of the genotypes at any salt level. While, the minimum plumule growth (7.9 mm) was recorded in *Uqab-2000* under 6 dS/m level of salinity (Table 3).

Table 3. Effect of different concentrations (dS/m) of NaCl on plumule growth (mm).

Wheat genotypes	Concentration (dS/m)					Genotypic means
	Control	2 dS/m	4 dS/m	6 dS/m	8 dS/m	
Bakhtawar-92	19.7 ^{ghij}	21.5 ^{defg}	25.3 ^{bc}	14.7 ^{mnop}	13.1 ^{pqr}	18.9 ^{c}
	-	(109.14)	(128.43)	(74.62)	(66.50)	
Bhakkar-2002	11.8 ^{qrs}	17.5 ^{jkl}	16.1 ^{lmno}	20.6 ^{efgh}	16.2 ^{lmno}	16.5 ^{d}
	-	(148.31)	(136.44)	(174.58)	(137.29)	
Fakhar-e-Sarhad	23.3 ^{cd}	17.4 ^{jkl}	16.9 ^{klm}	14.7 ^{mnop}	14.2 ^{nop}	17.3 ^{d}
	-	(74.68)	(72.53)	(63.09)	(60.94)	
Khyber-87	26.4 ^{b}	32.4 ^{a}	20.5 ^{efgh}	22.9 ^{d}	22.3 ^{def}	24.9 ^{a}
	-	(122.73)	(77.65)	(86.74)	(84.47)	
Nasir-2000	21.7 ^{defg}	22.4 ^{def}	22.8 ^{de}	18.7 ^{hijk}	17.8 ^{ijkl}	20.7 ^{b}
	-	(103.23)	(105.07)	(86.18)	(82.03)	
Pirsabak-2005	17.5 ^{jkl}	20.1 ^{fghi}	16.9 ^{klmn}	11.1 ^{rs}	10.0 st	15.1 ^{e}
	-	(114.86)	(96.57)	(63.43)	(57.14)	
Uqab-2000	22.2 ^{def}	10.4 ^{s}	16.3 ^{lmn}	7.9 ^{t}	13.9 ^{opq}	14.1 ^{e}
	-	(46.85)	(73.42)	(35.59)	(62.61)	
Concentration Means	20.4 ^{a}	20.3 ^{a}	19.3 ^{b}	15.8 ^{c}	15.4 ^{c}	
	-	(99.51)	(94.61)	(77.45)	(75.49)	

LSD value at 0.05 alpha level for genotype means = 1.048, concentration means = 0.8857 and interaction = 2.343
Means in the last column/ rows sharing the same letter do not differ significantly from each other at 5% level of probability.
Figures in parenthesis represent % of control.

In the present study, plumule growth varied considerably among different wheat genotypes. Overall different salt concentrations had a retarding effect on plumule growth. Interaction shows that plumule growth was dose dependent in different wheat genotypes. It decreased smoothly in *Fakhar-e-Sarhad* and *Uqab-2000* with increasing salt level while, it increased under salt treatment in the rest of the genotypes. Lower doses of salt were effective in increasing whereas, higher doses had a retarding effect on plumule growth. The present findings are in agreement with Ahmad *et al*., (2006) and Sadat-Noori *et al*., (2008) who reported severely reduced plumule growth under various levels of NaCl salinity in barley and corn, respectively.

Effect on radicle growth: ANOVA exhibited significant differences among various genotypes and different salt concentrations for radicle growth. The interaction between genotypes and concentrations was also significant (Table 1). Genotypic means showed that maximum radicle growth (42.8 mm) was observed in *Nasir-2000*, which was statistically at par with *Khyber-87* (40.8 mm). Radicle growth in *Bakhtawar-92* was 36.7 mm, followed by *Fakhar-e-Sarhad* (32.3 mm), *Pirsabak-2005* (31.1 mm), and *Bhakkar-2002* (29.4 mm). The minimum radicle growth (28.0 mm) was recorded in *Uqab-2000*. Concentration means reveal that maximum radicle growth (36.9 mm) was generated under 4 dS/m salt level, closely followed by 2 dS/m (36.3 mm) and control (35.9 mm). Radicle growth at 6 dS/m (30.9 mm) and at 8 dS/m (32.4 mm) level of salinity were statistically at par with each other and significantly less than the lower concentration of the applied salt. The interaction of genotypes and concentrations showed that radicle growth was maximum in *Nasir-2000* (49.5 mm) under control condition, followed by 2 dS/m level in *Khyber-87* (46.7 mm), 4 dS/m in *Bakhtawar-92* (45.8 mm) and 4 dS/m (45.7 mm) and 2 dS/m (45.4 mm) level in *Nasir-2000* (Table 4).

Radicle growth in the present findings was also promoted at lower salt concentrations whereas, higher salt concentration proved retarding except in *Fakhar-e-Sarhad* and *Nasir-2000* where it decreased under different salinity levels. Reduced radicle growth in barley (Ahmad *et al.*, 2006), wheat (Akbari *et al.*, (2007) and corn (Sadat-Noori *et al.*, 2008) under increasing concentrations of NaCl have been reported, which is line with the present findings.

Effect on fresh weight: ANOVA revealed significant differences for fresh weight per seedling among various genotypes, different salt concentrations and interaction of genotypes and concentrations (Table 1). Genotypic means revealed that fresh weight per seedling was maximum (143.4 mg) in *Uqab-2000* (126.2 mg), followed by *Pirsabak-2005* (132.1 mg), *Nasir-2000* (126.2 mg), *Fakhar-e-Sarhad* (124.4 mg), *Bhakkar-2002* (120.3 mg), *Bakhtawar-92* (114.6 mg) and *Khyber-87* (106.1 mg). Concentration means show that fresh weight was maximum (132.9 mg) under control condition, followed by 2 dS/m (131.7 mg) and 4 dS/m (131.0 mg) levels of salt. Fresh weight at 6 dS/m (112.6 mg) and 8 dS/m (111.1 mg) levels of salt were significantly higher than the lower doses of the applied salt. As regards the interaction of genotypes and salt concentration, maximum fresh weight per seedling (164.8 mg) was observed in *Uqab-2000* at 4 dS/m level of salt whereas, the minimum fresh weight (87.4 mg) was recorded in *Khyber-87* at 8 dS/m level of salt (Table 5).

Table 4. Effect of different concentrations (dS/m) of NaCl on radicle growth (mm).

Wheat genotypes	Concentration (dS/m)					Genotypic means
	Control	2 dS/m	4 dS/m	6 dS/m	8 dS/m	
Bakhtawar-92	37.7 ^{cdefgh}	40.6 ^{abcde}	45.8 ^{abc}	30.8 ^{fghij}	20.4 ^{ijkl}	36.7 ^{b}
	-	(107.69)	(121.49)	(81.70)	(75.33)	
Bhakkar-2002	20.9 ^{l}	34.7 ^{defghij}	29.7 ^{ghijkl}	30.3 ^{fghijk}	31.5 ^{fghij}	29.4 ^{cd}
	-	(166.03)	(142.11)	(144.98)	(150.72)	
Fakhar-e-Sarhad	37.8 ^{bcdefgh}	30.5 ^{fghij}	33.1 ^{defghij}	30.6 ^{fghij}	29.7 ^{ghijkl}	32.3 ^{c}
	-	(80.69)	(87.57)	(80.95)	(78.57)	
Khyber-87	41.9 ^{abcd}	46.7 ^{ab}	35.9 ^{defghi}	38.9 ^{bcdef}	40.7 ^{abcde}	40.8 ^{a}
	-	(111.46)	(85.68)	(92.84)	(97.14)	
Nasir-2000	49.5 ^{a}	45.4 ^{abc}	45.7 ^{abc}	38.3 ^{bcdefg}	35.2 ^{defghij}	42.8 ^{a}
	-	(91.72)	(92.32)	(77.37)	(71.11)	
Pirsabak-2005	32.2 ^{efghij}	35.3 ^{defghij}	32.5 ^{efghij}	26.3 ^{jkl}	29.3 ^{hijkl}	31.1 ^{cd}
	-	(109.63)	(100.93)	(81.68)	(90.99)	
Uqab-2000	30.9 ^{fghij}	21.3 ^{kl}	35.2 ^{defghij}	20.7 ^{l}	31.8 ^{efghij}	28.0 ^{d}
	-	(68.93)	(113.92)	(66.99)	(102.91)	
Concentration Means	35.9 ^{a}	36.3 ^{a}	36.9 ^{a}	30.9 ^{b}	32.4 ^{b}	
	-	(101.11)	(102.79)	(86.07)	(90.25)	

LSD value at 0.05 alpha level for genotype means = 4.026, concentration means = 3.402 and interaction = 9.001
Means in the last column/ rows sharing the same letter do not differ significantly from each other at 5% level of probability
Figures in parenthesis represent % of control

Table 5. Effect of different concentrations (dS/m) of NaCl on fresh weight/seedling (mg).

Wheat genotypes	Concentration (dS/m)					Genotypic means
	Control	2 dS/m	4 dS/m	6 dS/m	8 dS/m	
Bakhtawar-92	118.0 ^{efghijkl}	116.4 ^{fghijklm}	122.4 ^{defghi}	96.0 ^{mn}	120.0 ^{efghijk}	114.6 ^{de}
	-	(86.64)	(103.73)	(81.36)	(101.69)	
Bhakkar-2002	120.2 ^{efghijk}	138.6 ^{bcde}	126.8 ^{cdefgh}	116.6 ^{fghijklm}	99.4 ^{klmn}	120.3 ^{cd}
	-	(115.31)	(105.49)	(97.00)	(82.70)	
Fakhar-e-Sarhad	146.0 ^{abc}	125.8 ^{cdefghi}	126.2 ^{cdefgh}	112.8 ^{ghijklm}	111.0 ^{hijklm}	124.4 ^{bc}
	-	(86.16)	(86.44)	(77.26)	(76.03)	
Khyber-87	121.2 ^{defghij}	123.2 ^{defghi}	101.0 ^{jklmn}	97.8 ^{lmn}	87.4 ^{n}	106.1 ^{e}
	-	(101.65)	(83.33)	(80.69)	(72.11)	
Nasir-2000	132.4 ^{cdefg}	137.2 ^{bcdef}	134.4 ^{cdef}	122.0 ^{defghij}	105.0 ^{ijklmn}	126.2 ^{bc}
	-	(103.63)	(101.51)	(92.15)	(97.31)	
Pirsabak-2005	135.0 ^{cdef}	146.6 ^{abc}	141.6 ^{bcd}	124.4 ^{defghi}	113.0 ^{ghijklm}	132.1 ^{b}
	-	(108.59)	(104.89)	92.15	(83.70)	
Uqab-2000	157.8 ^{ab}	134.2 ^{cdef}	164.8 ^{a}	118.4 ^{efghijkl}	142.0 ^{bcd}	143.4 ^{a}
	-	(85.04)	(104.44)	(75.03)	(89.99)	
Concentration Means	132.9 ^{a}	131.7 ^{a}	131.0 ^{a}	112.6 ^{b}	111.1 ^{b}	
	-	(99.10)	(98.57)	(84.73)	(83.60)	

LSD value at 0.05 alpha level for genotype means = 9.405, concentration means = 7.949 and interaction = 21.03
Means in the last column/ rows sharing the same letter do not differ significantly from each other at 5% level of probability
Figures in parenthesis represent % of control

Effect on dry weight: ANOVA performed on dry weight per seedling revealed significant differences among various genotypes, different concentrations of salt and interaction between genotypes and concentrations (Table 1). Genotypic means showed that dry weight per seedling was maximum (36.1 mg) in *Khyber-87* followed by *Pirsabak-2005* (34.3 mg), *Uqab-2000* (33.0 mg), *Fakhar-e-Sarhad* (29.2mg), *Bhakkar-2002* (25.3mg), *Nasir-2000* (23.4mg) and *Bakhtawar-92* (22.2mg). Concentration means showed that maximum dry weight per seedling (30.4 mg) was observed under 2 dS/m salt level. Differences between control, 2, 4 and 8 dS/m levels of salt were non-significant. Dry weight per seedling under 6 dS/m level of salt (26.7 mg) was significantly lower than the rest of the treatments. Interaction between genotypes and salt concentrations revealed that maximum dry weight per seedling (38.4 mg) was recorded in control of *Khyber-87* while, the minimum dry weight (14.4 mg) at 6 dS/m salt level in *Bakhtawar-92* (Table 6).

Table 6. Effect of different concentrations (dS/m) of NaCl on dry weight/ seedling (mg).

Wheat genotypes	Concentration (dS/m)					Genotypic means
	Control	2 dS/m	4 dS/m	6 dS/m	8 dS/m	
Bakhtawar-92	23.4 ^{lmno} -	30.0 ^{defghij} (128.21)	18.0 ^{op} (76.92)	14.4 ^{p} (61.54)	25.4 ^{jklmn} (108.55)	22.2 ^{e}
Bhakkar-2002	32.0 ^{bcdefgh} -	25.0 ^{jklmn} (78.13)	25.6 ^{ijklmn} (80.00)	20.0 ^{nop} (62.50)	24.0 ^{klmn} (75.00)	25.3 ^{d}
Fakhar-e-Sarhad	27.6 ^{hijklm} -	28.6 ^{ghijkl} (103.62)	31.4 ^{cdefghi} (113.77)	29.6 ^{efghijk} (107.25)	28.8 ^{ghijkl} (104.35)	29.2 ^{c}
Khyber-87	38.4 ^{a} -	32.4 ^{ab} (97.40)	36.4 ^{abc} (94.79)	35.2 ^{abcde} (91.67)	33.0 ^{abcdefgh} (85.94)	36.1 ^{a}
Nasir-2000	22.0 ^{mno} -	23.8 ^{klmno} (108.18)	24.4 ^{jklmn} (110.91)	24.0 ^{klmn} (109.09)	22.6 ^{mno} (102.73)	23.4 ^{de}
Pirsabak-2005	34.8 ^{abcdef} -	35.8 ^{abcd} (102.87)	32.0 ^{bcdefgh} (91.95)	32.4 ^{bcdefgh} (93.10)	36.4 ^{abc} (104.60)	34.3 ^{ab}
Uqab-2000	29.2 ^{fghijkl} -	32.4 ^{bcdefgh} (110.96)	37.4 ^{ab} (128.08)	31.6 ^{bcdefgh} (108.22)	34.4 ^{abcdefg} (117.81)	33.0 ^{b}
Concentration Means	29.6 ^{a} -	30.4 ^{a} (102.70)	29.3 ^{a} (98.99)	26.7 ^{b} (90.20)	29.2 ^{a} (98.65)	

LSD value at 0.05 alpha level for genotype means = 2.600, concentration means = 2.197 and interaction = 5.813
Means in the last column/ rows sharing the same letter do not differ significantly from each other at 5% level of probability
Figures in parenthesis represent % of control

Effect on moisture contents: ANOVA showed that moisture contents varied significantly among various genotypes and different concentrations. Interaction between genotypes and concentrations was also significant (Table 1). Genotypic means revealed that moisture contents were maximum in *Bakhtawar-92* (464.2%) followed by *Nasir-2000* (431.87%) and *Bhakkar-2002* (408.6%). Moisture contents in *Fakhar-e-Sarhad* (333.6%), *Uqab-2000* (328.0%) and *Pirsabak-2005* (286.5%) were at par with each other and were significantly greater than the lowest moisture contents (197.3%) worked out for *Khyber-87*. Concentration means showed that moisture contents were maximum (392.1%) at 4 dS/m followed by control (367.1%), 6 dS/m (352.5%), 2 dS/m (346.8%) and 8 dS/m (291.6%) levels of salt. Interaction between genotypes and concentrations showed that maximum moisture contents (639.0%) were recorded in *Bakhtawar-92* under 4 dS/m level followed by 6 dS/m level (579.1%) in the same genotype. The minimum moisture contents (165.8%) were recorded in *Khyber-87* under 8 dS/m salt level (Table 7).

Table 7. Effect of different concentrations (dS/m) of NaCl on seedling moisture contents (%).

Wheat genotypes	Concentration (dS/m)					Genotypic means
	Control	2 dS/m	4 dS/m	6 dS/m	8 dS/m	
Bakhtawar-92	410.5 ^{cdefghij} -	315.8 ^{ijklmno} (76.93)	639.0 ^{a} (155.66)	579.1 ^{ab} (141.07)	376.6 ^{defghijkl} (91.74)	464.2 ^{a}
Bhakkar-2002	285.9 ^{lmnopq} -	464.1 ^{cde} (162.33)	454.9 ^{cdefg} 159.11	506.7 ^{bc} (177.23)	331.7 ^{hijklmn} (116.02)	408.6 ^{b}
Fakhar-e-Sarhad	439.8 ^{cdefgh} -	348.4 ^{fghijklm} (79.22)	302.3 ^{jklmnop} (68.74)	288.3 ^{lmnopq} (65.55)	289.2 ^{lmnopq} (65.80)	333.6 ^{c}
Khyber-87	216.5 ^{opqr} -	229.6 ^{nopqr} (106.05)	195.6 ^{pqr} (90.35)	179.1 ^{qr} (82.73)	165.8 ^{r} (76.58)	197.3 ^{d}
Nasir-2000	475.3 ^{bcd} -	468.6 ^{bcd} (98.59)	455.7 ^{cdef} (95.88)	405.2 ^{cdefghijk} (85.25)	354.2 ^{efghijklm} (74.52)	431.8 ^{ab}
Pirsabak-2005	321.6 ^{klmno} -	298.8 ^{jklmnop} (92.91)	342.8 ^{ghijklm} (106.59)	242.8 ^{mnopqr} (75.50)	226.6 ^{nopqr} (70.46)	286.5 ^{c}
Uqab-2000	419.9 ^{cdefghi} -	302.5 ^{jklmnop} (72.04)	354.2 ^{efghijklm} (84.35)	266.5 ^{lmnopqr} (63.47)	296.8 ^{klmnop} (70.68)	328.0 ^{c}
Concentration Means	367.1 ^{ab} -	346.8 ^{b} (94.47)	392.1 ^{a} (106.81)	352.5 ^{ab} (96.02)	291.6 ^{c} (79.43)	

LSD value at 0.05 alpha level for genotype means = 50.44, concentration means = 42.63 and interaction = 112.8
Means in the last column/ rows sharing the same letter do not differ significantly from each other at 5% level of probability
Figures in parenthesis represent % of control

Variability was also observed among different genotypes for fresh and dry weight and moisture contents of seedling under different concentrations of salt. Interaction studies show that increasing level of salt had a declining effect on fresh weight in *Fakhar-e-Sarhad*, dry weight in *Bhakkar-2000* and *Khyber-87* and moisture contents in *Fakhar-e-Sarhad*, *Nasir-2000* and *Uqab-2000*. These three characters flourished more at lower levels of salt as compared to the higher salt levels. Reduced fresh weight of seedling under salt stress in the present study is parallel to the findings of Ahmad *et al*., (2006) and Akbari *et al*., (2007) who observed reduced fresh weight of seedling under increasing concentration of salt in barley and wheat. Ahmad *et al*., (2006) and Akbari *et al*., (2007) also reported reduced dry weight of seedling with increasing level of salinity which strengthens the present study.

In the present study, genotypic variability for salt tolerance was found among different wheat genotypes. Genotypes with 100 to 75% germination include *Nasir-2000* (96.00%), *Khyber-87* (86.00%) and *Pirsabak-2005* (78.80%) could be recommended as salt tolerant while, genotypes with 75 to 50% germination viz: *Uqab-2000* (74.00%), *Fakhar-e-Sarhad* (73.20%) and *Bakhtawar-92* (69.60%) as moderately tolerant and those with less than 50% germination i.e., *Bhakkar-2002* (47.20%) as salt sensitive genotype. Further study is required to see the effect of salt stress on the germination and seedling growth of theses genotypes under field conditions.

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