Bangladesh J. Bot. **47**(3): 381-387, 2018 (September)

SCREENING OF WHEAT GENOTYPES AGAINST SALINITY AT EARLY VEGETATIVE STAGE IN POT CULTURE

MS UDDIN* AND KMW HOSSAIN[1]

Regional Agricultural Research Station, BARI, Rahmatpur, Barisal-8211, Bangladesh

Keywords: Screening, Wheat genotype, Salinity, Vegetative stage, Tolerant and susceptible

Abstract

Experiment was carried out to investigate intraspecific variation for salt tolerance and to classify the wheat genotypes into different salt tolerant groups. Considerable variations among the genotypes in response to salinity were observed for shoot length under 16 dS/m NaCl salinity in the both seasons. Salt tolerant genotype was found to be less affected at high salinity and could be produced better total dry matter compared to other genotypes. Five and seven genotypes appeared as tolerance during 2008 - 09 and 2009 - 10, respectively based on relative total dry matter (RTDM). On the other hand, six and three genotypes exhibited tolerant during 2008 - 09 and 2009 - 10, respectively based on visual scoring. The distribution pattern of the genotypes into various salinity tolerant groups remained fairly constant under two methods. Three genotypes G24, G33 and G40 exhibited tolerant category. RTDM compared to the control would be very useful trait in salinity tolerant improvement programme. However, visual scoring provide guidelines for mass screening of salt tolerant genotypes.

Introduction

There are several screening techniques available in the literature for isolating salt tolerant genotypes for genetic and physiological investigation, and for breeding. The methods which involve screening at seed germination, seedling growth and reproduction stage. Selection for salinity resistance appears as a laborious and hazardous task and plant breeders are, therefore, seeking for quick, cheap and reliable way to assess the salt resistance of selected material. The early vegetative stage of a crop is considered as the most important stage of a crop that determines the plant stand for crop yield. Shannon *et al.* (1984) reported that selection at vegetative stage of a crop was of great importance for at least two reasons. First, vegetative growth rates can be determined in a limited space under controlled conditions and within a relatively short time (4 - 6 weeks). Secondly, rapid vegetative development under saline conditions reflects a plant response to the stress environment and its capacity to produce additional resources for growth. Sensitive growth stage differs among the crops, among cultivars of the same crop and even different growth stages in a same cultivar (Blum 1985). According to Maas (1986) crops such as barley, corn, cowpea, rice, sorghum and wheat are most sensitive during early seedling growth and then become increasingly tolerant during later stages of growth and development. Several studies have shown that exposure of a plant to salinity at early seedling stage shows a greater yield loss than that exposure at later part of growth (Gill 1990 and Pasternak *et al.* 1979). Tolerance observed at the early vegetative stage is of great importance. Because it has been emphasized by many workers that the assessment of salt tolerance at vegetative stage of a plant species is of considerable value in determining the ultimate tolerance of the species (Ashraf and McNeilly 1988, Ashraf *et al*. 1990, Aslam *et al*. 1993, Ashraf 1994, Aziz *et al*. 2005 and Uddin *et al.* 2017).

*Author for correspondence: <mdsaleh03@yahoo.com>. [1]Department of Genetics and Plant Breeding, Bangladesh Agricultural University, Mymensingh, Bangladesh.

Mass screening for salt tolerance in soil culture or directly in the field is difficult and has a variety of limitations. It is complicated by the status of soil fertility, by irrigation and management practices (Maas and Hoffman 1977 and Ponnamperuma 1984), salinity type (Aslam *et al.* 1988) and metrological factors like temperature and humidity (Akbar 1986, Cabuslay and Akita 1986, Hasan and Miyake 2017) as well as natural variation within fields (Richards 1983). Aslam *et al.* (1993) reported that field screening techniques encountered/confronted the biggest problem of high degree of soil heterogeneity and only a limited number of genotypes could be handled. The pot culture method has the following advantages: (i) the salinity level is uniform throughout the pot, (ii) the number of irrigation is reduced, (iii) problems associated with salt depletion are overcome and (iv) the method is rapid, economical and more closely resembles to natural field conditions. Therefore, the study was undertaken to examine the intraspecific variation for salt tolerance and to classify the wheat genotypes into different salt tolerance groups at vegetative stage.

Materials and Methods

The experiment was carried out with 45 wheat genotypes, collected from Wheat Research Centre, BARI, Joydebpur, Gazipur, in pot culture under semi-controlled environment (inside plastic greenhouse) and natural light during two seasons of 2008 - 09 and 2009 - 10. The experiment was laid out in a randomized complete block (RCBD) with three replications. The materials were evaluated at Regional Agricultural Research Station, BARI, Rahmatpur, Barishal under control (non-saline) and 16 dS/m salinity level. Salt solution was prepared artificially by dissolving calculated amount of commercially available NaCl with tap water to make 160 mM NaCl solution. The salt solution was applied with an increment of 40 mM at every alternate day till the respective concentrations were attained. Plants in control were irrigated with tap water. Treatment solution was applied in excess so that extra solution dripped out from the bottoms of the pots. Treatments began 12 days after sowing and were continued for 10 days, after which the pots were flushed with tap water to leach out the accumulated salt and the plants were irrigated with tap water (Ashraf and McNeilly 1988 and Aziz *et al.* 2005, 2006). Data on different salinity parameters were recorded as follows:

$$\text{Reduction of shoot length (\%)} = \frac{\text{Shoot length at non-saline} - \text{Shoot length at saline}}{\text{Shoot length at non-saline}} \times 100$$

$$\text{Reduction of shoot dry matter} = \frac{\text{Shoot dry wt. at non-saline} - \text{Shoot dry wt. at saline}}{\text{Shoot dry wt. at non-saline}} \times 100$$

$$\text{Relative total dry matter (RTDM \%)} = \frac{\text{Shoot dry wt. at saline}}{\text{Shoot dry wt. at non-saline}} \times 100$$

Salinity scoring was done with 0 - 9 scale based on RTDM% (Ashraf and Waheed 1990) and 1 - 9 scale based on visually using the modified standard evaluation system of IRRI (Ray and Islam 2007).

Results and Discussion

Genotypes did not show significant difference under control condition (0 mM NaCl) for shoot length during the year of 2008 - 2009 and 2009 - 2010 (Table 1). It suggests that the shoot lengths of the genotypes at 30 DAS were identical for both seasons. Considerable variations among the genotypes in response to salinity were observed for shoot length under 16 dS/m NaCl salinity in the both seasons. At 16 dS/m salinity level, the shoot length during 2008 - 09 varied from 31 to 46 cm with the mean value of 41 cm. On the other hand, the shoot length under 16 dS/m salinity during 2009 - 10 ranged from 35 to 48 cm with an average of 41 cm. The coefficient of variation was 9.03 and 10.6% during 2004 - 05 and 2005 - 06, respectively.

Table 1. Maximum and minimum values, mean and coefficients of variation of different parameters under control and 16 dS/m NaCl salinity during 2008 - 09 and 2009 - 2010.

	Shoot length (cm)				Total shoot dry matter g/pl.				Visual score (1-9)			
	Control		16 dS/m		Control		16 dS/m		Control		16 dS/m	
	2008-09	2009-10	2008-09	2009-10	2008-09	2009-10	2008-09	2009-10	2008-09	2009-10	2008-09	2009-10
Maximum	48	48	46	48	3.16	5.04	2.27	1.85	3.3	2.7	7.3	7.7
Minimum	36	35	31	35	1.14	0.87	0.96	0.54	1.7	1.7	2.3	2.7
Mean	44	41	41	41	2.22	1.62	1.46	1.09	2.6	2.2	5.4	5.7
CV (%)	9.0	10.6	9.0	10.6	17.97	18.58	19.79	18.33	22.1	31.0	17.7	13.1
F-test	ns	**	**	**	**	**	**	**	**	ns	**	**

Per cent reduction of shoot length at 16/m salinity varied from 0 to 23% during 2008-09. The highest reduction was found from G28. No reduction of shoot length was observed from G7, G13, G17, G18, G23, G34, G38 and G44 at 16 dS/m salinity (Fig. 1). On the other hand, shoot length reduction ranged from 0 to 27% during 2009 - 10. The maximum reduction (27%) was noticed from G24.

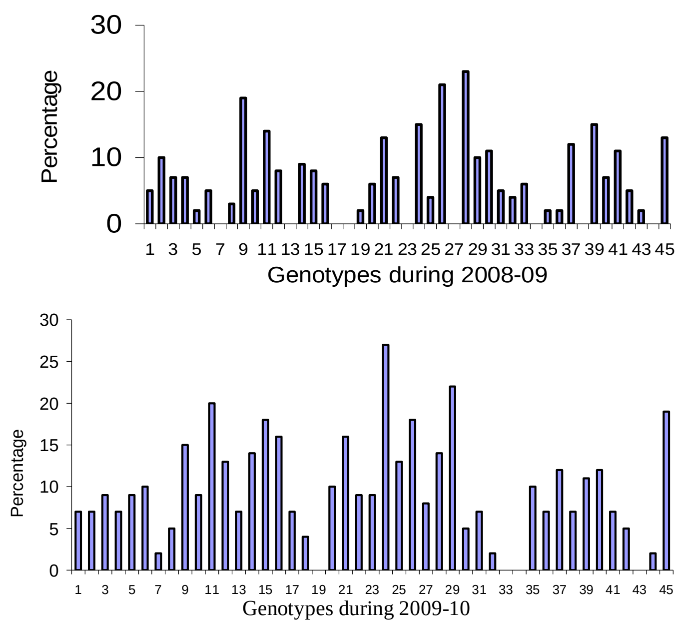

Fig. 1. Reduction of shoot length of 45 genotypes of wheat under 16 dS/m salinized condition during 2008 - 09 and 2009 - 10.

A significant variation among the genotypes was noticed for total shoot dry matter (TDM) under control and 16 dS/m salinity level condition during 2008 - 09 and 2009 - 10 (Table 1). At control condition, TDM varied from 1.14 to 3.16 g/plant with the average of 2.22 and 0.87 to 5.04 g/plant with the mean of 1.62 g/plant during 2008 - 09 and 2009 - 10, respectively. TDM at 16 dS/m NaCl salinity level, varied between 0.96 and 2.27 g/plant with the mean of 1.46 g/plant during 2008 - 09, while during 2009 - 10 it was 0.54 to 1.85 g/plant with the average of 1.09 g/plant.

Per cent reduction of shoot dry matter (RSDM) was statistically significant among the genotypes. The per cent RSDM varied from 01 to 64 during 2008 - 09. The maximum RSDM was obtained from G9 whilst the minimum from G25. On the other hand, during 2009 - 10, RSDM ranged 01 to 69%. The highest reduction of RSDM was found from G1 where the lowest was from G8 (Fig. 2).

The RTDM ranged from 36 to 99% with the mean value of 68% during 2008 - 09. The highest RTDM was obtained from G33 and G25 followed by G4 (95%), G24 and G40 (93%). (Fig. 3). During 2009 - 10, the RTDM varied from 29 to 97% with an average value was 72%.

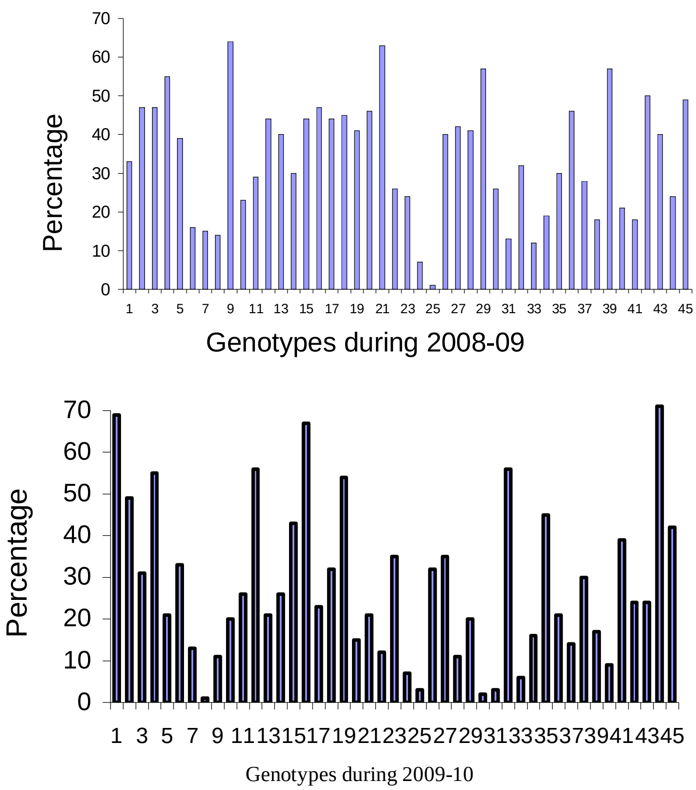

Fig. 2. Reduction of shoot dry matter of 45 genotypes of wheat under 16 dS/m salinized condition during 2008 - 09 and 2009 - 10.

The maximum RTDM was noticed from G8 followed by G25 and G33 (94%) and G40 (91%) (Fig. 3). Salt tolerant genotype was found to be less affected at high salinity level and could be produced better TDM compared to other genotypes (Ashraf and Waheed 1990 and Aziz *et al.* 2005).

Salt tolerance in plant is most usefully presented in terms of relative production over a range of salinities (Maas and Hoffman 1977) The genotypes examined in this study were classified into ten groups using 0 - 9 scale (Fig. 4). The genotypes were then categorized as tolerant (T), moderately tolerant (MT), susceptible (S) and highly susceptible (HS) (Ashraf and Waheed 1990). Fig. 4 shows that 0, 1 and 9 scales had no genotypes, during 2008 - 09. The highest number (16) of genotypes was found in scale no. 6 during 2008 - 09. On the contrary, the highest number (12) of genotypes was observed in scale No. 4 during 2009 - 10 and no genotype was found in 0 and 1 scale (Fig. 4). During 2008 - 09, five genotypes were exhibited in tolerant category. Moderately

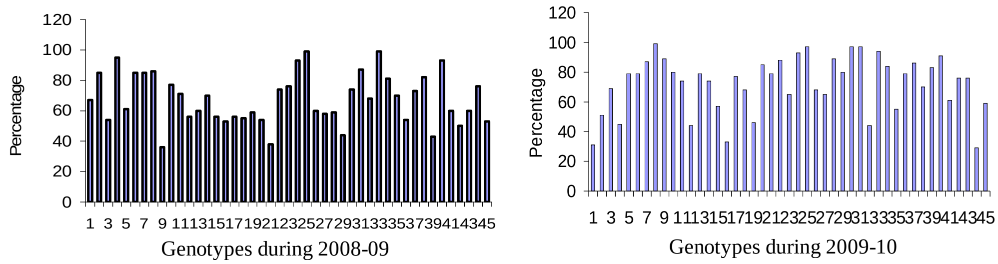

Fig. 3. Relative total dry matter of 45 genotypes of wheat under 16 dS/m salinized condition during 2008 - 09 and 2009 - 10.

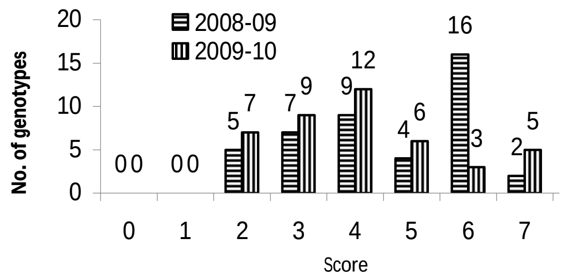

Fig. 4. Frequency distribution of 45 wheat genotypes in salt tolerant scale based on RTDM during 2008 - 09 and 2009 - 10.

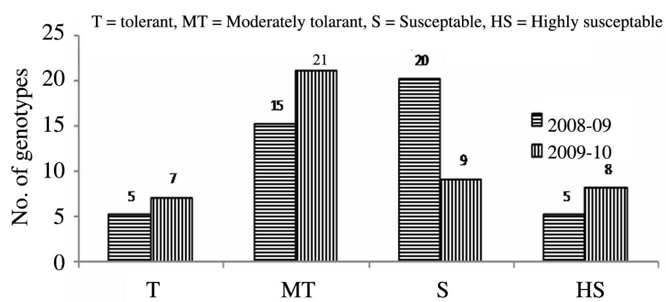

Fig. 5. Frequency distribution of 45 wheat genotypes based on relative performance and salt tolerant scale during 2008 - 09 and 2009 - 10.

tolerant, susceptible and highly susceptible categories included 15, 20 and 5 genotypes, respectively during same growing season (Fig. 5). On the other hand, tolerant, moderately tolerant, susceptible and highly susceptible categories remained 7, 21, 9 and 8 genotypes, respectively during 2009 - 10 (Fig. 5).

Visual score: The genotypes tested in this study were also categorized into four groups using 1- 9 scales. After 20 days salinization, salinity symptoms of each plant were scored. A significant variation was noticed among the genotypes for visual scoring under control and 16 dS/m salinity during 2008 - 09 and 2009 - 10. At control condition, visual score ranged from 1.7 to 3.3 with the mean of 2.6, and from 1.7 to 2.7 with the mean of 2.2 during 2008 - 08 and 2008 - 10, respectively. Visual score varied 2.3 to 7.3 with an average of 5.4 at 16 dS/m salinity during 2008 - 09. At 16 dS/m salinity, visual score ranged from 2.7 to 7.7 with the mean of 5.7 during 2009 - 10. Fig. 6 exhibits that the highest number of genotypes (32 and 34 during 2008 - 09 and 2009 - 10, respectively) were remained in moderately tolerant group. Six and three genotypes were found in tolerant group during 2008 - 09 and 2009 - 10, respectively. Three genotypes G24, G33 and G0 exhibited tolerant during both seasons. Visual score may lead to misleading interpretation, as leaves are liable to be damaged by other stress such as water deficit and diseases. In such situation

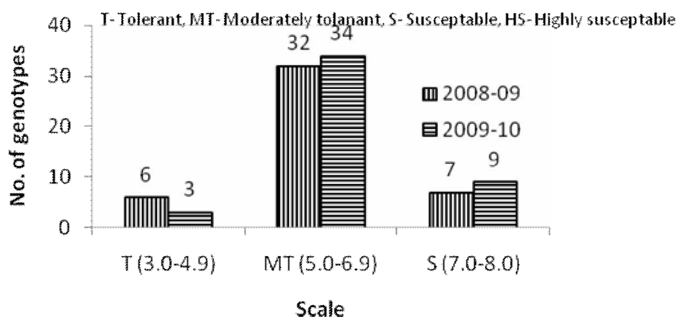

Fig. 6. Frequency distribution of 45 wheat genotypes based on visual scoring during 2008 - 09 and 2009 - 10.

more, indicator of salinity tolerance were used. However, visual scoring may be used in mass screening (Ray and Islam 2007). They also reported that varieties were different in their reactions from tolerant to moderately tolerant and moderately tolerant to susceptible or vice versa.

The results deal with the salt tolerance of the genotypes at the vegetative stage. It has been argued that selection for salinity tolerance at the vegetative stage may not produce tolerant adult plants (Kingsbury and Epstein 1984). In contrast, the performance of seeding under saline conditions has been considered highly predictive of the response of adult plants to salinity (Blum 1985, Aziz *et al.* 2005). Kingsbury and Epstein (1984), Ashraf (1994), Aziz *et al.* (2006) and Uddin *et al.* (2017) screened seedling of wheat, grass species and mungbean, respectively and found a considerable relationship in salt tolerance at the adult stage.

Nevertheless, tolerance observed at early vegetative stage is of great importance. Because it has been emphasized by many workers that the assessment of salt tolerance at vegetative stage of a plant species is of considerable value in determining the ultimate tolerance of the species (Ashraf and McNeilly 1988, Ashraf *et al.* 1990, Ashraf 1994 and Aziz *et al.* 2005). In consideration of the severe effect of salt on vegetative stage, the growth of crop cultivars in saline area is facilitated by leaching the salts and by other management practices. Therefore, knowing the tolerance that was observed at the vegetative stage of some genotype would be of considerable economic value for crop establishment on salt affected soils. From the data it may be concluded that the salt tolerant genotypes found in the diverse germplasm of wheat, examined in this study, could be of considerable economic value in increasing yield on saline areas.

Acknowledgements

The authors would like to thank to Mr. M. A. Newaz for his guidance to carry out the research work.

References

Akbar M 1986. Breeding for salinity tolerance in rice. *In:* Salt affected soils of Pakistan, India and Thailand. pp. 39-63. IRRI, Los Banos, Philippines.

Ashraf M 1994. Breeding for salinity tolerance in plants. CRE Critical Reviews in Plant Sciences **13**: 17-42.

Ashraf M and McNeilly T 1988. Variability in salt tolerance of nine spring wheat cultivars. J. Agron. Crop Sci. **160**: 14-21.

Ashraf M and Waheed A 1990. Screening of local/exotic accessions of lentil (*Lens culinaris* Medic.) for salt tolerance at two growth stages. Plant and Soil **128**: 167-176.

Ashraf M, Bokhari MH and Waheed A 1990. Screening of local/exotic accessions of mungbean (*Vigna radiata* (L.) Wilczek) for salt tolerance. J. Trop. Agric. **34**: 169-175.

Aslam M, Qureshi RH and Ahmed N 1993. A rapid screening technique for salt tolerance in rice (*Oriza sativa* L.). Plant and Soil. **150**: 99-107.

Aslam M, Qureshi RH, Ahmed N and Muhammed S 1988. Response of rice to salinity shocks at various growth stages and type of salinity in the rooting medium. Pak. J. Agric. Sci. **25**. 199-205.

Aziz MA, Karim MA, Hamid MA, Khaliq QA and Hossain M 2005. Salt tolerance in mungbean: Growth and yield response of some selected mungbean genotypes to NaCl salinity. Bangladesh J. Agri. Res. **30**(4): 529 - 535.

Aziz MA, Karim MA, Hamid MA, Khaliq QA and Karim AJMS 2006. Salt tolerance of mungbean at different growth stage: Effect of NaCl salinity on yield and yield components. Bangladesh J. Agri. Res. **31**(2): 313-322.

Blum A 1985. Breeding crop varieties for stress environments. CRC Critical Rev. Plant Sci. **2**: 199-238.

Cabuslay GS and Akita S 1986. Physiology of varietal response of salinity. 1. Effect of nutrient concentration and PH on salt tolerance. Japan J. Crop Sci. Extra Issue **1**: 26-27.

Gill KS 1990. Effect of saline irrigation at various growth stages on growth, yield attributes and ionic accumulation pattern in green gram. Indian J. Agril. Sci. **60**(4): 280-284.

Hasan R and Miyake H 2017. Salinity stress alters nutrient uptake and causes the damage of root and leaf anatomy in maize. KnE Life Sciences **3**: 219-225.

Kingsbury RW and Epstein E 1984. Selection for salt resistant spring wheat. Crop Sci. **34**: 310-315.

Maas EV 1986. Salt tolerance of plants. Applied Agri. Res. **1**: 12-26.

Maas EV and Hoffman GJ 1977. Crop salt tolerance-current assessment. J. Irrig. Drain, Div. Am. Soc. Civ. Eng. **103** (IR2**)**: 115-134.

Pasternak D, Twersky M and De-Malach Y 1979. Salt resistance in agricultural crops. *In:* Stress physiology in crop plants. Mussel H. and R. C. Staples (eds). pp. 127-142. John Wiley and Sons, New York.

Ponnamperuma FN 1984. Role of cultivar tolerance in increasing rice production on saline lands. *In:* salinity tolerance in plants strategies for crop improvement (Staple RC and GA Toenniessen Ed.). pp. 255-271. Willy, New York.

Ray PKS and Islam MA 2007. Combining ability for some salinity tolerance traits in rice. Bangladesh J. Agril. Res. **32**(2): 183-189.

Richards RA 1983. Should selection for yield in saline regions be made on saline or non-saline soils? Euphytica **32**: 431-438.

Shannon MC, Bohn GW and Creeght JD 1984. Salt tolerance among muskmelon genotypes during seed emergence and seeding growth. Hort. Sci. **19**(6): 828-830.

Uddin MS, Jahan N, Rahman MZ and Hossain KMW 2017. Growth and yield response of wheat genotypes to salinity at different growth stages. Int. J. Agron. Agri. R. **11**(2):60-67.

(Manuscript received on 10 September, 2017; revised on 18 July, 2018)