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Growth and salinity tolerance of wheat genotypes at early vegetative stage

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Abstract

Growth and salinity tolerance study of wheat genotypes were conducted at regional agricultural research station to evaluate the selected wheat genotypes against salinity and to classify the wheat genotypes in different salt tolerant group. The experiment was carried out with 12 wheat genotypes under semi-controlled environment (inside plastic greenhouse) and natural light in a randomized complete block (RCBD).The materials were evaluated under control (non-saline) and 16 dS/m salinity level. A significant variation among the genotypes was observed for shoot length under both environments. The lowest reduction (2%) was found from G11 followed by G40 (4%). The genotypes showed differences in production of total shoot dry matter (TDM) at both non-saline and saline conditions. The relative TDM per plant (% TDM to control condition) appears that three genotypes (G24, G33and G40) produced 90% RTDM. Salt tolerant genotype was found to be less affected at high salinity and could be produced better TDM compared to other genotypes. Three genotypes G24, G33 and G40 exhibited tolerant category. The distribution pattern of the genotypes into various salinity tolerance groups indicates that the overall pattern of behaviors of the genotypes tested remain fairly constant under two methods (based on RTDM and visual scoring).

Key words: Salinity, tolerant, susceptible, wheat genotype, vegetative stage

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Introduction

Wheat is one of the important cereal crops produced widely and intensively all over the world. It is grown in a wide range of latitudes (67^0N to 45^0S). Major world production comes from the south temperate zones. It ranks second in position among the cereals in Bangladesh next to rice. The winter season of Bangladesh is favorable for wheat cultivation. Wheat is gaining popularity as a staple crop of our country day by day. It plays a vital role in the national economy to reduce the deficit between the food production and food import. Due to continuous food shortage, changing food habit and introduction of dwarf type high yielding wheat varieties, cultivation of wheat have become popular to the farmers of Bangladesh after the world wide successful campaign of green revolution in mid sixties. During 1999- 2000, about 1.84 million tons of wheat was produced from about 0.80 million hectare with an average yield of 2.3 t/ha (BBS, 2000). Currently, during 2015-16 wheat production about 1.36 million tons from about 0.49 million hectare with an average yield of 2.8 t/ha (Anonymous, 2017). These decreasing trends of wheat production is due to some constraints such as socio economic condition, lack of irrigation facilities, lack of stress tolerant varieties, crop competition with others more profitable crops, sterility in the spikes, diseases, short duration of winter etc.

On a global scale, nearly 40% of the earth's land surface is potentially endangered by salinity problems (Orcutt and Nilsen, 2000). In the coastal and southeastern districts of Bangladesh 3 million hectares of land are affected by salinity with EC values ranging from 4 to 16 dS/m (Zaman and Bakri, 2003). Amount of saline affected area is increasing continuously due to the effect of sea level rise, coastal subsidence, increased tidal effect and continuous reduction of river flow, particularly during dry period.

In principle, the loss of agricultural land resulting from increasing salinity could be reversed either by soil desalinization or the use of salt tolerant varieties (Flowers and Yeo, 1986). Alleviation of saline soil through various methods such as reclamation, irrigation and drainage are not always economical or practical. Therefore, improving the crop varieties for salt tolerance offers a more effective, less costly, non-polluting and long lasting strategy to manage salt affected soils. Breeding for salt tolerance offers a more promising, energy efficient, economical and socially acceptable approach to solving these problems than doing major engineering processes and soil amelioration. Therefore, high priority must be given not only by breeding very high yielding varieties for favorable ecosystems, but also by the development of modern varieties for less favorable sub-ecosystems like submergence and soil salinity prone coastal areas. 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, 1987, Ashraf *et al*., 1990; Aslam *et al*., 1993; Ashraf, 1994 and Aziz *et al*., 2005). This experiment, therefore, was conducted to evaluate the selected wheat genotypes against salinity and to classify the wheat genotypes in different salt tolerant group.

Materials and Methods

The experiment was carried out with 12wheat genotypes (Table 1), collected from Wheat Research Centre, BARI, Joydebpur, Gazipur, in pot culture under semi-controlled environment (inside plastic greenhouse) and natural light during seasons of 2009-10. The experiment was laid out in a randomized complete block (RCBD) with three replications. The materials were evaluated 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, 1987; Aziz *et al.,* 2005, 2006). Data on different salinity parameters were recorded as follows:

- Reduction of shoot length (%):

$$\frac{\text{Shoot length at non-saline - shoot length at saline}}{\text{Shoot length at non-saline}} \times 100$$

- Reduction of shoot dry matter (RSDM):

$$\frac{\text{Shoot dry wt. at non-saline – shoot dry wt. at saline}}{\text{Shoot dry wt. at non-saline}} \times 100$$

- 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 (SES) of IRRI (Ray and Islam, 2007).The collected data were analyzed statistically following Gomez and Gomez (1984).

Table 1. List of wheat entries with pedigree used in the experiment

Sl. No.	Genotype code #	Variety/Line/ Pedigree	*Source*
1	G1	Akber	Wheat Research Centre, BARI, Joydebpur, Gazipur
2	G11	Shatabdi	
3	G15	JUN/PRL	
4	G18	Barkat/Bulbul	
5	G22	Chirya-3	
6	G24	PVN/BL1022	
7	G26	RAWAL-87	
8	G32	YIE86-60774	
9	G33	AKR/BALAKA// FAN/PVN	
10	G37	G162/BL1316// NL-297	
11	G40	KRL 1-4	
12	G45	RAWAL87//BUC/ BJY	

Results and Discussion

The performance of twelve wheat genotypes under control and 16dS/m level of salinity is shown in Table 2. A significant variation among the genotypes was observed for shoot length under both environments. The tallest shoot length (57 cm and 50 cm) at 30 DAS was noticed from G15 under control and G18 under 16 dS/m, respectively. Reduction of shoot length of the selected wheat genotypes is shown in Figure 1. It appears that the highest reduction (30%) was obtained from G15, G22, G26 and G37. Again, the lowest reduction (2%) was found from G11 followed by G40 (4%). NaCl salinity induced changes in dry matter production at seedling stage. Accumulation to dry matter showed considerable variation among the genotypes. The genotypes showed differences in productions of total shoot dry matter (TDM) at both non-saline and saline conditions. Under control condition (0mMNaCl), the TDM per plant of the genotypes varied from 1.10 g to 3.25 g. The lowest TDM was produced by G22 and the highest obtained from G15. The TDM at 160mMNaCl varied between 0.90 to 2.21 g/plant. The genotype G22 produced the lowest TDM and while G40 produced the highest TDM.

The reduction of shoot dry matter (RSDM) is presented in Figure 2. It shows that the maximum reduction of TDM (56%) was found from G18 followed by G1 (51%) and G45 (42%). The lowest reduction of TDM (6%) was exhibited from G37followed by G24and G40 (7%). The relative TDM per plant (% TDM to control condition) appears that three genotypes (G24, G33and G40) produced 90% RTDM. The lowest RTDM was obtained from G15 (44%) followed by G1 (49%) and 45(58%) (Fig.3). Salt tolerant genotype was found to be less affected at high salinity and could be produced better TDM compared to other genotypes (Aziz e*t al.* 2005, Asharf and Waheed 1990). Salt tolerance in plant is most usefully presented in terms of relative production over a range of salinities (Mass and Hoffman, 1977). The selected genotypes were classified into ten groups using 0-9 scale based on RTDM. The genotypes were then categorized as tolerant (T), moderately tolerant (MT), susceptible (S) and highly susceptible (HS) (Ashraf and Waheed, 1990). Three genotypes G24, G33 and G40 exhibited tolerant category. MT, S and HS categorized included 3 (G11, G22 and G37), 4 (G18, G26, G32 and G45) and 2 (G1 and G15) genotypes, respectively (Table 3).

The genotypes tested in this study were also categorized in to four groups using 1- 9 scale based on visually using the modified standard evaluation system (SES) of IRRI. After 20 days of salinization, salinity symptoms of each plant were scored. Under control, the genotypes did not differ significantly. While, under 16 dS/m salinity, the genotypes showed significant difference due to salinity. It suggests that all genotypes under non-salinity showed similar. The genotypes G24, G33and G40obtained the lowest score while, G1, G15, G18, G26, G32 and G40 showed the highest score. The genotypes tested in this study were categorized into tolerant (T), moderately tolerant (MT) and susceptible (S). Three genotypes G24, G33 and G40 also exhibited tolerant. MT and S categorized had 3 (G11, G22 and G37) and 6 (G1, G15, G18, G26, G32 and G45) genotypes, respectively.

Table 2. Performance of selected genotype at control and 16dS/m level of NaCl salinity under validity test

Sl. No.	Genotypes	Shoot length (cm)		Total shoot dry matter (g/pl.)		Visual score (1-9)	
		Control	16dS/m	Control	16dS/m	Control	16ds/m
1.	G1	49 b-d	45 bc	2.65 ab	1.31 cd	2.25	7.8 a
2.	G11	47 c-e	46 bc	2.62 ab	2.05 ab	2.00	5.3 b
3.	G15	57 a	46 bc	3.25 a	1.43 b-d	1.75	7.3 a
4.	G18	53 ab	50 a	2.87 ab	1.97 ab	1.75	7.8 a
5.	G22	42 e	34 e	1.10 d	0.90 d	2.00	5.5 b
6.	G24	52 a-c	47 b	1.75 cd	1.62 a-c	1.75	2.5 c
7.	G26	47 c-e	43 c	2.77 ab	1.87 a-c	1.25	7.5 a
8.	G32	54 ab	44 c	2.79 ab	1.85 a-c	1.75	8.3 a
9.	G33	48 c-e	45 bc	2.11 bc	2.06 ab	1.50	3.3 c
10.	G37	46 de	38 d	2.10 bc	1.62 a-c	1.75	5.3 b
11.	G40	49 b-d	37 d	2.37 bc	2.21 a	2.25	3.0 c
12.	G45	52 a-c	40 d	2.65 ab	1.53 bc	2.25	7.8 a
CV(%)		7.05	3.9	21.6	22.5	39.3	13.4

Within column values followed by same letter (s) did not differ significantly at $p < 0.05$ by DMRT

Table 3. Comparative salt tolerance group of wheat genotypes based on RTDW and visual scoring methods under validity test

Sl. No.	Genotypes	RTDW (%)			Visual score		Final rating
		Value	Scale	Score	Scale	Score	
1.	G1	49	7	HS	7.8	S	S
2.	G11	78	4	MT	5.3	MT	MT
3.	G15	44	7	HS	7.3	S	S
4.	G18	69	5	S	7.8	S	S
5.	G22	82	3	MT	5.5	MT	MT
6.	G24	93	2	T	2.5	T	T
7.	G26	67	5	S	7.5	S	S
8.	G32	66	5	S	8.3	S	S
9.	G33	94	2	T	3.3	T	T
10.	G37	77	4	MT	5.3	MT	MT
11.	G40	93	2	T	3.0	T	T
12.	G45	58	6	S	7.8	S	S

T = Tolerant, MT = Medium tolerant, S = Susceptible and HS = Highly susceptible

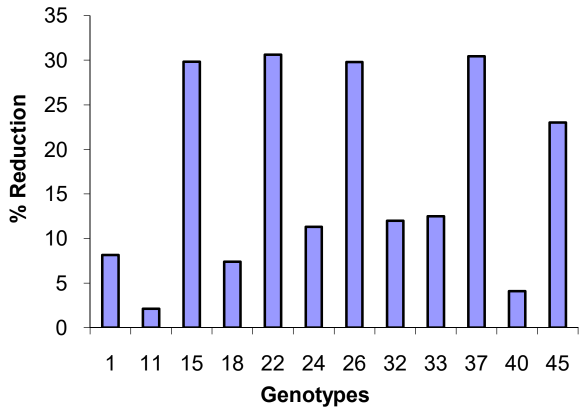

Figure 1. Reduction of shoot length of 12 selected genotypes of wheat

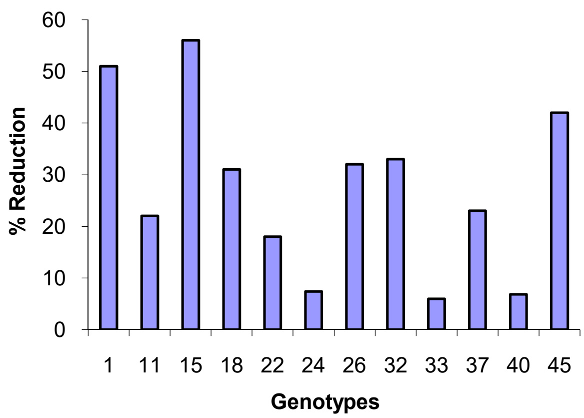

Figure 2. Reduction of shoot dry matter of 12 selected genotypes of wheat.

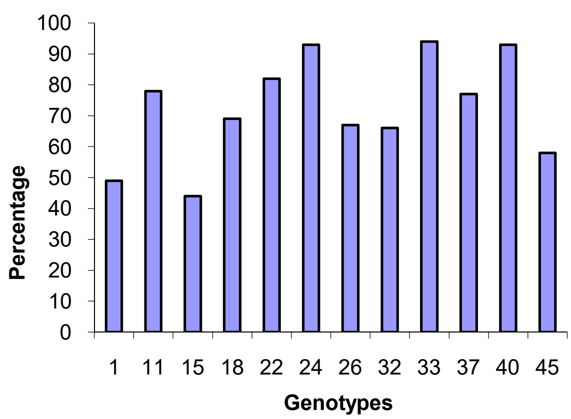

Figure 3. Relative total dry matter of 12 selected genotypes of wheat.

Comparative salt tolerance group of wheat genotypes based on RTDM and visual scoring methods is presented in Table 3. The distribution pattern of the genotypes into various salinity tolerance groups indicates that the overall pattern of behaviors of be the genotypes tested remain fairly constant under two methods. G1 and G15 showed highly susceptible in RTDM and these genotypes changed to susceptible in scoring method. However, other genotypes did not change their rank. The genotypes G24, G33and G40 proved to be the tolerant while G11, G22and G37were the moderately tolerant and other genotypes were the susceptible to salinity. Ray and Islam (2007) reported that varieties were different in their reactions from tolerant to moderately tolerant and moderately tolerant to susceptible but not tolerant to susceptible or vice versa.

The results presented in this study 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 seedlings under saline condition 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) and Aziz *et al.* (2006) 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, 1987; Ashraf *et al.,* 1990; Ashraf, 1994; 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 also 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 this study it is observed that salt tolerant genotype was found to be less affected at high salinity and could be produced better TDM compared to other genotypes. Three genotypes G24, G33 and G40 proved to be the tolerant.

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