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Germination Scenario of Barley Genotypes to Chloride and Sulphate Salinities of Sodium

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ABSTRACT

Biodiversity for germination responses of 15 barley genotypes was studied. Two levels of salinity i.e. -0.60 and -0.75 MPa each for NaCl and Na_2SO_4 in addition to control were developed before sowing. Great diversity was noted among the 15 barley genotypes especially for germination percentage, radicle and plumule length, and their dry weights. Chloride salinity proved to be more damaging than the sulphate for almost all the germination parameters, Genotype B-90068 responded best for both salts and their levels while Jau-87 turned out to be the most sensitive genotype.

Key Words: Barley; Embryonic tissues; Germination; Ionic toxicity; Sulphate; Chloride salinity

INTRODUCTION

There is a continuous spectrum of salinity tolerant plants ranging from very sensitive glycophytes showing the effect of salts at concentrations less than 50 mol m^{-3} to halophytes that can complete their life cycles at 500 mol m^{-3} (Flowers, 1985; Ungar, 1991). Unfortunately, majority of the important crops are invariably glycophytic (Mass, 1986). Salinity is probably the most pervasive problem affecting crop production in irrigated lands. It causes a decrease in plant growth (Sharma, 1995) by hampering various physiological phenomena. Although growth of plant is affected at all stages of development, but sensitivity varies greatly at different stages (Carvajal *et al*., 1998; Akram *et al*., 2002; Wilson *et al*., 2000). Germination and seedling emergence are critical stages in the plant growth cycle because of their obvious effect on plant stand and eventual yield of the crop (Pearen *et al*., 1997). Salinity stress during this initial phase can greatly increase plant mortality. If the resulting plant population density is less than optimum, significant reduction in yield could result. It is important therefore to evaluate salt tolerance of crops during germination (and seedling emergence). Dell'Aqula and Spada (1992) indicated that decrease in germination capacity due to salinity was related to decrease in water absorption. Furthermore, increased nutrient concentration of seed or propagules play a key role in the tolerance of a species during germination and seedling establishment (Wahid *et al*., 1999). Among the different ions affecting plant growth higher concentration of Na^+ and Cl^- are more toxic as these reduce the uptake and utilization of NO_3^- (Munns & Termaat, 1986), Ca^{2+}, N and P (Wahid *et al*., 1997) which may be one of the reason for growth reduction. NaCl and Na_2SO_4 salts were used to develop root zone salinization as these are the predominant ions in the soils of Pakistan (Akhtar *et al*., 2001). Experiments were conducted to study the germination response of barley genotypes to the mentioned salinization and screen out some tolerant genotypes performing better at this stage of growth.

MATERIALS AND METHODS

Some studies on comparative germination responses of barley (*Hordeum vulgar* L.) genotypes to chloride and sulphate salinity were carried out. Two levels each of NaCl and Na_2SO_4 i.e. -0.60 and -0.75MPa were used in addition to control i.e. -0.0 MPa. Germination was studied in petridishes in growth chamber with dark light period of 12/12 hours. Fifty seeds of each genotype were sown in petridishes separately lined with filter paper containing 10 mL solution of the salinity levels. The data for final germination percentage, length and dry weight of plumule and radicles of seedlings were recorded seven days after exposure of seeds to salinity. Treatments in this factorial experiment was arranged in CRD was arranged in CRD with three replicates.

RESULTS AND DISCUSSION

Germination percentage. All the genotypes and salt treatments indicated significant ($P<0.01$) difference for this parameter (Table I). Splitting of treatment effect revealed significant ($P<0.01$) difference for an overall treatment effect with control. Moreover, the applied salts and their levels also indicated significant ($P<0.05$) differences, but the interaction of salt x level was non-significant ($P>0.05$). However, there was a significant interaction of genotypes x treatment. NaCl salinity was more damaging than Na_2SO_4. A comparison of genotypes revealed that genotype B-90068 was the top notcher giving upto 86 and 84.67% germination under a ψs of -0.75 MPa, 88 and 89.98 % at –0.60 MPa of NaCl and Na_2SO_4, respectively. Genotype B-90068 was closely followed by B-98016 and B-93006 for the said level of NaCl and Na_2SO_4, respectively. Genotype Jau-87 turned out to be the most sensitive genotype at both the salt and salt levels (Table II & III).

Table I. Statistical analysis (mean square) of some germination parameters of barley genotypes exposed to chloride and sulphate salinity

S.O.V	d.f.	Germination (%)	Radicle length (cm)	Plumule length (cm)	Dry weight of radical (mg)	Dry weight of Plumule (mg)
Genotypes (G)	14	3602.2**	16.235**	20.161**	13.754**	25.59**
Treatment (T)	4	26522.4**	225.247**	251.293**	182.907**	326.32**
Treatment vs control	1	59747.7**	715.509**	785.550**	682.167**	1071.89**
Salt	1	1686.7**	27.2335**	21.362*	6.283**	22.58**
Level	1	27325.6**	8.665**	99.110**	21.536**	105.12**
Salt x level	1	2.0ns	0.407ns	0.020ns	0.053ns	0.29ns
G xT	56	353.0*	1.557**	1.688**	0.814**	2.47**
Error	150	40.8	0.569	0.263	0.354	0.19

Significant at * P<0.05; **P<0.01.; ns. Non- significant

Table II. Percentage decrease in germination parameters under –0.75 MPa NaCl and Na_2SO_4 salinity

Genotypes	Germination percentage		Radical length (cm)		Plumule length (cm)		Radical dry weight (mg)		Plumule dry weight (mg)	
	NaCl	Na_2SO_4	NaCl	Na_2SO_4	NaCl	Na_2SO_4	NaCl	Na_2SO_4	NaCl	Na_2SO_4
Jau-83	84.78	80.29	68.09	63.26	65.99	58.70	63.67	55.77	71.24	57.88
Jau-87	96.74	92.03	78.84	64.39	80.88	77.46	87.64	78.83	90.90	79.49
B-90015	63.04	60.15	69.49	51.56	50.99	46.56	63.53	59.75	64.70	38.25
B-90068	14.00	15.33	26.62	17.61	37.00	31.22	58.18	51.71	20.00	18.00
B-91035	55.41	65.21	60.51	54.66	60.94	59.56	77.74	67.70	70.01	65.92
B-91037	76.22	80.07	62.41	54.26	63.48	50.97	63.26	64.38	70.08	62.97
B-91101	79.48	70.14	60.79	45.27	62.01	50.28	64.62	59.13	75.55	68.84
B-92077	60.69	60.35	65.27	59.93	62.65	51.92	58.65	51.70	72.97	72.28
B-92114	60.80	52.09	52.06	46.77	61.39	57.53	63.95	58.59	69.75	66.58
B-92115	80.84	70.00	48.77	36.96	67.26	63.80	75.67	68.03	63.78	54.28
B-93006	47.58	30.00	57.91	56.52	39.14	66.20	55.58	52.47	73.86	46.99
B-93016	44.44	40.40	64.90	56.09	67.81	60.04	77.68	66.11	65.37	55.77
B-93037	66.67	39.33	59.19	54.65	46.11	35.36	72.94	68.59	74.19	62.37
B-93075	68.84	52.17	65.27	58.78	65.33	56.34	69.40	58.00	79.76	60.39
B-93118	56.68	54.87	65.39	59.28	74.32	67.43	71.52	68.45	53.76	54.75

Table III. Percentage decrease in germination parameters under –0.60 MPa NaCl and Na_2SO_4 salinity

Genotypes	Germination percentage		Radical length (cm)		Plumule length (cm)		Radical dry weight (mg)		Plumule dry weight (mg)	
	NaCl	Na_2SO_4	NaCl	Na_2SO_4	NaCl	Na_2SO_4	NaCl	Na_2SO_4	NaCl	Na_2SO_4
Jau-83	71.22	68.41	60.31	55.21	52.30	45.24	60.20	52.40	66.40	60.20
Jau-87	81.09	78.31	66.51	65.51	71.40	62.81	81.21	76.41	81.20	73.90
B-90015	59.20	57.10	61.21	53.61	42.71	36.34	60.00	54.32	60.10	45.20
B-90068	12.00	10.02	21.10	17.42	30.20	24.81	54.10	48.32	19.10	17.80
B-91035	50.31	45.34	50.31	44.71	54.10	53.80	71.20	64.31	63.40	61.20
B-91037	71.35	70.01	51.24	45.93	55.20	52.61	57.40	50.10	62.80	58.40
B-91101	74.50	72.62	49.31	46.41	50.40	47.31	60.10	52.30	70.10	61.20
B-92077	58.41	56.03	60.10	53.54	52.90	50.00	50.10	47.90	63.20	56.40
B-92114	56.32	50.11	47.37	45.64	49.41	47.41	61.40	55.40	60.20	52.70
B-92115	74.40	71.12	40.10	33.90	58.20	58.00	62.30	49.20	54.20	47.60
B-93006	40.59	27.25	48.21	40.24	31.41	28.24	48.40	41.70	61.30	42.90
B-93016	37.25	32.83	53.45	47.31	60.21	55.45	71.20	61.20	53.20	50.00
B-93037	56.41	48.47	47.31	38.42	40.21	36.11	64.70	63.20	62.30	49.20
B-93075	59.21	56.42	53.20	50.13	60.21	52.30	61.20	41.30	66.60	53.20
B-93118	47.50	38.12	50.40	46.32	70.20	64.40	63.40	44.20	44.20	38.70

Radicle and plumule length (cm). Barley genotypes, various salt treatments and their interaction exhibited (P<0.01) difference as for as radicle and plumule length were concerned. Comparison of salt, their increasing levels and interaction of overall treatment effect was also significant (P<0.01). However, interaction of salts with their levels was not event (P>0.05). A perusal of the data (Table II & III) indicates that under salt stress condition. B-90068 proved the best as was data (Table II & III) indicates that under salt stress conditions B-90068 proved the best as best as was evident from the minimum reduction of 26.62 and 17.61% for radicle and the salt 31.22% for plumule length at lowest ψs -0.75 MPa and 20.1 and 7.4% at -0.60 MPa level of both the salt, respectively as expressed over control. The most affected genotype as Jau-87 under both the salt and their levels. Plumule length showed the maximum decrease of 80.88 and 77.48% for higher level, 71.4 and 62.81% at lower level of the two salts for this genotype. For radical length the worth affected genotype was again Jau-87 showing a maximum reduction of 78.84 and 64.39% under -0.75 and 66.51% and 65.51% at -0.60 MPa of NaCl and Na_2SO_4, respectively. Rest of the genotypes showed a fairly variable pattern of plumule and radical elongation. A comparative effect of both the salts of NaCl to more toxic than Na_2SO_4 for most of the genotypes.

Radicle and plumule dry weight (mg). There was a significant ($P<0.01$) difference among the genotypes, between salts and their interaction for radicle and plumule dry weight (Table II & III). Splitting of treatments effects indicated a significant ($P<0.01$) difference between control and overall treatments, individual salts and their levels. However, interaction of salts and levels was not evident ($P>0.05$). Great genetic variability was displayed by different genotypes in response to Cl^- and SO_4^{-2} of sodium also at their different levels. Increased salinity reduced the radical and plumule dry weight of all the genotypes. B-90068 had the greatest plumule dry weight (NaCl 8.0 mg and Na_2SO_4 8.2 mg under lower solute ψs (-0.75 MPa) and 8.9mg and 8.22 mg at -0.60 MPa of both the salts. Contrarily, Jau-87 responded poorly to decrease ψs of both the salts giving a reduction 88.64 and 79.83% for radicle and decreased of 90.90 and 79.49 % for plumule under lowest ψs of NaCl and Na_2SO_4 and 81.21 and 76.41 for radical and 81.2 and 73.9% for plumule dry weight at -0.60 MPa, respectively (Table II & III). A comparison of both the levels of the two salts depicted more toxic effect of NaCl than Na_2SO_4.

Plant growth in a saline environment is affected adversely and the effects are manifested at each of its phonological stage of development such as germination, tillering, botting and grain filling (Maas & Grieve, 1990). At different growth stages, tolerance towards salinity in different crops is quite variable (Shannon, 1984; Rashid *et al.*, 1999; Wilson *et al*., 2000; Javed *et al*., 2001; Pessarakli, 2001; Akram *et al*., 2002). In the present pursuit, an attempt has been made to determine salinity tolerance potential of elite barley genotypes and of some promising varieties at germination stage. Although barley genotypes under study exhibited a wide range of tolerance to salinity but the genotypes showing greater germination percentage and considerable elongation and dry matters yield of radicle and plumule were regarded as suitable to obtain better crop establishment for salt affected areas. The observed tolerance to salinity at germination stage of barley genotypes revealed that except for B-920068 followed by B-93006 and B-93016, all the genotypes manifested reduced germination towards increased levels of salts applied. The reduction in germination is due to alteration of the physiological and biochemical activities by inhibiting the anabolic and stimulating the catabolic processes (Guerrier, 1986; Torres-Schuman *et al*., 1989), excessive accumulation of toxic ions and decrease in the mobilization of important nutrient, thus restricting the development of embryonic tissues (Mondel *et al*., 1988). Zidan and Eleva (1995) noted that the rate of respiration increases sharply with the increase in NaCl level. The reduction in germination parameters of different genotypes is also due to the extra utilization of metabolic energy to sustain in the saline medium and to restrict the absorption of toxic ions (Why Jones & Gorham, 1983; Yeo, 1983). Genetic variability is exhibited by different genotypes to tolerate the toxic levels of salinity. Genotypes B-90068 can be declared best at this stage of growth for tolerance to both the salts. Cl^- ion was proved more toxic than the SO_4^{-2} at all the applied levels. It is also exhibited that tolerant genotypes displayed its tolerance ability/mechanism for both the Cl^- and SO_4^{-2} salts equally.

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