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Effects of Na_2SO_4 and NaCl Salinity Levels on Different Yield Parameters of Barley Genotypes

ABID NISAR AHMAD, INTSHAR-UL-HAQ JAVED, SHAMSHAD AKHTAR AND MUHAMMAD AKRAM
Department of Botany, University of Agriculture, Faisalabad-38040, Pakistan

ABSTRACT

Experiments in Botanical Garden, University of Agriculture were carried out to study the yield responses of 15 different barley genotypes. Effects of Na_2SO_4 and NaCl salinity levels were studied on total tillers, length of ear, number of spikelet/spike, biomass/plant and grain yield per plant. Chloride salinity of 0.75 MPa adversely affected almost all yield parameters of the most genotypes but B-90068 exhibited least negative effects of the salinities while Jau-87 was worst affected at 0.60 and 0.75 MPa levels of both sulphate and chloride salts of sodium especially for chloride.

Key Words: Chloride salinity; Sulphate salinity; Barley; Yield

INTRODUCTION

Salt sensitivity changes considerably during the development of plant (Akhtar *et al*., 2001). Four developmental stages namely germination, vegetative, reproductive growth and grain filling can be distinguished with respect to salt tolerance. Developmental shifts in relation to salt tolerance also vary according to the genotypes in barley, sugarcane (Akhtar *et al*., 2001), pearl millet (Javed *et al*., 2001) and wheat (Akram *et al*., 2002). Salinity tolerance is crucially important at reproductive stage of the plant growth (Francois & Kleiman, 1990). Salinity reduces tillering capacity, number of spike/plant, spike length, number of spikelets per spike, and kernel per spike and ultimately grain yield (Grieve *et al*., 1993). Moreover, salinity stress also delayed the maturity phase of development (Razzouk & Whitlington, 1991). Fifteen genotypes of barley exhibiting differential morphological features were exposed to two levels of sulphate and chloride salinities of sodium with the following objectives:
(i) To study the differential affects of salt varieties on barley growth, (ii) To screen out some genotypes showing better yield responses at the reproductive growth, (iii) To study and compare the genotypic responses to different salts.

MATERIALS AND METHODS

Fifteen elite barley genotypes for these studies were obtained from Ayub Agricultural Research Institute (ARRI), Faisalabad. A great deal of genetic variability was observed during preliminary selection of material based on seed and plant morphology. Following genotypes were used on the basis of high yield and good grain quality for this study.

Jau-83	B-91037	B-93006
Jau-87	B-91010	B-93016
B-9001	B-92077	B-93037
B-960068	B-92114	B-93075
B-91035	B-9214	B-93118

Experimental detail and growth conditions. Genotypes were sown in 30 cm earthen pots filled with 10 kg of soil. The pots were lined with double layer of good quality polyethylene to restrict seepage of soil solution. Healthy seed of each barley genotype were sown at the rate of 10 seed per pot separately. The seedlings of uniform size were thinned to three per pot at three leaf stage. The pots were kept in net house in Botanical Garden University of Agriculture, Faisalabad, Pakistan. Experiment was triplicated in completely randomized design.

Treatment application. Two levels each of NaCl and Na_2SO_4 i.e. 0.60 and 0.75 MPa were developed based on the field capacity of soil. The original salinity (-0.15 Mpa) of the soil was accounted for while developing the salinity for each salt. Salt levels were accomplished by a daily increment of 0.15 MPa until the final levels were achieved.

RESULTS

Number of tillers per plant. Barley genotypes under increased levels of NaCl and Na_2SO_4 indicated significant ($P<0.01$) differences with one another but there was no interaction ($P>0.05$) of these factors (Table I). The splitting effect of treatments revealed a significant ($P<0.01$) interaction of control x treatments. Salts and their increased levels had a significant ($P<0.01$) difference but the interaction of both these factors was non-significant ($P>0.05$). All the barley genotypes exhibited a substantial reduction in the number of tillers per plant but the most highly affected genotypes were Jau-87 under increased levels of both the salt. Jau-87 showed maximum reduction of 83 and 72% for the increased levels of NaCl and Na_2SO_4, respectively (Table II). On the other hand, B-900068 indicated the highest number of tillers under increased levels of NaCl and Na_2SO_4 as expressed over controls. Rest of the genotypes exhibited great variation for this parameter. However, the effect of NaCl was greater than Na_2SO_4.

Spike Length (cm) and number of spikelet per spike. Statistical analysis of data revealed that barley genotypes and various salts treatments had significant (P<0.01), differences for the spike length and number of spikelet per spike with a significant (P<0.01) interaction of genotypes x treatments (Table I). Analysis of the effect of treatments revealed that there was a significant (P<0.01) interaction of control x overall treatment effects. Salts and their levels also showed a significant (P<0.01) difference but the interaction of both these factors was non-significant (P>0.05). Although all the barley genotypes showed a decrease in length of spike and spikelet per spike under increased levels of both the salts, the effect of NaCl was greater than Na_2SO_4. Among the genotypes, B-90068 was minimally affected under increased levels of both the salts.

Biomass per plant (g). Barley genotypes and various salts treatments indicated significant (P<0.01) difference for this parameter with a non-significant (P>0.05) interaction of both the factors (Table I). The effect of treatments when analysed revealed a significant (P<0.01) interaction of control with rest of the treatments. Salts and their increased levels also indicated significant (P<0.01) difference but salts x levels interaction was non-significant (P>0.05). Although biomass per plant decreased in all the genotypes as expressed over the control, B-93037 for NaCl and B-91101 for Na_2SO_4 indicated greatest reduction. The reductions calculated at decreased Ψs of NaCl and Na_2SO_4 were 82.11 and 72.04% for B-93037 and B-91101, respectively over their respective controls. However, a minimum reduction in this parameter was noted in B-90068 under increased levels of both the salts. B-90068 showed a minimum reduction of 17.26 and 11.29% for Ψs 0.60 MPa of NaCl and Na_2SO_4 while the values calculated for Ψs 0.75 MPa were 44.33 and 32.73%, respectively for Na_2SO_4. On the average, NaCl was relatively more detrimental than Na_2SO_4 as regards total biomass per plant (Table II).

Grain yield per plant. The grain yield per plant decreased significantly (P<0.01) in all the barley genotypes under the effect of increased levels of NaCl and Na_2SO_4 but there was no interaction (P>0.05) of genotypes x treatments (Table I). The analysis of effect of treatments revealed a significant (P<0.01) interaction of control x overall treatments mean. Salts and their levels also indicated significant (P>0.01) differences but there was no interaction (P>0.05) of salts x levels. Data revealed a considerable reduction in grain yield under increased levels of both the salts. However, B-90068 indicated a minimum decrease of 44.33 and 32.73% for higher levels of NaCl and Na_2SO_4, respectively. On the other hand, Jau-87 depicted a maximum decrease of 90.65% for NaCl; whereas, B-92105 showed maximum decrease of 74.38% for Na_2SO_4 (Table II). Comparison of the effects of salts revealed that NaCl was far more damaging than Na_2SO_4 to all the genotypes.

Table I. Statistical analysis (mean square) of yield parameters under NaCl and Na_2SO_4 salinities

S.O.V	d.f	Total tillers per plant	Fertile tillers per plant	Length of ear	No. of spikelet per ear	Biomass per plant	Grain yield per plant
Genotypes (G)	14	53.11**	79.52**	43.77**	1218.25**	666.80**	59.59**
Treatment (T)	4	789.91**	497082**	424.83**	2634.63**	1758.61**	512.53**
T vs Control	1	2249.92**	1257.88**	1019.46**	7785.24**	5863.73**	1542.71**
Salt (S)	1	110.45**	99.76**	96.35*	266.26**	261.97**	77.12**
Level (L)	1	399.00**	313.60**	289.78**	1243.52**	449.24**	214.71**
Salt x Level	1	0.63ns	3.21ns	1.97ns	0.09ns	5.15ns	0.45ns
G x T	56	5.59ns	30.10ns	3.35**	28.90**	27.90ns	5.33ns
Error	150	5.70	4.06	1.94	8.59	21.94	5.85

Significant at *, P<0.05; **, P<0.01; ns , non-significant

Table II. Percentage decrease in growth under the application of 0.75 Mpa NaCl and Na_2SO_4 salinities

Genotypes	Total tillers per plant		Fertile tillers Per Plant		Length of ear (cm)		Number of Spikelet per ear		Biomass per plant (mg)		Grain yield per plant (mg)	
	NaCl	Na_2SO_4	NaCl	Na_2SO_4	NaCl	Na_2SO_4	NaCl	Na_2SO_4	NaCl	Na_2SO_4	NaCl	Na_2SO_4
Jau-83	64.97	47.49	62.49	57.44	50.77	47.02	57.67	44.09	55.93	46.54	67.85	57.84
Jau-87	82.58	71.75	79.97	75.02	64.53	57.23	80.12	73.44	79.17	31.62	90.65	67.94
B-90015	63.16	58.16	63.26	55.11	56.23	19.56	79.65	62.76	70.66	57.76	77.32	67.72
B-90068	38.89	31.50	41.29	63.01	22.03	13.92	22.41	18.31	44.33	32.76	37.40	28.61
B-91035	39.24	49.00	67.52	62.49	47.90	40.09	67.58	61.81	69.06	65.19	76.80	72.41
B-91037	73.68	63.16	71.15	65.38	51.75	43.02	60.17	66.08	69.04	65.85	73.08	67.15
B-91101	58.31	50.00	61.35	50.03	39.14	29.68	70.86	65.41	77.07	72.04	78.33	74.36
B-92077	41.29	60.86	63.64	54.55	23.26	37.12	66.68	55.94	76.73	70.11	69.72	64.33
B-92114	63.82	61.71	75.00	61.08	42.85	37.19	63.05	58.65	64.52	61.86	63.12	56.48
B-92115	68.96	43.09	80.74	73.13	53.69	40.70	67.77	58.54	73.78	69.57	79.97	74.39
B-93006	68.75	60.44	82.10	67.85	55.24	41.53	68.07	60.91	72.01	59.64	76.10	72.11
B-93016	71.10	60.38	80.54	50.04	54.00	23.41	62.63	58.31	73.35	66.30	66.15	60.38
B-93037	61.11	53.72	69.20	61.54	47.02	41.42	77.75	60.24	82.11	49.89	66.13	56.25
B-93075	79.61	66.67	77.22	54.57	46.38	38.17	70.60	61.23	75.78	65.12	85.54	63.75
B-93118	61.71	53.22	48.66	37.79	40.33	33.90	71.73	59.48	56.09	56.49	59.61	49.33

DISCUSSION

Plant growth in a saline environment is affected adversely and the effects are manifested at each of its phenological stage of development such as germination, tillering, booting and grain filling stage (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 *at 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 reproductive stage of growth. The salinity tolerance has been based upon greater number of fertile tiller, number of spikelet/spike increased number of grains/spikelet and higher grain yield.

It is important to note that different plant species tested under saline conditions may show a different behaviour at different growth stages. Similar results have been reported in Atriplex (Wilson *et al*., 2000), sugarcane (Wahid *et al*., 1997), tomato (Pessarakli, 2001) and sunflower (Francois *et al*., 1994). In the present study, a substantial variation at germination, tillering booting and grain filling stages was exhibited by different genotypes for various parameters. The results revealed that B-90068 was capable of thriving under salinity at all the growth stages. It is greatly advantageous because exposure of crop to saline spell at a sensitive stage may lead to its complete failure. Among the yield parameters, greater tillering and greater yield enable the tolerant plant to grow better under saline condition. In the present study, genotype B-90068 has been earmarked as highly salt tolerant and Jau-87 as salt sensitive genotype. In order to determine the detailed mechanism for salt tolerance, the above screened genotypes were used as experimental material. The tolerant genotype B-90068 exhibited highest yield under all increased levels of both salt which is a useful criterion for expression of salt tolerance (Maas & Hoffman, 1977; Maas, 1986; Aslam *et al*., 1993). It is also clear that the genotypes displayed same tolerance mechanism for both sulphate and chloride salinities of the sodium, as the genotypes displayed batter yield under sulphate salt, was also good for the chloride.

The reduction of yield even in the tolerant genotypes was due to the extra energy utilization for osmotic accumulation which is much more ATP consuming for osmotic adjustment (Wyn Jones & Gorham, 1983).

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