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Response of Barley (*Hordeum vulgare* L.) at Various Growth Stages to Salt Stress

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Abstract: A pot experiment was conducted during winter 1996-97, to determine the response of barely (*Hordeum vulgare* L.) at various growth stages to salt stress (0, 8, 12 and 16 dS m^{-1} NaCl). A progressive decrease occurred in all the growth and yield parameters with increasing soil salinity. Grain yield was reduced by 45.83% at higher salinity level as compared to control. Among the varieties, Jow-83 proved comparatively better than Jow-87. Salinity affected at all the growth stages but it was more pronounced at vegetative stage than flower initiation and grain filling stages.

Key words: Growth stages, NaCl salinity, barley

Introduction

Salinity is a global problem that limits crop production especially on irrigated area of the world. In Pakistan, salinity is one of the major soil problem. The soil of Pakistan has a great productive potential but salinity has hampered its crop production in some areas and inhibited it completely in others. The rapid increase in unproductive salt affected land is adversely affecting the economy of Pakistan. Many curative and management practices have been adopted by soil scientists to overcome the salinity problem. However, most of these are highly expensive and have not given satisfactory results. The least expensive measure is the development of cultivars tolerant to high salt concentration. Thus the biological approach has received considerable attention in the last few decades. There is now strong evidence that all the varieties of a crop are some times not equally sensitive to salinity and in most crop species the degree of salt tolerance varies with the change in growth stages as in wheat, rice, maize, barley and sugarbeet (Ahsan and Wright, 1998; Akbar and Yabuno, 1974; Jan *et al.*, 1995; Kingsburg and Epstein, 1986; Norlyn, 1980). Barley is one of the highly salt tolerant crop. High specific ion effect of chloride (Cl^-) particularly during germination have been reported by a number of research workers (Ahmad *et al.*, 1980). The aim of present study was, therefore, to determine the response of barley at different growth stages to salt stress.

Materials and Methods

The pot experiment was conducted during winter 1996-97, in the Botanical Garden of the University of Agriculture, Faisalabad, to study the effect of salinity at different growth stages of barley. The seeds of two barley varieties, namely Jow-83 and Jow-87 were obtained from Ayub Agricultural Research Institute (AARI), Faisalabad. The earthen pots of 30 cm diameter lined with polythene bags were filled with 10 kg of sandy loam soil, having ECe, 1.46 dS m^{-1}, pH, 8 and Saturation percentage 32. The sowing was done on November 21, 1996 and nine seeds were sown 2 cm deep in each pot. 72 pots in total were used, allocating 36 pots to each variety. Tap water was used for irrigation, whenever needed. After germination five plants were maintained in each pot. Three salinity levels (8, 12 and 16 dS m^{-1}) were developed using NaCl solution. While normal soil having ECe 1.56 dS m^{-1} was considered as control. The salinity treatment was imposed as 6 percent NaCl solution in 3, 4 and 5 installments for ECe 8, 12 and 16 dS m^{n} respectively at three different growth stages i.e. vegetative stage (S_1), flower initiation stage (S_2) and grain filling stage (S_3). The experiment was laid out in Completely Randomized Design with three factors having four treatments for each variety. Each treatment was replicated thrice. The data for different growth and yield parameters were recorded at maturity of the crop and analysed statistically using analysis of variance technique (Steel and Torrie, 1980). Treatment means were compared by applying Duncan's New Multiple Range test.

Results and Discussion

Analysis of variance of data presented in Table 1 showed that salinity had significant effect on all the growth parameters at different growth stages. Plant height, root length, number of leaves/plant decreased significantly with increasing salinity of the growth medium (Table 1). The maximum decrease was found at highest salinity level as compared to control (non-saline). Varieties differed significantly. Growth stages also differed highly significant. In both varieties (Table 2), the more adverse effect of salinity was found at vegetative stage than flower initiation or grain filling stage. These results are generally in accordance with those obtained by Ahmad *et al.* (1980), Kumar *et al.* (1981) and Sharma and Garg (1985) in barley and wheat in which they reported that salinity decrease the plant growth in terms of plant height, root length and number of leaves/plant. The decrease in plant growth could be attributed to the toxic effects of Na^+ or Cl^- on plant metabolism, nutritional imbalance or osmotic reduction in water availability in the growth medium (Greenway and Munns, 1980). In view of Shoe and Gale 1983, the lesser number of leaves at high salinities may be due to decreased amount of photosynthates reaching the growing region because of inhibition of photosynthesis due to stomatal closure or by direct effects of salts on the photosynthetic apparatus. Flag leaf area decreased significantly with increasing salinity in both varieties of barley (Table 1). But more adverse effect of salinity was found at vegetative stage than latter growth stages. Reduction in leaf area under salt stress may have been due to suppressed cell division or fewer number of cells (Ashraf and Naqvi, 1996; Malibar *et al.*, 1993). These results support the earlier findings of El-Kady *et al.* (1980), Yaseen *et al.* (1987) and Kalaji and Nalborczyk (1991) who found that increasing salinity of the growth medium decrease the leaf are ain barley cultivars. Table 1 showed that salinity had significant effect on fresh and dry weights of root and shoot. Varieties differed significantly in case of shoot fresh and dry weights but in case of root fresh weight, varieties did not differed significantly. Stages mean also showed highly significant differences. In both varieties fresh and dry weights of root and shoot decreased consistently with increase in external salinity level (Table 2). However, vegetative stage was affected more adversely than flower initiation or grain filling stage. These findings are parallel to those of Roth (1989), Al-Khafaf *et al.* (1990) Ashraf and

Table 1: Analysis of variance summaries (mean squares) of data for growth parameters of barley under salt stress

S.O.V.	D.F.	Plant height	Root length	No.of leaves/ Plant	Flag leaf area	Fresh wt.of shoot	Fresh wt.of root	Dry wt. of shoot	Dry wt. of root
Varieties (V)	1	2639.01**	10.54NS	83.20**	362.25**	4.01**	0.050NS	8.260**	0.020**
Treatments (T)	3	413.43**	59.83**	143.33**	277.34**	23.76**	0.670**	1.440**	0.040**
Stages (S)	2	494.17**	114.35**	131.49**	59.55NS	58.08**	0.360**	1.570**	1.060**
V x T	3	67.82*	5.21NS	11.45NS	17.06NS	0.22NS	0.031NS	0.104NS	0.001NS
V x S	2	40.90NS	22.97*	126.04**	137.48**	10.48**	0.016NS	0.557NS	0.004NS
T x S	6	36.40NS	4.27NS	5.96NS	15.73NS	0.87NS	0.110NS	0.036NS	0.001NS
V x T x S	6	9.01NS	1.76NS	7.39NS	5.98NS	0.15NS	0.054NS	0.121NS	0.002NS
Error	48	16.53	5.23	0.57	21.55	0.51	0.099	0.205	0.005
Total	71								

* = Significant, ** = Highly significant, NS = Non significant at 5 and 1% level of probability

Table 2: Response of barley (*Hordeum vulgare* L.) At different growth stages of salt stress (0,8,12 and 16 dsm^{-1} NaCl)

Stages	Plant height (cm)	Root length (cm)	No.of leaves/ Plant	Flag leaf area (cm^2)	Fresh wt.of shoot(g)	Fresh wt.of root (g)	Dry wt. of shoot (g)	Dry wt. of root (g)
Jow-83								
Vegetative Stage								
T0	78.08	12.55	12.16	22.04	5.51	1.93	4.80	0.46
T1	71.20	12.45	7.50	21.57	4.78	1.85	4.00	0.45
T2	70.10	10.78	7.33	15.12	4.43	1.36	3.36	0.35
T3	63.28	8.15	3.96	13.71	3.37	1.23	2.98	0.31
Flower initiation stage								
T0	86.00	13.38	12.33	19.12	15.76	2.25	12.91	0.61
T1	82.58	11.70	9.00	17.49	12.01	1.78	9.41	0.20
T2	74.91	11.40	9.33	16.61	10.36	1.46	8.23	0.18
T3	71.33	7.66	5.83	10.99	10.25	1.00	7.10	0.16
Grain filling stage								
T0	85.00	20.00	18.83	30.75	8.83	2.56	6.17	0.71
T1	74.33	14.88	15.83	27.67	7.00	2.36	5.39	0.51
T2	66.33	16.83	14.16	17.74	5.93	2.18	4.89	0.40
T3	64.50	13.33	10.66	17.73	5.01	2.06	3.92	0.31
Jow-87								
Vegetative stage								
T0	61.55	13.48	7.50	18.34	5.91	1.08	3.66	0.38
T1	59.65	13.23	6.83	13.42	4.95	1.06	2.76	0.36
T2	59.45	11.58	6.66	12.72	3.81	1.00	2.13	0.30
T3	59.12	10.00	6.66	10.88	3.25	0.81	1.91	0.25
Flower initiation stage								
T0	70.41	10.95	15.33	20.00	14.25	1.43	10.96	0.33
T1	68.36	10.83	11.33	17.23	10.70	1.21	7.13	0.18
T2	65.41	10.25	8.33	16.53	10.03	1.10	6.03	0.17
T3	63.66	9.80	8.00	11.21	9.23	1.08	5.68	0.16
Grain filling stage								
T0	62.40	16.23	11.16	18.75	8.10	1.73	6.00	1.73
T1	61.66	13.66	10.00	14.92	6.00	1.41	4.23	1.41
T2	53.50	12.75	7.83	11.54	6.42	1.03	4.00	0.51
T3	53.26	11.16	4.50	11.18	5.17	0.93	4.09	0.31

T1 = 0 dSm^{-1}; T2 = 8 dSm^{-1}; T3 = 12 dSm^{-1}; T4 = 16 dSm^{-1}

Table 3: Analysis of variance summaries (mean squares) of data for yield and yield attriobuting parameters of barley under salt stress

S.O.V.	D.F.	No.of fertile tillers/plant	Spike length	No.of spikelets/ spike	No.of grains spikelets	100-grain weight	Grain yield /plant
Varieties (V)	1	0.222NS	65.83**	572.06**	0.045NS	1.150**	5.520**
Treatments(T)	3	0.269NS	24.03**	1014.92**	0.230*	0.189**	2.510**
Stages (S)	2	0.198NS	9.59*	406.32**	0.243*	0.201**	0.690**
V x T	3	0.009NS	1.01NS	57.82NS	0.015NS	0.073**	0.041NS
V X S	2	0.128NS	3.03NS	88.69NS	0.080NS	0.190**	0.004NS
T X S	6	0.022NS	1.39NS	47.10NS	0.132NS	0.071**	0.139NS
V X T X S	6	0.054NS	0.36NS	117.69NS	0.059NS	0.086**	0.098NS
Error	48	0.111	2.45	69.55	0.060	0.000	0.117
Total	71						

* = Significant, ** = Highly significant, NS = Non significant at 5 and 1% level of probability

Table 4: Response of barley (Hordeum vulgare L.) At different growth stages to salt stress (0, 8, 12 and 16 dSm^{-1})

Stages	No.of fertile tillers/plant	Spike length (cm)	No.of spikelets/ spike	No.of grains/ spikelets	100-grain weight (g)	Grain yield /plant
Jow-83						
Vegetative stage						
T0	1.50	17.43	50.00	1.00	1.26	2.13
T1	1.26	17.28	43.66	0.83	1.21	1.98
T2	1.19	15.73	43.33	0.66	1.13	1.89
T3	1.00	13.65	26.00	0.50	1.08	1.36
Flower initiation stage						
T0	1.46	15.66	55.33	1.00	1.11	2.13
T1	1.20	15.33	50.50	0.83	1.08	1.51
T2	1.11	15.25	49.00	0.66	1.04	1.31
T3	1.00	12.78	36.66	0.66	1.03	1.21
Grain filling stage						
T0	1.67	17.83	45.75	1.53	1.21	2.53
T1	1.42	16.16	44.73	0.83	1.18	1.86
T2	1.33	15.85	39.33	0.83	1.61	1.61
T3	1.20	15.00	38.66	0.66	1.14	1.55
Jow-87						
Vegetative stage						
T0	1.30	14.53	37.50	0.83	1.10	1.51
T1	1.17	14.01	36.33	0.66	1.08	1.38
T2	1.00	12.46	28.33	0.66	1.04	1.15
T3	1.00	12.30	26.00	0.36	1.01	0.93
Flower initiation stage						
T0	1.26	14.08	48.00	1.00	0.95	1.30
T1	1.16	13.83	43.00	0.66	0.86	1.26
T2	1.16	13.65	41.83	0.66	0.84	1.03
T3	1.00	12.23	38.00	0.36	0.82	0.48
Grain filling stage						
T0	1.50	16.01	57.83	1.00	0.96	1.98
T1	1.30	14.78	42.66	1.00	0.93	1.40
T2	1.26	13.86	29.83	1.00	0.90	0.98
T3	1.15	13.33	29.00	0.66	0.90	0.93

T1 = 0 dSm^{-1}; T2 = 8 dSm^{-1}; T3 = 12 dSm^{-1}; T4 = 16 dSm^{-1}

Idrees (1995) who also found that increasing salinity in the growth medium reduced the fresh and dry weights in wheat, barley, rice and *Pennisetum glaucm.* Under salinity stress, fresh and dry weights of root and shoot decreases due to maintenance of turgor in plants.

Yield and yield attributing characters are the most important criteria to judge the merit of a particular treatment. Analysis of variance of data presented in Table 3 showed that number of fertile tillers/plant decreased progressively with increasing salinity. However, non-significant differences were observed between varieties, treatment and stages means. More tillers were observed when salinity was applied at grain filling stage as compared to its treatment at flower initiation or at vegetative stage (Table 4). These results are in agreement with those of Senin *et al.* (1985) and Francois *et al.* (1994) who also reported that increasing salinity in the growth medium decreased the number of fertile tillers/plant in barley. According to Narale *et al.* (1969) the production of less number of tillers under saline environment may be due to poor growth as a result of decreased membrane permeability or enzyme activity. Table 3 showed that salinity had a significant effect on spike length, number of spikelets per spike, number of grains/spikelets, 100-grain weight and grain yield/plant. Varieties and stages means showed significant differences in all these parameters but non significant differences in case of number of grains/ spikelet. However, in both barley varieties, more adverse effect of salinity on all these parameters was found at vegetative stage than flower initiation or grain filling stage. The decrease in yield and yield components under saline conditions may have been due to the retarted growth of plants as a result of low uptake of water and nutrients as well as due to the specific ion effects. These results support the earlier findings in which it was reported that increasing salinity decreased all the earlier mentioned parameters in barley (Aloy *et al.*, 1992; Dutt, 1988), wheat (Khan *et al.*, 1999; Raghav and Pal, 1994) and maize (Sharif *et al.*, 1999). From these studies, it is thus concluded that salinity affected negatively at all growth stages on all the parameters in both barley varieties. However, vegetative stage was affected more adversely than flower initiation and grain filling stage. Among the varieties, Jow-83 proved better than Jow-87.

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