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SALT TOLERANCE STUDIES IN DIFFERENT CULTIVARS OF BARLEY (*HORDEUM VULGARE* L.)

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Abstract

Twelve barely cultivars were tested for their salt tolerance in cemented tanks lined with polyethylene sheet containing gravel saturated with nutrient solution maintained at electrical conductivity (EC) of 3, 5, 10, 15 and 20 mS cm^{-1}. Barley cultivars highly differed in their response to rootzone salinity. Salt tolerance limits (50% reduction in green matter yield) of these cultivars ranged from 10.0 – 18.4 mS cm^{-1}.

Introduction

Barley (*Hordeum vulgare* L.) is relatively salt resistant non-halophyte (Bower & Tamimi, 1979; Lynch & Lauchli, 1984; Norlyn & Epstein, 1982). A large variation exists among the various cultivars of barley as to its ability to tolerate various salinity levels (Ayers *et al.*, 1952; Bhatti *et al.*, 1976; Epstein & Norlyn, 1977). The object of the present investigation was to screen the germplasm of barley collected from arid and semi arid areas of Pakistan for its salt tolerance.

Materials and Methods

Seed germination: The effect of different salinity levels (3, 5, 10, 15 and 20 mS cm^{-1}) on seed germination of 12 barley cultivars as listed in Table 1, was studied. Salinity levels of 3–20 mS cm^{-1} were prepared by the addition of Na_2SO_4, $CaCl_2$, $MgCl_2$ and NaCl in molar ratios of 10:5:1:4 (Qureshi *et al.*, 1977) to the Hoagland nutrient solution (Arnon & Hoagland, 1940). Ten seeds of each variety were placed in Petridishes lined with filter paper soaked with 10 ml of the respective solution. Fresh solution was added to the dishes daily after rinsing them with the same solution. Each treatment had three replicates. Germination of seeds (emergence of radicle) was recorded daily over a period of 5 days. Germination Index (G.I.) was determined by the formula:

$$G.I. = \frac{\Sigma\ T_i\ N_i}{S}$$

Where:

T_i = number of days after sowing,
N_i = number of seeds germinated on day i,
S = total number of seeds planted (Scott *et al.*, 1984).

Plant growth: Cemented tanks, 254 cm long, 82 cm wide and 23 cm deep, lined with polyethylene sheet were filled with acid washed inert quartz gravel (5–25 mm dia). After saturating the gravel with Hoagland nutrient solution 5 seedlings of each barley accession, already grown for a week in sand, were transplanted in the tanks. After a week, the plants were subjected to salinity levels of 5, 10, 15 and 20 mS cm^{-1} by a stepwise increase of 2.5 mS cm^{-1} every alternate day. The rootzone salinity levels were checked daily and maintained either by the addition of water (EC = 0.254 mS cm^{-1}) or by adding salt solution. The experiment lasted for 20 weeks. During first 8 weeks, for maintaining sufficient nutrients status, solutions were completely replaced at monthly interval followed by fortnightly interval. Aeration and mixing of salts in the tanks were made by intermittent recirculation of nutrient solution. The plants harvested at flag leaf stage were used for observations on plant height, number of tillers $plant^{-1}$, green and dry weights $plant^{-1}$. From the biomass yield, salt tolerance limits of all the varieties tested were calculated. The plant samples were analysed for Na^+, K^+ and Ca^{++} on a flame photometer after wet digestion with HNO_3 and $HClO_4$ (Anonymous, 1954).

Table 1. Effect of salinity levels on germination index of different cultivars of barley.

Cultivars	Salinity (mS cm^{-1})				
	3 (Control)	5	10	15	20
PK-30139	4.96	5.40	5.10	3.80	4.30
PK-30163	8.20	8.97	7.30	5.90	3.80
PK-30109	6.80	7.10	3.60	5.80	2.20
PK-30046	5.30	6.00	5.90	4.80	4.20
PK-30175	8.63	9.57	11.30	9.70	9.80
PK-30130	11.33	9.60	9.20	10.10	5.80
PK-30136	14.83	13.60	12.60	14.20	11.60
PK-30118	14.53	11.60	11.80	11.90	10.10
PK-30148	6.30	4.10	3.40	3.20	2.60
PK-30172	10.70	9.00	8.10	6.30	4.60
PK-30055	14.60	13.30	13.10	11.50	11.70
PK-30166	11.27	9.10	8.00	5.80	5.10

L.S.D. at 5%: For Cultivars = 1.21
For Salinity levels = 1.12

Results and Discussion

Germination responses of barley accessions to salinity were highly variable (Table 1). For accessions PK-30139, PK-30163, PK-30109 and PK-30046, germination index was higher at low salinity (5 mS cm^{-1}) and then decreased as salinity increased. For accession PK-30175, the germination index was higher at all salinity levels as compared to control. For the remaining 7 accessions, there was a significant reduction in germination index at low salinity (5 mS cm^{-1}) and with further increase in salinity, it gradually decreased in most of the cases. A relationship between germination index and salt tolerance of various accessions of barley was not consistent (Table 1 & 4). Torello & Symington (1984) reported similar inconsistent relationship between germination and salt tolerance of various cultivars of turf grass species. Ranking of cultivars only considering their germination responses may be misleading as Alkali grass (*Puccinellia distans*) show increase in salt tolerance with increasing age (Torello & Symington, 1984). As salinity affects germination and plant growth differently (Ayers *et al.*, 1952; Francois *et al.*, 1984), long term plant growth studies are necessary to characterize inherent salt tolerance of species or cultivars.

The tillering behaviour of different cultivars of barley was highly different. In 3 cultivars, number of tillers increased at low salinity (5 mS cm^{-1}) as compared to control, in one of which number of tillers even increased at 15 mS cm^{-1}. In general, a negative significant correlation was found between the root medium salinity and number of tillers (Table 2). However, the magnitude of reduction in number of tillers with increasing salinity was not same for all cultivars. Percentage reduction in number of tillers ranged from 14 to 58 when the root medium salinity increased from 3 to 20 mS cm^{-1}. Hence the cultivars showed significantly different responses to salinity as regards to their tillering behaviour (Table 2).

The effect of rootzone salinity on plant height of barley cultivars (Table 3) showed that in eight cultivars, the plant height has increased at low salinity (5 mS cm^{-1}) as compared to control. A significant negative correlation was found between the rootzone salinity and the plant height. Percentage reduction in plant height varied from 25 to 46 when the root medium salinity increased from 3 to 20 mS cm^{-1}. Similar results have been reported by Niazi *et al.* (1985) in case of Ipil-Ipil (*Leucaena leucocephela* L.) cv. K-8.

In most of the cultivars the green matter yield as well as dry weight increased at 5 mS cm^{-1} as compared to control (Table 4 & 5). Similar increased growth responses at low salinity in barley have been reported (Dregne & Mojallali, 1968; Hassan *et al.*, 1970). Most of the cultivars were statistically significant among themselves as their biomass production potential was concerned. A significant negative correlation was found between the green and dry matter yield and the rootzone salinity. About 60–83% reduction

Table 2. Effect of rootzone salinity on number of tillers plant^{-1} in different cultivars of barley.

Cultivars	Salinity (mS cm^{-1})				
	3 (Control)	5	10	15	20
PK-30130	25.5	21.5	19.5	16.5	11.0
		(15.7)	(23.5)	(35.3)	(57.0)
PK-30136	21.5	30.5	25.5	22.0	18.5
		(41.9)*	(18.6)*	(2.3)*	(14.0)
PK-30118	22.5	18.0	21.0	15.5	12.5
		(20.0)	(6.7)	(31.0)	(44.4)
PK-30139	29.5	26.5	16.5	13.5	15.5
		(10.2)	(44.1)	(54.2)	(47.5)
PK-30148	23.5	22.0	18.0	14.5	13.5
		(6.4)	(23.4)	(38.3)	(42.6)
PK-30172	33.0	33.5	30.5	29.0	14.5
		(1.5)*	(7.6)	(12.1)	(56.0)
PK-30163	28.5	23.5	25.0	16.5	12.0
		(17.5)	(12.3)	(42.1)	(58.0)
PK-30055	31.0	33.0	17.0	18.5	20.5
		(6.5)*	(45.2)	(40.3)	(34.0)
PK-30109	21.5	21.5	17.0	13.0	16.5
		(0.0)	(21.0)	(39.5)	(23.3)
PK-30166	39.5	31.5	28.5	23.5	16.5
		(20.3)	(27.8)	(40.5)	(58.2)
PK-30046	31.5	30.5	20.0	18.5	17.0
		(3.2)	(36.5)	(41.3)	(46.0)
PK-30175	27.5	26.0	23.5	15.0	13.0
		(5.5)	(14.5)	(45.5)	(52.7)

Figures in the parenthesis are % decrease over control; parenthesis with * indicate % increase over control.

L.S.D. at 5%: For Cultivars = 3.73
For Salinity levels = 3.47

in green matter yield and 40–78% reduction in dry matter yield were recorded in various cultivars of barley as the rootzone salinity increased from 3 to 20 mS cm^{-1}. These differences in reduction of green and dry matter yields may be attributed to variability among cultivars as regards their ability for water uptake at different salinity treatments. Kingsbury & Epstein (1984) reported that biomass of spring wheat was reduced with the increasing level of salinization of nutrient solution with sea water. Based on these results the salt tolerance limit of reduction in green matter yields by 50% has been calculated. There were six cultivars (Table 4) whose salt tolerance limits were in the range of 16 to 18.4 mS cm^{-1}. Salt tolerance limits of these 12 cultivars varied from 10 to 18.4 mS cm^{-1}. Further, the cultivars whose green matter yields were higher at control had lower salt tolerance limits and vice versa (Table 4). Cultivar PK-30166 gave the maximum green matter yield (297 g $plant^{-1}$) but its salt tolerance limit was only 11.0 mS cm^{-1} whereas the most salt tolerant cultivar PK-30130 (salt tolerance limit 18.4 mS cm^{-1}) gave only 160 g $plant^{-1}$ green matter yield.

Table 3. Effect of rootzone salinity on plant height (cm) of different cultivars of barley.

Cultivars	Salinity (mS cm^{-1})				
	3 (Control)	5	10	15	20
PK-30130	107.0	109.5 (2.3)*	107.5 (0.5)*	89.0 (16.8)	73.0 (31.8)
PK-30136	103.5	102.5 (0.9)	98.0 (5.3)	89.5 (13.5)	69.0 (33.5)
PK-30118	92.0	105.5 (14.7)*	98.0 (6.5)*	83.0 (9.8)	66.5 (27.7)
PK-30139	107.5	121.5 (13.0)*	99.0 (7.9)	86.0 (20.0)	66.5 (38.0)
PK-30148	98.5	107.0 (8.6)*	105.0 (6.6)*	97.5 (1.0)	66.0 (33.0)
PK-30172	96.0	102.5 (6.8)*	95.0 (1.0)	73.5 (23.4)	52.0 (45.8)
PK-30163	107.5	105.5 (1.9)	100.0 (7.0)	83.5 (22.3)	59.0 (45.1)
PK-30055	113.0	115.0 (1.8)*	93.5 (17.3)	90.5 (19.9)	75.0 (33.6)
PK-30109	92.5	103.0 (11.4)*	93.0 (0.5)	92.5 (0.0)	61.5 (33.5)
PK-30166	101.0	98.0 (3.0)	92.0 (8.9)	81.5 (19.3)	56.5 (44.1)
PK-30046	104.5	118.5 (13.4)*	104.5 (0.0)	103.0 (1.4)	78.0 (25.0)
PK-30175	104.0	102.0 (1.9)	101.0 (2.9)	90.5 (13.0)	63.0 (39.4)

Figures in the parenthesis are % decrease over control; parenthesis with * indicate % increase over control.
L.S.D. at 5%: For Cultivars = 5.01 For Salinity levels = 2.66

Table 4. Effect of rootzone salinity on green matter yield (g plant^{-1}) of different cultivars of barley, and salt tolerance limits.

Cultivars	Salinity (mS cm^{-1})					
	3 (Control)	5	10	15	20	Salt tolerance limits (mS cm^{-1})
PK-30130	160.0	184.0	154.2	137.5	52.6	18.4
		(15.0)*	(3.6)	(14.1)	(67.0)	
PK-30136	161.6	247.3	131.6	121.0	58.9	17.9
		(53.0)*	(18.6)	(30.6)	(63.6)	
PK-30118	129.0	155.0	118.0	83.6	43.0	17.3
		(20.1)*	(8.5)	(35.0)	(67.0)	
PK-30139	177.0	267.2	169.2	104.2	70.0	17.3
		(51.0)*	(4.3)	(41.0)	(60.4)	
PK-30148	176.4	158.0	135.0	110.0	61.0	17.2
		(10.5)	(24.0)	(38.0)	(65.4)	
PK-30172	136.0	251.0	203.4	163.5	51.6	16.1
		(85.4)*	(50.0)*	(20.6)*	(62.0)	
PK-30163	242.6	220.4	221.2	117.0	66.8	14.6
		(9.2)	(9.0)	(52.0)	(73.0)	
PK-30055	230.0	254.0	131.2	110.0	69.7	14.0
		(10.3)*	(42.9)	(52.2)	(70.0)	
PK-30109	151.0	195.0	88.3	70.0	54.0	13.6
		(29.3)	(42.0)	(54.0)	(65.0)	
PK-30166	297.0	228.0	154.0	125.3	51.1	11.0
		(23.3)	(48.3)	(58.0)	(83.0)	
PK-30046	247.0	305.0	128.0	86.4	51.0	10.6
		(23.3)*	(48.0)	(65.0)	(79.4)	
PK-30175	166.0	162.0	157.4	133.0	34.4	10.0
		(2.5)	(5.2)	(20.0)	(79.2)	

Figures in the parenthesis are % decrease over control; parenthesis with * indicate % increase over control.

L.S.D. at 5%: For Cultivars = 38.42 For Salinity levels = 25.70

Sodium contents of most of the cultivars grown in control were statistically non-significant among themselves (Table 6). Sodium contents of all the cultivars have increased significantly as the rootzone salinity increased from 3–20 mS cm^{-1}. A positive significant correlation was found between the rootzone salinity and sodium contents of barley cultivars. Sodium contents of barley cultivars increased about 5–12 times as the rootzone salinity increased from 3 to 20 mS cm^{-1}. No consistent relationship was found between plant tolerance and sodium contents. Similar results have been reported by Russel (1976).

Table 5. Effect of rootzone salinity on dry matter yield (g plant^{-1}) of different cultivars of barley.

Cultivars	Salinity (mS cm^{-1})				
	3 (Control)	5	10	15	20
PK-30130	18.2	20.3 (11.5)*	17.2 (5.5)	17.0 (6.6)	7.1 (61.0)
PK-30136	15.5	22.1 (42.6)*	16.8 (8.4)	13.8 (11.0)	7.8 (50.0)
PK-30118	12.6	16.0 (27.0)*	16.1 (27.8)*	10.1 (20.0)	5.8 (54.0)
PK-30139	16.4	28.8 (75.6)*	25.2 (54.0)*	17.6 (7.3)*	9.8 (40.2)
PK-30148	17.6	15.0 (14.8)	15.7 (10.8)	14.3 (18.8)	7.8 (56.0)
PK-30172	14.4	25.6 (44.0)*	28.3 (97.0)*	22.2 (54.2)*	7.4 (49.0)
PK-30163	30.2	28.6 (5.3)	34.2 (13.2)*	19.3 (36.0)	9.4 (69.0)
PK-30055	22.8	27.8 (22.0)*	10.8 (53.0)	13.8 (39.5)	9.7 (58.0)
PK-30109	15.5	20.3 (31.0)*	9.5 (39.0)	7.9 (49.0)	7.2 (54.0)
PK-30166	25.1	18.8 (25.1)	14.9 (41.0)	12.2 (51.4)	7.0 (72.1)
PK-30046	23.9	33.2 (39.0)*	13.2 (45.0)	9.8 (59.0)	6.8 (71.5)
PK-30175	18.2	17.9 (1.6)	18.0 (1.6)	15.1 (17.0)	4.1 (78.0)

Figures in the parenthesis are % decrease over control; parenthesis with * indicate % increase over control.

L.S.D. at 5%: For Cultivars = 4.42 For Salinity levels = 4.00

Most of the cultivars were statistically different in their potassium contents at control (Table 7). Potassium contents of all the cultivars decreased significantly as the rootzone salinity increased, a significant negative correlation was found between the rootzone salinity and the potassium contents of barley cultivars. The increased absorption of sodium (Table 6) was accompanied by a substantial decrease of potassium (Table 7) in all cultivars of barley. Similar observation has been made in barley (Greenway, 1962). No association of plant potassium concentration with salt tolerance was evident. Similar results have been reported by Noble *et al.* (1984) in lucerne (*Medicago sativa*).

Table 6. Effect of rootzone salinity on sodium content (mg 100 g^{-1}) of barley cultivars

Cultivars	Salinity (mS cm^{-1})				
	3 (Control)	5	10	15	20
PK-30130	26.2(1)	118.3 (4.5)	160.2 (6.1)	173.4 (6.6)	183.8 (7.0)
PK-30136	21.5(1)	136.5 (6.4)	161.2 (7.5)	183.4 (8.5)	205.4 (9.6)
PK-30118	23.9(1)	130.5 (5.5)	149.0 (6.2)	183.4 (7.7)	192.1 (8.0)
PK-30139	30.0(1)	115.3 (3.8)	141.0 (4.7)	149.0 (5.0)	158.6 (5.3)
PK-30148	19.2(1)	141.0 (7.3)	152.6 (8.0)	177.8 (9.3)	208.6 (10.9)
PK-30172	29.8(1)	126.0 (4.2)	139.0 (4.7)	161.5 (5.4)	169.0 (5.7)
PK-30163	29.8(1)	103.8 (3.5)	135.0 (4.5)	147.0 (4.9)	153.8 (5.2)
PK-30055	23.9(1)	116.8 (4.9)	163.4 (6.8)	189.4 (7.9)	192.1 (8.0)
PK-30109	19.2(1)	130.4 (6.8)	157.8 (8.2)	186.6 (9.7)	192.5 (10.0)
PK-30166	19.1(1)	146.1 (7.7)	177.4 (9.3)	186.2 (9.8)	201.7 (10.6)
PK-30046	22.7(1)	111.5 (4.9)	153.0 (6.7)	201.7 (8.9)	211.8 (9.3)
PK-30175	16.8(1)	146.1 (8.7)	177.4 (10.5)	186.2 (11.1)	201.7 (12.0)

( ) = Relative value as compared to control.
L.S.D. at 5%: For Cultivars = 10.36
For Salinity levels = 10.57

Most of the cultivars did not differ among themselves in their calcium contents at all levels of salinity. However there was a substantial decrease in calcium contents of all the barley cultivars as the rootzone salinity increased from 3 to 20 mS cm^{-1}. A significant negative correlation was found between the rootzone salinity and the calcium contents of all the barley cultivars tested. Similar results were reported by Niazi *et al.* (1984) in Ipil-Ipil (*Leucaena leucocephela*) cv. K-8.

Table 7. Effect of rootzone salinity on potassium content (mg 100 g^{-1}) of barley cultivars.

Cultivars	Salinity (mS cm^{-1})				
	3 (Control)	5	10	15	20
PK-30130	156.5	130.8	83.5	77.5	59.5
PK-30136	156.0	134.5	90.1	79.0	62.5
PK-30118	199.3	147.0	94.3	80.5	70.0
PK-30139	151.0	94.4	86.5	71.5	67.0
PK-30148	175.5	145.0	86.5	73.0	67.0
PK-30172	160.0	134.5	91.0	71.5	64.0
PK-30163	149.5	127.5	83.5	77.5	67.0
PK-30055	180.0	135.0	112.0	88.7	70.0
PK-30109	160.5	165.0	123.8	94.3	70.0
PK-30166	175.0	170.0	101.0	89.1	71.5
PK-30046	181.0	132.0	87.0	77.5	73.0
PK-30175	163.0	147.0	98.0	92.4	70.0

L.S.D. at 5%: For Cultivars = 12.84 For Salinity levels = 10.18

Table 8. Effect of rootzone salinity on calcium content (mg 100 g^{-1}) of barley cultivars.

Cultivars	Salinity (mS cm^{-1})				
	3 (Control)	5	10	15	20
PK-30130	37.5	33.8	29.4	22.5	13.1
PK-30136	37.5	41.3	26.3	21.9	15.6
PK-30118	35.0	32.5	26.9	25.0	15.0
PK-30139	30.0	22.5	23.1	17.5	14.4
PK-30148	38.8	35.0	24.4	20.6	15.6
PK-30172	31.3	27.5	26.9	24.4	15.6
PK-30163	26.3	20.0	21.3	18.1	13.1
PK-30055	35.0	27.5	27.5	23.1	16.3
PK-30109	26.3	35.0	31.9	21.3	16.9
PK-30166	38.3	38.8	32.5	20.0	17.5
PK-30046	37.5	31.3	26.9	21.3	16.9
PK-30175	36.3	42.5	26.3	20.0	15.0

L.S.D. at 5%: For Cultivars = 3.21 For Salinity levels = 5.15

Results obtained from the investigation have shown that first six cultivars of barley (Table 4) are reasonably salt tolerant. These cultivars may be used as secondary colonizers in a plant succession scheme (Sandhu & Malik, 1975; Malik, 1978; Naqvi, 1983) for economical utilization of salt-affected soils. Further, this germplasm can also be utilized in programme of breeding for salt tolerance.

References

Anonymous. 1954. Diagnosis and improvement of saline and alkali soils. USDA Hadbook No. 60. U.S. Govt. Printing Office, Washington, D.C., pp. 160.

Arnon, D.I. and D.R. Hoagland. 1940. Crop production in artificial culture solutions and in soil with special reference to factors influencing yields and absorption of inorganic nutrients. *Soil Sci.*, 50: 463-483.

Ayers, A.D., J.W. Brown and C.H. Wadleigh. 1952. Salt tolerance of barley and wheat in soil pots receiving several salinization regimes. *Agron. J.*, 44: 307-310.

Bhatti, A.S., G. Sarwar, K.H. Sheikh, M. Hanif and M. Sharif. 1976. Effects of sodium chloride on the growth and ion content of barley. *Pak. J. Sci. Ind. Res.*, 19: 190-192.

Bower, C.A. and Y.N. Tamimi. 1979. Root adjustments associated with salt tolerance in small grains. *Agron. J.*, 71: 690-693.

Dregne, H.E. and H. Mojallali. 1968. Salt fertilizer specific ion interactions in soil. *New Mex. Agr. Exp. Sta. Bull.* 541. 16 p.

Epstein, E. and J.D. Norlyn. 1977. Sea water-based production; a feasibility study. *Science*, 197: 249-251.

Francois, L.E., T. Donowan and E.V. Maas. 1984. Salinity effects on seed yield, growth and germination of grain sorghum. *Agron. J.*, 76: 741-744.

Greenway, H. 1962. Plant response to saline substrates. Growth and ion uptake of several varieties of *Hordeum vulgare* during and after sodium chloride treatment. *Aust. J. Biol. Sci.*, 15: 16-38.

Hassan, N.A.K., V.D. James, D. Kundsen and R.A. Olsen. 1970. Influence of soil salinity on production of dry matter and uptake and distribution of nutrients in barley and corn: I. Barley (*Hordeum vulgare* L.) II. Corn. (*Zea mays* L.). *Agron. J.*, 62: 43-48.

Kingsbury, R.W. and E. Epstein. 1984. Selection for salt resistant spring wheat. *Crop Sci.*, 24: 310-315.

Lynch, J. and A. Lauchli. 1984. Potassium transport in salt-affected barley (*Hordeum vulgare*) roots. *Planta* (Berl.) 161: 295-301.

Malik, K.A. 1978. Biological methods of reclamation of salt-affected soils. In: "Technology for increasing production". (Ed.) J.C. Holmes; Proc. 2nd FAO/SIDA Seminar on Field Food Crops in Africa and near East, Lahore, Pakistan. Sept. 18 – Oct. 5, 1977, pp. 207-219.

Naqvi, S.H.M. 1983. Saline sodic soils and their management in Pakistan. Proc. Symp. Isotope and Radiation Techniques in Soil Physics and Irrigation Studies, IAEA, Vienna, pp. 207-219.

Niazi, M.L.K., M.I. Haq and K.A. Malik. 1985. Salt tolerance stuidies on Ipil-Ipil (*Leucaena leucocephela* L.) cv. K-8. *Pak. J. Bot.*, 17: 43-47.

Nobel, C.L., G.M. Halloran and D.W. West. 1984. Identification and selection for salt tolerance in lucerne (*Medicago sativa*). *Aust. J. Agric. Res.*, 35: 239-252.

Norlyn, J.D. and E. Epstein. 1982. Barley production: Irrigation with sea water on coastal soil. pp. 525-529. In A. San Pietro (Ed.) Biosaline Research: A look to the future. Plenum Press, New York.

Qureshi, R.H., M. Salim, Z. Aslam and G.R. Sandhu. 1977. An improved gravel culture technique for salt tolerance studies on plants. *Pak. J. Agri. Sci.*, 14: 11-18.

Russel, J.S. 1976. Comparative salt tolerance of some tropical and temperate legumes and tropical grasses. *Aust. J. Expt. Agric. and Animal Husbandry*, 16: 103-109.

Sandhu, G.R. and K.A. Malik. 1975. Plant Succession. A key to the utilization of saline soils. *Nucleus*, 12: 35-38.

Scott, S.J., R.A. Jones and W.A. Williams. 1984. Review of data analysis methods for seed germination. *Crop Sci.*, 24: 1192-1199.

Torello, W.A. and A.G. Symington. 1984. Screening of turfgrass species and cultivars for NaCl tolerance. *Plant and Soil*, 82: 155-161.

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