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IDENTIFICATION OF SALT TOLERANT BARLEY GENOTYPES FOR COASTAL REGION OF BANGLADESH

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Abstract

Identification of salt tolerant barley (*Hordeum vulgare* L.) genotypes and effects of different levels of salinity on their growth, grain development and yield were studied. One hundred and eighty nine barley germplasms were subjected in five levels of NaCl concentration which were equivalent to Electrical Conductivity (EC) of 0, 10, 15, 20 and 25 ds/m. Among the genotypes 39 proved to be saline tolerant at 15 ds/m of salinity. Out of 39 genotypes, 33 were evaluated at Sonagazi and Patuakhali salt area of Bangladesh. All the genotypes were evaluated in the non-saline area at BARI, Gazipur to observe their performance in normal soil. Highest grain yield was recorded from the genotypes BSH-32 and BSH-142 over the three locations. Significantly higher yield was recorded from the experimental site of Gazipur followed by Patuakhali and Sonagazi. Tiller per plant had positive correlation with grain per spike, maturity and grain yield. Grain per spike and maturity was positively correlated with grain yield. From the multivariate analysis it appears that 1st, 2nd and 3rd principal components together account for 79 per cent of the total experimental variation. The two selected genotypes are expected to be released for commercial cultivation in the saline area of Bangladesh.

Introduction

Soil salinity is a major factor limiting plant productivity, affecting about 95 million hectares world-wide (Szabolcs 1994). The UNEP (United Nations Environment Program) estimates that 20% of the agricultural land and 50% of the cropland in the world is salt stressed (Flowers and Yeo 1995). Salinity imposes serious environmental problems that affect grassland cover and the availability of animal feed in arid and semi-arid region (El-Kharbotly *et al.* 2003). In Bangladesh, saline soils occur mainly along the coastal areas of the southern part of the country. The total saline area of the country is about 0.88 million hectares (MPO 1985) of which more than 0.36 million hectares is in Khulna, 0.22 million hectares in Patuakhali and 0.11 million hectares in Chittagong region and 0.17 million hectares in Barisal and Noakhali region. Salinity levels vary in different months of the year. Maximum salinity occurs in the months of March-April, the peak dry season, and minimum in the months of July-August after the onset of monsoon rain (BARI Annual Report 1991-'92).

Several methods are used to reduce the soil salinity, such as reclamation, irrigation and drainage. Salt tolerant cereals with better adaptability and land management technologies offer more opportunities for increasing crop production. Breeding for salt tolerance is difficult because the tolerance depends on water regime, temperature and the developmental stage of plant (Ikehashi 1981). Therefore, not only the genetics of salt tolerance, but also the physiological and cultural manipulation aspects of salinity are needed. Although, breeding efforts for salinity tolerance has been done, they have not yet been fully successful. Several authors reported the presence of considerable genetic variation in salinity tolerance among barley varieties (Hunshai *et al.* 1990, Duczek 1993, Karim *et al.* 1994 and Papa 1994). Therefore, it may be possible to improve tolerance to salinity by adopting various breeding methods and cultural manipulation of soils.

Little is known about the genetic basis of salt tolerance in winter cereals, because plant response to salinity stress is complex and considerably influenced by the environment. Salt tolerance is believed to be controlled by a large number of polygenes (Hansen 1995, Tal 1985, Blum 1988). Many authors have reported successful screening of barley and wheat germplasm for

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salt tolerance (Jana *et al.* 1983, Srivastava and Jana 1984). It is essential, however, to determine efficient selection criteria to exploit genetic diversity in breeding material. The progress in breeding for salt tolerance is hampered not so much by the lack of diversity in the target species for the lack of appropriate procedures to exploit this diversity. The present study was conducted to find out the salt tolerance barley genotypes and the effect of different levels of salinity on the growth, grain development and yield.

Materials and Methods

The study was conducted using 189 Barley (*Hordeum vulgare* L.) germplasms at BARI, Gazipur. Five levels of NaCl concentration which were equivalent to EC of 0, 10, 15, 20 and 25 ds/m were used in the experiment. One hundred seeds of each entry were germinated for all the treatments. Germination percentage at 15 ds/m used to characterize the degree of tolerance where 0-20 (highly susceptible = HS), 21-40 (susceptible = S), 41-60 (moderate = M), 61-80 (tolerant = T) and 81-100 (highly tolerant = HT).

Field experiments were conducted at BARI, Gazipur (a non-saline area), and Potuakhali, Noakhali, Khulna (saline areas) in the year 2002-2003 barley growing season. In all the locations experiment was carried out in a Randomized Complete Block Design with three replications. Each entry was sown continuously in a row of 2.5 m long with a spacing of 30 cm between rows. NPK fertilizers at the rate of 100: 60: 40 kg/ha were applied. Soil salinity was measured monthly from three random samples of each field in the top 0-15 cm soils during cropping season. Electrical conductivity in soil solution was measured using conductivity bridge (model- EIJKLKAMP pH/EC 18.38).

Results and Discussion

Considerable variation among the genotypes in response to salinity was observed for germination percentage. Among the genotypes No. 22 was identified as tolerant and No. 17 as highly tolerant. Germination was greatly reduced at the highest level of salt concentration (25 ds/m). Highest (81.7%) germination was recorded from non saline condition (0 ds/m) and lowest (28.73%) at 25 ds/m of salinity (Table 1). These results were in agreement with Othman *et al.* (2006), as they reported that seed germination decreased significantly by increasing salinity level. Basalah (1991) found that highest levels of soil salinity can significantly inhibit seed germination. Salt induced inhibition of seed germination could be attributed to osmotic stress or specific ion toxicity (Huang and Redmann 1995).

Table 1. Germination percentage of 189 barley lines under different Electrical Conductivity (ds/m).

EC	0	10	15	20	25
Mean	81.7	53.54	37.32	33.23	28.73
Range	60-100	0-100	0-100	0-100	0-100
Sd	10.81	32.48	33.21	41.41	29.45

Soil salinity was low in the experimental sites during the time of sowing (3.2-4.9 ds/m). However, commencing from January, EC started to increase and reached the peak of 12-13.3 ds/m at the time of harvesting. EC had reciprocal relationship with rainfall. Rainfall and temperature are the key factors, which influence intensities of soil salinity (Hoque 1998 and Husain *et al*. 1999).

At Sonagazi and Patuakhali saline area, significantly higher grain yield was recorded from six genotypes, BSH-2, BSH-32, BSH-141, BSH-142 and BSHL-6 (Table 2). A hull-less genotype BSHL-2 also showed significantly higher yield than the other genotypes at Patuakhali multilocation testing site. Highest grain yield was recorded from the genotypes BSH 32, BSH 142, BSH 141 at Gazipur. At Sonagazi BSH 141, BSH 142, BSHL 6 and at Patuakhali BSH 2, BSH 32, BSH 141 gave considerably high yield (Table 2).

Table 2. Performance of 33 barley lines at three locations of Bangladesh.

Sl. No.	Entry	Plant height (cm)			Tiller/ plant (No.)			Spike length (cm)			Yield/ plant (g)		
		L_1	L_2	L_3	L_1	L_2	L_3	L_1	L_2	L_3	L_1	L_2	L_3
1	BSH-1	62 c-h	65 b-e	94 a-h	3b	3 a-c	5 ab	9 ab	9 b-c	8 de	5.90 de	5.67 bc	8.33 a-f
2	BSH-2	70 b	70 a-d	94 a-h	4a	3 a-c	5 ab	10 ab	10 ab	9 b-e	6.20 b-d	6.53 a	8.40 a-e
3	BSH-3	50 k	54 fg	84 hi	2b	2c	6 a	9 ab	9 bc	9 b-e	5.20 f-i	5.23 cd	7.17 d-h
4	BSH-4	58 f-j	57 e-g	87 e-i	3b	3 a-c	6 a	9 ab	9 bc	9 b-e	4.50 j-m	4.23 f-h	8.23 a-g
5	BSH-5	63 b-g	56 e-g	99 a-d	2b	2c	5 ab	9 ab	9 bc	8 de	3.30 q	4.47 d-g	6.83 e-h
6	BSH-7	54 i-k	57 e-g	104 ab	3b	2c	5 ab	9 ab	8 d	9 b-e	4.80 i-l	4.50 d-f	6.17 g-h
7	BSH-9	63 b-g	57 e-g	100 a-c	2b	2c	5 ab	9 ab	89 bc	8 b-e	4.90 h-k	4.40 e-h	7.23 c-h
8	BSH-30	52 j-k	55 e-g	97 a-g	3b	2c	4 b	9 ab	9 bc	8 b-e	4.00 n-p	4.17 f-h	6.73 e-h
9	BSH-32	77a	76 a	97 a-g	3b	3 a-c	6 a	10 ab	10 ab	8 b-e	6.40 a-c	6.50 a	9.73 a
10	BSH-33	65 b-f	63 c-f	85 g-i	2b	2c	6 a	9 ab	9 bc	8 b-e	4.20m-o	4.23 f-h	8.10 a-g
11	BSH-34	62 c-h	59 e-g	85 g-i	3b	2c	6 a	9 ab	9 bc	8 b-e	4.60 j-m	4.37 e-h	7.36 c-h
12	BSH-36	69 bc	62 c-g	100 a-c	2b	2c	5 ab	10 ab	9 bc	8 b-e	3.90 op	3.67 h	7.20 c-g
13	BSH-37	63 b-g	58 e-g	105 a	3b	2c	5 ab	8 b	8 c	8 b-e	5.00 g-m	5.23 cd	6.73 e-h
14	BSH-38	54 i-k	56 e-g	93 b-i	2b	2c	5 ab	8 b	8 c	7 e	5.40 f-h	5.20 cd	6.23 f-g
15	BSH-46	63 b-g	56 e-g	88 d-i	2b	2c	4 b	9 ab	9 bc	8 de	3.60 pq	3.90 f-h	7.13 d-h
16	BSH-47	65 b-f	65 b-e	84 h-i	2b	2c	5 ab	9 ab	9 bc	8 de	4.20 m-o	3.80 f-h	6.33 e-h
17	BSH-59	61 d-i	62 c-g	90 c-i	3b	2c	5 ab	10 ab	9 bc	9 b-e	3.80 op	3.70 gh	5.67 h
18	BSH-89	58 f-i	60 d-g	91 c-i	2b	2c	5 ab	9 ab	9bc	9 b-e	5.00 h-j	5.20 cd	7.00 e-h
19	BSH-112	62 c-h	57 e-g	98 a-e	2b	2c	5 ab	9 ab	9 bc	9 b-e	5.60 ef	5.37 c	7.23 c-h
20	BSH-127	66 b-e	63 c-g	86 e-i	2b	2c	5 ab	9 ab	9 bc	10 ab	5.00 h-j	5.17 cd	6.73 e-h
21	BSH-130	65 b-f	58 e-g	81 i	2b	2c	4 b	9 ab	9bc	11 a	5.10 g0i	5.10 c-e	6.60 e-h
22	BSH-133	58 f-j	55 e-g	86 f-i	3b	2c	4 b	9 ab	9 bc	10 ab	5.50 e-g	5.20 cd	7.00 e-h
23	BSH-141	69 bc	74 ab	85 g-i	4a	4a	4 b	10 ab	10 ab	9 b-e	6.70 a	6.40 a	9.60 ab
24	BSH-142	80 a	74 ab	86 f-i	4a	4a	4 b	11 a	11a	8 de	6.50 a-c	6.30 ab	9.70 a
25	BSH-144	57 g-k	57 e-g	87 e-i	2b	2c	4 b	9 ab	8 c	10 ab	5.50 f-g	5.23 cd	7.67 a
26	BSH-145	68 b-d	65 b-e	103 ab	2b	2c	5 ab	9 ab	9 bc	10 ab	4.90 i-k	4.47 d-g	6.43 e-h
27	BSH-147	52 jk	57 e-g	87 e-i	3b	2c	5 ab	9 ab	10 ab	10 ab	5.20 f-i	5.33 c	6.37 e-h
28	BSHL-1	55 h-k	57 e-g	97 a-g	2b	2c	5 ab	10 ab	10 ab	8 de	4.50 k-m	4.33 f-h	6.73 e-h
29	BSHL-2	62 c-h	64 b-f	95 a-h	4a	4a	5 ab	10 ab	10 ab	11 a	6.10 cd	6.13 ab	9.27 a-c
30	BSHL-4	55 h-k	53 g	85 g-i	2b	2c	6 a	9 ab	10 ab	10 ab	4.50 j-m	4.7 f-h	7.37 c-h
31	BSHL-5	59 e-j	58 e-g	87 e-i	3b	2c	4 b	9 ab	9 bc	9 b-e	4.40 l-n	4.50 d-f	6.67 e-h
32	BSHL-6	65 b-f	64 b-f	87 e-i	3b	3 a-c	4 b	10 ab	10 ab	9 b-e	6.60 ab	6.30 ab	9.20 a-d
33	BSHL-1	70 b	71 a-c	95 a-h	2b	2c	5 ab	9 ab	9 bc	9 b-e	4.20 m-o	4.17 f-h	7.30 c-h
	CV(%)	4.78	6.55	4.91	21.14	18.27	18.03	11.38	5.22	7.85	4.41	6.24	10.89

Mean separation by DMRT, $p = 0.01$. Values followed by same letters do not differ significantly at 1% level.
L_1 = Sonagazi (saline area), L_2 = Patuakhali (saline area), L_3 = Gazipur (non saline area).

When performance of all the 33 genotypes were taken into consideration significant higher yield was recorded from the experimental site of Gazipur followed by Patuakhali and Sonagazi saline area (Table 3). Among the genotypes, different responses to salinity were found, which were partially related to genotypic affect or salt exclusion. The data indicated that adapted genotypes could be used for studying the processes related to salt tolerance as well as for practical breeding for tolerance of saline soils.

Correlation analyses for yield and yield contributing characters were studied. Grain yield was dependent and others were independent variables. Plant height was positively correlated with tiller per plant, spike length, grain per spike, maturity and grain yield. Tiller per plant had positive correlation with grain per spike, maturity and grain yield. Grain per spike and maturity was positively correlated with grain yield (Table 4).

The co-efficient of 1st four principal components are presented in Table 5. Yield and yield contributing characters were studied in the experiment, 1st (Z_1), 2nd (Z_2) and 3rd (Z_3) principal components together account for 79 per cent of the total experimental variation, which is more than 3/4 of the total variation. This value may be considered sufficient for many purposes, so that first three principal components may bring out the essential characteristics of the multivariate system. Adding 4th principal component increases the attributable variation to 87 per cent.

Table 3. Performance of 33 barley genotypes over the locations.

Location	Plant height (cm)	Tiller/plant (no.)	Spike length (cm)	Yield/plant (g)	Yield/m^2 (g)
Sonagazi	63.24 b	1.9 c	7.6 c	4.61 b	137.7 b
Patuakhali	61.16 c	2.5 b	9.30 a	4.95 b	140.4 b
Gazipur	91.62 a	4.9 a	8.9 b	7.41 a	156.3 a
CV(%)	5.41	20.03	8.14	9.12	4.63

Table 4. Correlation among yield and yield contributing characters.

Characters	Plant height (cm)	Tiller/plant (No.)	Spike length (cm)	Grain/spike (No.)	Maturity (day)	Yield/m^2 (g)
Plant height (cm)		0.38**	0.72**	0.65**	0.75**	0.52**
Tiller/plant (cm)			0.15	0.47**	0.34**	0.33**
Spike/length (cm)				0.54**	0.57**	0.40**
Grain/spike (No.)					0.57**	0.60**
Maturity (day)						0.50**
Yield/m^2 (g)						

Table 5. Latent vectors of first four principal components.

Indicators	Z_1	Z_2	Z_3	Z_4
Plant height (cm)	0.466	0.001	– 0.210	0.239
Tiller/plant (cm)	0.275	– 0.397	0.698	0.407
Spike/length (cm)	0.393	0.081	– 0.525	0.234
Grain/spike (No.)	0.437	– 0.213	0.075	– 0.134
Maturity (day)	0.440	0.216	– 0.045	0.147
Yield/m^2 (g)	0.379	– 0.160	0.084	– 0.824
% cumulative variation	51.919	66.223	79.011	87.446
Per cent variation	51.919	14.304	12.787	8.436
Latent roots	3.634	1.001	0.895	0.591

The first principal component Z_1 = 0.466 (plant height) + 0.275 (tiller/plant) + 0.393 (spike length) + 0.437 (grain/spike) + 0.440 (maturity) + 0.379 (grain yield) accounts for close to 52 per cent of the total variation. From the latent root of the 1st (3.634), 2nd (1.001) and 3rd principal component (0.895), it was concluded that the highest contribution was from the 1st and 2nd principal components (Table 5).

It appears that selection for the improvement of grain yield in barley can be made based mainly on grain per spike, plant height and spike length. The highest grain yield over the locations was recorded from advanced lines BSH-32 and BSH-142, which may be released as varieties for commercial cultivation in saline soils of Bangladesh.

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