Responses of Wheat Genotypes to Salt Stress in Relation to Germination and Seedling Growth

M. Khatun[1], M. H. R. Hafiz[1*], M. A. Hasan[1], M. A. Hakim[2] and M. N. Siddiqui[3]

[1]Department of Crop Physiology and Ecology, Hajee Mohammad Danesh Science and Technology University, Dinajpur (5200), Bangladesh
[2]Wheat Research Centre, Nashipur, Dinajpur, Bangladesh
[3]Department of Biochemistry & Molecular Biology, Bangabandhu Sheikh Mujibur Rahman Agricultural University, Gazipur (1706), Bangladesh

Article History

Manuscript No. 418
Received in 18th July, 2013
Received in revised form 8th November, 2013
Accepted in final form 4th December, 2013

Correspondence to

*E-mail: hafizhstu@hotmail.com

Keywords

Wheat genotypes, salinity, germination, seedling growth, STI

Abstract

To evaluate germination characters and seedling growth of wheat as screening criteria against salt stress, twenty wheat genotypes were tested at crop physiology and ecology Laboratory, Hajee Mohammad Danesh Science and Technology University (HSTU), Dinajpur during October to November 2010. Speed of germination as expressed by rate of germination, co-efficient of germination and germination vigor index of all wheat genotypes was delayed due to salinization compared to control but the degree of reduction in all the three parameters from control to 12 dS m^{-1} salinity level was not similar for all wheat genotypes. Shoot length and root length of 10 days old seedlings were found to be affected due to salinization and the increment in root to shoot length ratio at saline condition indicated shoot was more affected than root in saline condition. The magnitude of variation in all the four parameters from control to 12 dSm^{-1} salinity level was not similar for all wheat genotypes. Salt tolerance index (STI) based on seedling dry weight (10 days old) indicated a wide difference in salt tolerance among the wheat genotypes. Shatabdi, BAW 1135 and Bijoy showed more than 0.6 STI value, the wheat genotypes BARI Gom 26, BAW 1122 and BAW 1148 provided less than 0.4 STI value and the other wheat genotypes (Prodip, BARI Gom 25, BAW 1111, BAW 1118, BAW 1130, BAW 1138, BAW 1140, BAW 1142, BAW 1143, BAW 1146, BAW 1147, BAW 1150, Sonora and BAW1153) showed 0.4 to 0.6 STI value.

1. Introduction

Among various environmental stresses, soil salinity has become a critical problem worldwide due to its dramatic effects on plant physiology and performance. Over 400 mha of land across the world are affected by salinity that is about 25% of the world's total area including 950,780 hectares of Bangladesh's lands (Ghassemi et al., 1995). The areas affected by salinity and the salinity level in the coastal region have been increasing significantly over the recent years due to rise in the sea level caused by global warming. A study showed that the salt-affected areas in the coastal region of Bangladesh increased sharply, by 26.71%, to 950,780 hectares in 2009 from 750, 350 hectares in 1973 (Ali, 2011).

Wheat, the second most important cereal in Bangladesh, is mainly cultivated in the north and north-west part of Bangladesh. A vast area of cultivable land of the coastal region remains fallow (seasonal or complete) and the dominant cropping pattern of there is fallow-aman-fallow. Introduction of wheat into the existing cropping pattern in the saline soil may become a worthy effort to utilize these lands to meet up the food and nutritional deficit of the ever increasing population of Bangladesh. So, selection of wheat genotypes tolerant to salinity may be a feasible and economical approach for utilizing salt affected soil.

Salinity delays the onset, reduces the rate and increases the dispersion of germination events, resulting in reduced plant growth and final crop yield (Ashraf and Foolad 2005). Soil salinity may affect the germination of seeds either by creating osmotic potential external to the seeds preventing water uptake or through the toxic effects of Na^+ and Cl^- ions on germinating seed (Khajeh-Hosseini et al., 2003). Salinity changes the morphology, physiology and metabolism of plants (Rhoades 1993), ultimately diminishing growth and yield (Ashraf and Harris 2004). The varietal differences in salinity tolerance that exist among crop plants can be utilized through screening programs by exploiting appropriate traits for salt tolerance (Kingsbury et al., 1984). Grain yield is frequently used in crops such as wheat as the main criteria for salt tolerance (Jafari-Shabestari et al., 1995). Other agronomic traits such as number of tiller, fertile tillers with other indices have been used for the assessment of salt tolerance. Separately, Flowers and Yeo (1995) reported that these parameters are not satisfying for selecting genotypes resistant to salinity Also the use of only physiological markers such as content of Na^+, K^+ the ratio of K^+:Na^+ and the proline accumulation pattern are less feasible and in the view of some researchers are not promising (Shannon 1984). The use of physiological tolerance along with agronomic traits has been shown to be applicable and their relationship with salt tolerance indices are considered strong enough to be exploited as a selection tool in the breeding of salt tolerance cultivars (Allakhverdiev et al., 2000). Therefore, to expand wheat cultivation and to sustain wheat yield under coastal saline area the present investigation was carried out to evaluate germination characters and seedling growth of wheat as screening criteria against salt stress.

2. Materials and Methods

The experiment was conducted at Crop Physiology and Ecology Laboratory, Hajee Mohammad Danesh Science and Technology University (HSTU), Dinajpur during the period from October to November 2010. The experiment was carried out in two factors completely randomized design with three replications.

The treatment factors A and B were -
A. Two salinity levels (Control and 12 dS m^{-1})
B. Twenty wheat genotypes
Twenty wheat genotypes (Table 1) including six varieties and fourteen advanced lines collected from Wheat Research Centre (WRC) of BARI, Dinajpur were used for the present study.

2.1. Placement of seed for germination

Seeds of twenty wheat genotypes collected from Wheat Research Centre (WRC) of BARI, Dinajpur, Bangladesh were surface sterilized by dipping the seeds in 1% mercuric chloride solution for 2 minutes and rinsed thoroughly with sterilized water. Saline solution (12 dS m^{-1}) was prepared dissolving calculated amount of NaCl in tap water. Tap water was used as control. 30 seeds of each genotype were placed in petridish (9 cm diameter) on sand bed irrigated with saline and control solution as per treatment and were kept at room temperature. The petridishes were irrigated daily with required amount of solution. For each salinity levels, three batches of petridishes were used.

2.2. Data recorded on germination characters

Germination was counted at 24 hour interval and continued upto 5^{th} day (120 h). A seed was considered germinated as plumule and radicle came out and were >2 mm long.

The rate of germination was calculated following Krishnasamy and Seshu (1990)

Co-efficient of germination and vigor index were calculated using the following formulae (Copeland 1976).

$$\text{Rate of germination (\%)} = \frac{\text{No. of seeds germinated at 48 h}}{\text{No. of seeds germinated at 120 h}} \times 100$$

$$\text{Co-efficient of germination (\%)} = \frac{100\,(A_1 \pm A_2 + \text{----} + A_n)}{A_1 T_1 + A_2 T_2 + \text{------} A_n T_n} \times 100$$

$$\text{Vigor index (\%)} = \frac{A_1}{T_1} + \frac{A_2}{T_2} + \frac{A_n}{T_n}$$

Where,

A=Number of seeds germinated,
T=Time (days) corresponding to A,
n=No. of days to final count

2.3. Data recorded on shoot length and root length

At 5^{th} day after placement for germination, all other seedlings were removed from each petridish keeping 10 healthy seedlings and allowed to grow upto 10 days by adding required amount of respective solution daily. At 10 days after placement for germination, five seedlings from each petridish were sampled. Shoot and root length of individual seedling were recorded

Table 1: List of wheat genotypes used for the present study

Sl. No.	Genotypes	Remarks
1.	Shatabdi	Variety
2.	Prodip	Variety
3.	BARI Gom 25	Variety
4.	BARI Gom 26	Variety
5.	BAW 1111	Advanced line
6.	BAW 1118	Advanced line
7.	BAW 1130	Advanced line
8.	BAW 1135	Advanced line
9.	BAW 1138	Advanced line
10.	BAW 1140	Advanced line
11.	BAW 1122	Advanced line
12.	BAW 1142	Advanced line
13.	BAW 1143	Advanced line
14.	BAW 1146	Advanced line
15.	BAW 1147	Advanced line
16.	BAW 1148	Advanced line
17.	Bijoy	Variety
18.	BAW 1150	Advanced line
19.	Sonora	Variety
20.	BAW 1153	Advanced line

manually with scale.

2.4. Salt tolerance index (STI)

Salt tolerance index was calculated as (Goudarzi and Pakniyat, 2008) by the following formula-

$$\text{Salt tolerance index} = \frac{\text{Variable measured under stress condition}}{\text{Variable measured under normal condition}}$$

2.5. Statistical analysis

The data were analyzed by partitioning the total variance with the help of computer using MSTAT program. The treatment means were compared using Duncan's Multiple Range Test.

3. Results and Discussion

The results of the present study have been presented in Tables 2 and 3 and figure 1.

3.1. Germination Characters

3.1.1. Rate of germination

Rate of germination was significantly influenced by the interaction effect of salinity level and wheat genotypes during germination (Table 2). Rate of germination was significantly higher at control, with a range from 89.20 in BAW 1150 and Sonora to 100.00 in BAW 1143 and a mean of 95.17 compared to that at 12 dS m^{-1} salinity level (with a range from 19.80 in BAW 1153 to 98.73 in BARI Gom 25 and a mean of 77.88) except BAW 1135 in which the rate of germination was even increased.

3.1.2. Co-efficient of germination

Co-efficient of germination was significantly influenced by the interaction effect of salinity level and wheat genotypes during germination (Table 2). Co-efficient of germination was found to be higher at control, with a range from 24.79 in BAW 1150 to 27.42 in Shatabdi and a mean of 25.55 compared to that at 12dS m^{-1} salinity level (with a range from 22.82 in BAW 1153 to 25.39 in BAW 1130 and a mean of 24.44). But the degree of reduction in co-efficient of germination from control to 12 dS m^{-1} salinity level was not similar for all wheat genotypes.

3.1.3. Germination vigor index

Salinity level interacted significantly wheat genotypes to influence germination vigor index which expressed the speed of germination (Table 2). Germination vigor index was found higher at control, with a range from 35.34 in Bijoy to 55.05 in BAW 1143 and a mean of 45.14 compared to that at 12dS m^{-1}

Table 2: Rate of germination, co-efficient of germination and germination vigor index of different wheat genotypes as influenced by salt stress

Gonotypes	Rate of germination		Co-efficient of germination		Germination vigor index	
	Control	Saline (12 dS m^{-1})	Control	Saline (12 dS m^{-1})	Control	Saline (12 dS m^{-1})
Shatabdi	98.87^{a}	85.27^{bg}	27.42^{a}	24.92^{ei}	47.00^{bf}	41.03^{gj}
Prodip	97.73^{ab}	85.53^{bg}	25.15^{di}	24.74^{gi}	44.83^{ch}	41.33^{fi}
BARI Gom 25	98.87^{a}	98.73^{a}	25.79^{bf}	25.09^{ei}	50.00^{bc}	40.95^{gj}
BARI Gom 26	94.37^{ad}	69.33^{h}	24.98^{ei}	24.17^{ij}	42.53^{eh}	34.72^{kl}
BAW 1111	97.73^{ab}	96.57^{ac}	25.54^{cg}	24.90^{ei}	47.84^{be}	42.52^{eh}
BAW 1118	97.70^{ab}	93.10^{ae}	25.26^{ch}	24.87^{ei}	42.52^{eh}	41.38^{fi}
BAW 1130	91.87^{ae}	91.77^{ae}	26.13^{bd}	25.39^{ch}	47.84^{be}	39.39^{hk}
BAW 1135	91.07^{af}	91.87^{ae}	25.22^{ch}	24.88e^{i}	43.46^{dh}	41.07^{gj}
BAW 1138	95.50^{ad}	84.07^{cg}	25.06^{ei}	24.59^{gi}	43.20^{dh}	40.20^{gk}
BAW 1140	93.23^{ae}	73.33^{gh}	25.17^{ci}	23.63^{jk}	44.39^{ch}	43.07^{dh}
BAW 1122	90.93^{af}	78.90^{fg}	25.82^{be}	24.49^{hj}	49.76^{bc}	38.99^{hk}
BAW 1142	97.70^{ab}	95.47^{ad}	26.16^{bc}	24.90^{ei}	52.49^{ab}	42.46^{eh}
BAW 1143	100.00^{a}	91.10^{af}	26.64^{ab}	24.80^{fi}	55.05^{a}	43.27^{dh}
BAW 1146	96.63^{ac}	94.13^{ad}	25.23^{ch}	24.76^{gi}	45.47^{cg}	40.73^{gj}
BAW 1147	95.50^{ad}	82.77^{dg}	25.57^{cg}	24.54^{gi}	48.39^{bd}	39.44^{hk}
BAW 1148	98.83^{a}	83.73^{cg}	25.56^{cg}	24.58^{gi}	39.03^{hk}	39.03^{hk}
Bijoy	93.07^{ae}	28.77^{ij}	24.97^{ei}	23.08^{k}	35.34^{jl}	29.48^{m}
BAW 1150	89.20^{af}	32.43^{i}	24.79^{fi}	23.16^{k}	35.87^{il}	30.71^{lm}
Sonora	89.20^{af}	80.97^{eg}	25.30^{ch}	24.46^{hj}	42.84^{dh}	42.00^{eh}
BAW 1153	95.40^{ad}	19.80^{j}	25.25^{ch}	22.82^{k}	44.89^{ch}	29.29^{m}

Values having same letter(s) do not differ significantly by DMRT at 5% level

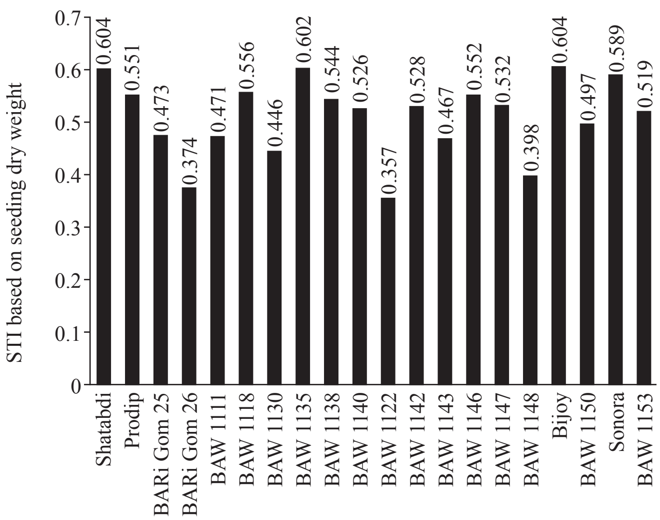

Figure 1: Salt tolerance index (STI) based on dry weight of 10 days old seedling of different wheat genotypes.

salinity level (with a range from 29.29 in BAW 1153 to 43.27 in BAW 1143 and a mean of 39.05) except BAW 1148 in which reduction in germination vigor index was not found. But the magnitude of reduction in germination vigor index from control to 12 dS m^{-1} salinity level was not equal for all wheat genotypes. Among the wheat genotypes, BARI Gom 25, BARI Gom 26, BAW 1135, BAW 1122, BAW 1142, BAW 1143, BAW 1147, Bijoy, BAW 1153 showed more than 15% reduction. Whereas, Prodip, BAW 1118, BAW 1135, BAW 1138, BAW 1140 and Sonora less than 10% reduction in germination vigor index. The other four wheat genotypes (Shatabdi, BAW 1111, BAW 1146 and BAW 1150) affected moderately in germination vigor index due to salt stress.

Decrease and delay in germination in saline medium has also been reported by Rahman et al. (2000), Mirza and Mahmood (1986), Mujeeb-ur-Rahman et al. (2008), Singh et al. (2000), Akbarimoghaddam et al. (2011) and Datta et al. (2009). Salinity affects germination in two ways: there may be enough salt in the medium decrease the osmotic potential to such a point which retard or prevent the uptake of water necessary for mobilization of nutrient required for germination and the salt constituents or ions may be toxic to the embryo (Mujeeb-ur-Rahman et al. 2008). Physiologically absolute ratio of K/Na in the tissue is important. The increase in salinity shortened this ratio (Cramer et al. 1994) and probably caused injury to embryo. In the present study, differential sensitivity was also found among the wheat genotypes tested during germination. Mujeeb-ur-Rahman et al. (2008), Datta et al. (2009) and Singh et al. (2000) also found differential sensitivity of wheat genotypes during germination in their studies. George and William (1964) have the opinion that greater tolerance to salinity during germination is associated with lower respiration rates and greater reserve of respiratory substances.

3.2. Seedling growth

3.2.1. Shoot length

Shoot length of 10 days old seedling was significantly influenced by the interaction effect of salinity level and wheat genotypes in sand culture (Table 3). The shoot length was found to be higher at control, with a range from 13.60 cm in BARI Gom 26 to 17.51 cm in Shatabdi and a mean of 15.34 cm compared to that at 12dS m^{-1} salinity level (with a range from 3.09 cm in BARI Gom 26 to 8.75 cm in Sonora and a mean of 6.19 cm). But the degree of reduction in shoot length from control to 12 dS m^{-1} salinity level was not similar for all wheat genotypes. Among the wheat genotypes, Prodip, BARI Gom 26, BAW 1111, BAW 1130, BAW 1138, BAW 1122, BAW 1146, BAW 1147, Bijoy, BAW 1150 and BAW 1153 showed more than 60% reduction in shoot length. Whereas, BAW 1140, BAW 1142 and Sonora showed less than 50% reduction in shoot length. The other wheat genotypes (Shatabdi, BARI Gom 25, BAW 1118, BAW 1135, BAW 1143 and BAW 1148) affected moderately in shoot length due to salt stress.

3.2.2. Root length

Root length of 10 days old seedlings was significantly influenced by the interaction effect of salinity level and wheat genotypes in sand culture (Table 3). The root length was found significantly higher at control, with a range from 8.28 cm in BARI Gom 26 to 16.15 cm in BAW 1150 and a mean of 13.45 cm compared to that at 12 dS m^{-1} salinity level (with a range from 4.17 cm in BARI Gom 26 to 8.81 cm in BAW 1148 and a mean of 6.72 cm). But the degree of reduction in root length from control to salt stress was not similar for all wheat genotypes. Among the wheat genotypes, Prodip, BARI Gom 26, BAW 1111, BAW 1118, BAW 1135, BAW 1143, BAW 1146, BAW 1147, BAW 1148 and Sonora showed less than 50% reduction in root length. The other wheat genotypes affected more than 50% in root length due to salt stress.

3.2.3. Root to shoot length ratio

The root to shoot length ratio was found higher at saline condition, with a range from 0.81 in BAW 1140 to 1.57 in Prodip and a mean of 1.12, than that at control (with a range from 0.60 in BARI Gom 26 to 1.13 in BAW 1150 and a mean of 0.94) except in BAW 1140, BAW 1142 and Sonora in which the root to shoot length ratio was even decreased in saline condition (Table 3). But the increment in root to shoot length ratio was more than 50% in Prodip, BARI Gom 26, BAW 1122 and BAW 1147 and it was less than 25% in Shatabdi, BARI Gom 25, BAW 1130, BAW 1135, BAW 1138 and BAW 1150. Other wheat genotypes showed moderate increment in root to shoot length ratio in saline condition.

3.2.4. Salt tolerance index based on seedling dry weight

Table 3: Root length, shoot length and root to to shoot length ratio of 10 days old seedling of different wheat genotypes as influenced by salt stress

Genotypes	Shoot length (cm)		Root length (cm)		Root to shoot length ratio	
	A	B	A	B	A	B
Shatabdi	17.51[a]	7.82[eg]	14.24[af]	7.00[im]	0.81	0.90
Prodip	16.17[ab]	5.57[hk]	15.45[ac]	8.80[hi]	0.96	1.58
BARI Gom25	15.45[ad]	7.02[ej]	13.48[bf]	6.47[in]	0.87	0.92
BARI Gom26	13.60[d]	3.09[l]	8.28[ij]	4.17[n]	0.61	1.35
BAW 1111	15.95[ac]	6.01[fk]	12.54[dg]	6.96[im]	0.79	1.16
BAW 1118	16.22[ab]	6.85[ej]	10.69[gh]	6.01[jn]	0.66	0.88
BAW 1130	14.68[bd]	5.34[ik]	12.07[eg]	4.92[mn]	0.79	0.92
BAW 1135	16.09[ac]	7.72[eh]	15.15[ac]	7.87[ik]	0.94	1.02
BAW 1138	14.61[bd]	5.61[gk]	14.09[af]	6.03[jn]	0.96	1.08
BAW 1140	14.95[bd]	8.18[ef]	13.99[af]	6.65[kn]	0.94	0.81
BAW 1122	16.21[ab]	4.24[kl]	13.87[af]	5.76[kn]	0.86	1.36
BAW 1142	14.58[bd]	7.39[ei]	15.73[ab]	7.37[il]	1.08	100
BAW 1143	15.75[ad]	6.34[fk]	12.71[dg]	7.13[im]	0.81	1.13
BAW 1146	13.83[cd]	4.96[jl]	14.38[ae]	7.47[il]	1.04	1.51
BAW 1147	16.35[ab]	6.39[fk]	13.31[cf]	8.11[ik]	0.81	1.27
BAW 1148	16.22[ab]	6.68[ej]	14.71[ad]	8.81[hi]	0.91	1.32
Bijoy	14.30[bd]	5.37[ik]	12.44[dg]	6.19[jn]	0.87	1.15
BAW 1150	14.21[bd]	5.24[ik]	16.15[a]	6.07[jn]	1.14	1.16
Sonora	14.63[bd]	8.75[e]	13.76[bf]	7.24[im]	0.94	0.83
BAW 1153	15.55[ad]	5.29[jk]	11.98[fg]	5.36[ln]	0.77	1.01

A: Control; B: Saline (12 dS m^{-1});

Values having same letter(s) do not differ significantly by DMRT 5% level

Salt tolerance index (STI) based on seedling dry weight (10 days old) varied among twenty wheat genotypes, with a range of 0.357 to 0.0.604 and an average of 0.509 (Figure 1). These STI values indicated a wide difference in salt tolerance among the wheat genotypes. Shatabdi, BAW 1135 and Bijoy showed more than 0.6 STI value, the wheat genotypes BARI Gom 26, BAW 1122 and BAW 1148 provided less than 0.4 STI value and the other wheat genotypes (Prodip, BARI Gom 25, BAW 1111, BAW 1118, BAW 1130, BAW 1138, BAW 1140, BAW 1142, BAW 1143, BAW 1146, BAW 1147, BAW 1150, Sonora and BAW1153) showed 0.4 to 0.6 STI value.

In the present study, shoot length and root length of 10 days old seedling were affected by salt stress. The result on root to shoot length ratio indicated that shoot was more affected than root in saline condition. Moud and Maghsoudi (2008), Datta et al. (2009), Karim et al. (1992), Gupta (1980), Khan and Sheikh (1976), Bandopadhyay (1986), Mujeeb et al. (2008) also found similar result in their study. Seedling dry weight is the ultimate result of all physiological and biochemical activities of plant. High salinity stress markedly reduced this parameter (Akbarimoghaddam et al. 2011, Bhatti et al. 2004 and Rumena 2006). It has been reported that salinity stress significantly reduced net photosynthetic rates, increased energy losses for salt exclusion mechanism, largely decreased nutrient mobilization, suspending the cell division and enlargement and finally reduced plant growth (Meiri and Poljakoff-Mayber 1970, Long and Baker 1986 and Seeman and Sharkey 1986). In the present study, seedling dry weight was found to be affected by salt stress. But the adverse effect on seedling dry weight was different in different wheat genotypes which indicate different sensitivity of wheat genotypes to salt stress. Singh et al. (2000) and Moud and Maghsoudi (2008) also found differential sensitivity of wheat genotypes based on seedling growth in their study and Karim et al (1992) suggested that seedling growth is one of the most important characters for screening salt tolerance at early stage of growth.

4. Conclusion

The present study suggest that Shatabdi and BAW 1135 are salt tolerant because of showing faster speed of germination, lesser reduction in shoot and root length, lesser increment in root to shoot length ratio, lesser reduction in seedling dry weight and higher salt tolerance index value under saline condition are salt sensitive because BARI Gom 26 and BAW 1122 showing slower speed of germination, greater reduction in shoot and root length, greater increment in root to shoot length ratio, greater reduction in seedling dry weight and lower salt tolerance index value under saline condition.

5. References

Akbarimoghaddam, H., Galavi, M., Ghanbari, A., Panjehkeh, N., 2011. Salinity effects on seed germination and seedling growth of bread wheat cultivars. Trakia Journal of Sciences 9(1), 43-50.

Ali, S.S., 2011. Salinity doubles in Bangladesh's coastal belt. EJC-Online.htm

Allakhverdiev, S.I., Sakamoto, A., Nishiyama, Y., Inaba, M., Murata, N., 2000. Ionic and Osmotic effects of NaCl-induced in activation of photo systems I and II in *synechoccus* sp. Plant physiology 123, 1047-56.

Ashraf, M., Harris, P.J.C., 2004. Potential biochemical indicators of salinity tolerance in plants. Plant Science 166, 3-16.

Ashraf, M., Foolad, M.R., 2005. Pre-sowing seed treatment-a shotgun approach to improve germination, plant growth, and crop yield under saline and non-saline conditions. Advance Agronomy 88, 223-271.

Bandayopadhyay, A.K., 1986. Varieties screened for acid saline soils. International Rice Research Newsletter 110,

11(6), 14.
Bhatti, M.A., Ali, Z., Bakhsh, A., Razaq, A., Jamali, A.R., 2004. Screening of wheat lines for salinity tolerance. International Journal of Agricultural Biology 6(4), 627-628.
Cramer, G.R., Alberico, G.J., Schmidt, C., 1994. Salt tolerance is not associated with the sodium accumulation of two maize hybrids. Australian Journal of Plant Physiology 21, 675-692.
Datta, J.K., Nag, S., Banerjee, A., Mondal, N.K., 2009. Impact of salt stress on five varieties of Wheat (*Triticum aestivum* L.) cultivars under laboratory condition. Journal of Applied Science and Environment 13(3), 93-97.
Flowers, T.J., Yeo, A.R., 1995. Breeding for salt tolerance in crop plants-Where next? Australian Journal of Plant Physiology 22, 875-884.
George, L.Y., Williams, W.A., 1964. Germination and Respiration of Barley, Strawberry, clover and ladine doverseed in salt solutions. Crop Science 4, 450-452.
Ghassemi, F., Jakeman, A.J., Nik, H.A., 1995. Stalinization of land and water resources. Human causes, extent, management and case studies, University of New South Wales Press, Sydney, 526.
Goudarzi, M., Pakniyat, H., 2008. Evaluation of wheat cultivars under salinity stress based on some agronomic and physiological traits. Journal of Agriculture Society 4, 35-38.
Gupta, S., 1980. Comperative studies on germination and seedling growth of some salt tolerant selections at different salinity levels. International Rice Research Newsletter 18, 3-17.
Jafari-Shabestari, J., Corke, H., Qualset, C.O., 1995. Field evaluation of tolerance to salinity stress in Iranian hexaploid wheat landrace accessions. Genetic Research on Crop 42, 147-156.
Karim, M.A., Utsunomiya, N., Shigenaga, S., 1992. Effect of sodium chloride on germination and growth of hexaploid triticale at early seedling stage. Japan Journal of Crop Science 61(2), 279-284.
Khaje-Hosseini, M., Powell, A.A., Bingham, I.J., 2003. The interaction between salinity stress and seed vigour during germination of soybean seeds. Seed Science Technology 31, 715-725.
Khan, S.S., Sheikh, K.H., 1976. Effects of different level of salinity on seed germination and growth of *Capsicum annum* L. Biologia 22, 15-25.
Kingsbury, R.W., Epstein, E., Peorcy, R.W., 1984. Physiological responses to salinity in selected lines of wheat. Plant physiology 74, 417-425.
Krishnasamy, V., Seshu, D.V., 1990. Germination after accelerated aging and associated characters in rice varieties. Seed Science Technology 18, 353-359.
Long, S.P., Baker, N.R., 1986. Saline Terrestrial Environments. In: Baker, N.R., Long, S.P. (Eds.), Photosynthesis in Contrasting Environments, 63-102. Elsevier, Amsterdam.
Meiri, A., Poljakoff-Mayber, A., 1970. Effect of various salinity regimes on growth, leaf expansions and transpiration rate of bean plants. Plant Soil Science 109, 26-34.
Mirza, R.A., Mahmood, K., 1986. Comparative effect of sodium chloride and sodium bicarbonate on germination, growth and ion accumulation in *Phaseolus aureus,* Roxb, c.v. 6601. Biologia 32, 257-268.
Moud, A.M., Maghsoudi, K., 2008. Salt stress effects on respiration and growth of germinated seeds of different wheat (*Triticum aestivum* L.) cultivars. World Journal of Agrilcultural Science 4(3), 351-358.
Mujeeb, U.R., Soomro, U.A., Haq, M.Z.U., Gul, S., 2008. Effects of NaCl salinity on wheat (*Triticum aestivum* L.) cultivars. World Journal of Agricultural Science 4(3), 398-403.
Rahman, M., Kayani, S.A., Gul, S., 2000. Combined effects of temperature and salinity stress on corn cv. Sunahry. Pakistan Journal of Biological Science 3(9), 1459-1463.
Rumena, Y., 2006. Physiology of rice genotypes under salt stress conditions. A PhD. Thesis. Department of Crop Botany, BSMRAU, Salna, Gazipur.
Seeman, J.R., Sharkey, J.D., 1986. Salinity and Nitrogen effects on photosynthesis, Ribulose-1, 5 bisphosphate carboxylase and metabolites pool size in *Phaseolus vulgaris* L. Plant physiology 82, 555-560.
Shannon, M.C., 1984. Breeding, selection and the genetics of salt tolerance. In: Staple, R.C., Toenniessen, G.H. (Eds.), Salinity Tolerance in Plants, 231-55, Wiley, New York.
Singh, A.K., Prakash, V., Sastry, E.V.D., 2000. Effect of salinity stress on seed germination and seeding growth of wheat. Agriculture Science Digestion 20(2), 96-98.