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PERFORMANCE OF WHEAT (*Triticum aestivum* L.) GENOTYPES UNDER DIFFERENT LEVELS OF SALT STRESSES

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ABSTRACT

Studying genetic variability for abiotic stresses like salt is important for crop improvement. To identify the genotypic diversity of wheat for salt tolerance, this study was carried out at Regional Agricultural Research Station, Bangladesh Agricultural Research Institute, Rahmatpur, Barisal in 2007-2008 using 12 genotypes under five different salinity levels (e.g. 4, 8, 12, 16 dS/m) and control. Plant morphological and yield contributing traits showed a range of variability. Genotypic variabilities were more prominent in plant height, number of spikes plant^{-1}, number of grains plant^{-1}, 100-grain weight and grain yield plant^{-1}. Genotype G40 ranked top for most of the yield related traits followed by G33. While, G24 outperformed over all the genotypes for 100-grain weight and grain yield per plant. There was no effect of heading on salinity though other plant characters were affected by increasing level of salinity. Considering the responses of plant characters to salinity G40, G33 and G24 were found to be more salt tolerant than others. These three genotypes can therefore be useful for further genetic and physiological study.

Key words: Wheat (*Triticum aestivum* L.); salt tolerance; genetic variation; abiotic stress

INTRODUCTION

Wheat *(Triticum aestivum* L.*)* is one of the important cereal crops widely and intensively grown all over the world. Major world production comes from the south temperate zones. Wheat ranks first in acreage and production among the crops of the world (FAO, 2000). In Bangladesh, wheat is the second most important cereal next to rice. The winter season of Bangladesh is favorable for wheat cultivation. Wheat is gaining popularity as a staple food of the country day by day. It plays a vital role in the national economy and reduces the deficit between the food production and food import. Due to continuous food shortage, changing of food habit and introduction of dwarf type high yielding varieties, cultivation of wheat has become popular to the farmers of Bangladesh. In terms of food value, wheat is more nutritious than rice.

On a global scale, nearly 40% of the earth's land surface is potentially endangered by salinity problems (Orcutt and Nilsen, 2000). Bangladesh has almost 3

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million hectares of land affected by salinity, mainly in the coastal and southeastern districts with EC values ranging from 4 to 16 dS/m (Zaman and Bakri, 2003). This salinity is caused primarily by sea water intrusion in both surface and ground water. More areas are under threat of salinisation due to the effect of sea level rise, coastal subsidence, increased tidal effect and continuous reduction of river flow, particularly during dry period (Nishat and Chowdhury, 1986; World Bank, 1996). It is estimated that, by the year 2020, Bangladesh will have 880 million m^3 shortage of freshwater. On the other hand, it would need to extend irrigation from the current 1.9 to 6.9 million hectares of land for agricultural purpose that will add a hues pressure on the surface and ground water systems (BCAS, 1998). Therefore, the study was done to examine the variability of twelve wheat genotypes to salinity stresses in order to develop or identify salinity tolerant genotype.

MATERIALS AND METHODS

The experiment was conducted at the Experimental Farm of the Regional Agricultural Research Station, Rahmatpur, Barisal which lies at the 22^0 42″ North latitude and 90^0 23″ East longitude at an elevation of 4 meter above the sea level. It belongs to the Non-calcareous Grey Floodplain Soils (Non saline, Ganges Tidal Alluvium) under AEZ 13 (BARI, 1997). The experiment comprised 12 (twelve) genotypes of wheat collected from Wheat Research Centre (WRC), Bangladesh Agricultural Research Institute (BARI), Joydebpur, Gazipur and five doses of salinity: 0 (control), 4, 8, 12, 16 dS/m in pot culture under natural light during crop seasons of 2007-08 in a randomized complete block design (RCBD) with three replications consisting of two factors i.e; A is genotype and B is salinity level.

Table 1. List of wheat genotypes with pedigree and source used in this experiment

Genotype code #	Variety/Line/Pedigree	Source
G1	Akber	Wheat Research Centre, BARI, Gazipur
G11	Shatabdi	
G15	JUN/PRL	
G18	Barkat/Bulbul	
G22	Chirya-3	
G24	PVN/BL1022	
G26	RAWAL-87	
G32	YIE86-60774	
G33	AKR/BALAKA//FAN/PVN	
G37	G162/BL1316//NL-297	
G40	KRL 1-4	
G45	RAWAL87//BUC/BJY	

Salt solution was prepared artificially by dissolving calculated amount of commercially available NaCl with tap water to make 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 until maturity (Ashraf *et al.*, 1990).

RESULTS AND DISCUSSION

Mean and relative values of growth, yield and yield contributing characters at different salinity levels:

Seedling height at 30 DAS (Table 2)

The highest mean seedling height was observed in G15 at control (48.67 cm), in G22 at 4 dS/m (49.00 cm) and at 8 dS/m (47.67 cm) and in G33 at 12 dS/m (47.33 cm) and at16 dS/m (47.67 cm). Again the lowest seedling height was found in G37 at control (42.33 cm), in G45 at 4 dS/m (42.00 cm) and in G11 at 12 dS/m (39.33 cm) and at 16 dS/m (36.00 cm). The relative seedling height (% relative to control) appeared that two genotypes G22 and G37 produced above 100% relative seedling height at 4 dS/m and 8 dS/m. It means that these two genotypes are less affected at 4 dS/m and 8 dS/m salinity level. At 12 dS/m G1, G22, G33 and G37 produced above 90% relative seedling height. Again, at 16 dS/m, G1, G18, G22, G32 and G33 produced above 90% relative seedling height, suggesting these genotypes are less affected at higher salinity levels.

Table 2. Mean and relative values of seedling height (cm) of twelve wheat genotypes at five salinity levels

Genotype	Salt treatment – Electrical conductivity dS/m								
	Mean seedling height (cm)					Relative seedling height (cm)			
	0 dS/m	4 dS/m	8 dS/m	12 dS/m	16 dS/m	4 dS/m	8 dS/m	12 dS/m	16 dS/m
G1	44.00	43.00	41.67	41.33	41.33	97.72	94.70	93.93	93.93
G11	44.67	44.00	39.33	36.67	36.00	98.50	88.05	82.09	80.59
G15	48.67	46.33	41.33	41.33	40.33	95.12	84.92	84.92	82.86
G18	47.67	46.00	46.00	39.00	46.00	96.50	96.50	81.81	96.50
G22	46.33	49.00	47.67	44.33	42.33	105.7	102.9	95.68	91.37
G24	47.67	44.33	40.00	37.67	34.67	92.99	83.91	79.02	72.73
G26	45.33	45.00	41.67	34.33	36.67	99.27	91.93	75.73	80.90
G32	47.67	43.67	42.00	42.33	47.00	91.61	88.11	88.80	98.59
G33	48.00	46.33	45.67	47.33	47.67	96.52	95.15	98.60	99.31
G37	42.33	48.00	46.67	42.00	37.33	113.4	110.3	99.22	88.19
G40	42.67	43.33	41.33	36.00	37.67	101.6	96.86	84.37	88.28
G45	47.67	42.00	41.67	39.33	39.33	88.11	87.41	82.50	82.50
LSD (0.05)			6.53						

Table 3. Mean and relative values of shoot dry matter (g/plant) of twelve wheat genotypes at five salinity levels

Genotype	Salt treatment – Electrical conductivity dS/m								
	Mean shoot dry matter (g/plant)					Relative shoot dry matter(g/plant)			
	0 dS/m	4 dS/m	8 dS/m	12 dS/m	16 dS/m	4 dS/m	8 dS/m	12 dS/m	16 dS/m
G1	2.03	1.84	1.35	0.86	0.62	90.64	66.50	42.36	30.54
G11	1.25	1.11	1.25	0.95	0.92	88.80	100.0	76.00	73.60
G15	1.65	1.31	0.98	1.02	0.94	79.39	59.39	61.82	56.97
G18	1.63	1.59	1.35	1.13	1.10	97.55	82.82	69.33	67.48
G22	1.69	1.62	1.36	1.24	1.49	95.86	80.47	73.37	88.17
G24	1.37	1.30	1.35	1.51	1.28	94.89	98.54	110.2	93.43
G26	1.35	1.29	1.18	1.09	0.92	95.56	87.41	80.74	68.15
G32	2.16	1.84	1.48	1.18	0.96	85.19	68.52	54.63	44.44
G33	1.45	1.43	1.67	1.71	1.36	98.62	115.2	117.9	93.79
G37	1.11	1.13	1.08	0.98	0.95	101.8	97.30	88.29	85.59
G40	1.64	1.60	1.54	1.54	1.49	97.56	93.90	93.90	90.85
G45	2.12	1.91	1.71	1.48	1.24	90.09	80.66	69.81	58.49
LSD (0.05)			0.15						

Shoot dry matter (Table 3)

The highest mean shoot dry matter was obtained in the genotype G32 at control (2.16 g/plant), followed by G45 at 4 dS/m (1.91 g/plant) and at 8 dS/m (1.71 g/plant), G33 at 12 dS/m (1.71 g/plant) and G22 at 16 dS/m (1.49 g/plant). The lowest was in G1 at 16 dS/m (0.62 g/plant), G11 at 4 dS/m (1.11 g/plant), G15 at 8 dS/m (0.98 g/plant), G1 at 12 dS/m (0.86 g/plant) and 16 dS/m (0.62 g/plant). The relative shoot dry matter showed that all genotypes except G11, G15 and G32 produced above 90% relative shoot dry matter at 4 dS/m but at 8 dS/m five genotypes such as G11, G24, G33, G37 and G40 exhibited above 90% relative shoot dry matter. Again, above 90% relative shoot dry matter was obtained in G24, G33 and G40 at 12 dS/m and at 16 dS/m salinity level. G1 at 12 dS/m and G1 and G32 at 16 dS/m produced below 50% relative shoot dry matter.

Days to maturity (Table 4)

The earliest days to maturity was obtained in G32 at 8 dS/m which was followed by G18 at 12 dS/m (96.67) in G32 at 12 dS/m (97) and at 16 dS/m and G18 at control (98%). The latest days to maturity was observed in G45 at control (109.00), in G37 at 4 dS/m (110.67) and at 16 dS/m (103.00), in G33 at 8 dS/m (106.00), and in G15 at 12 dS/m (103.67). The relative days to maturity shows that all genotypes exhibited above 90% relative days to maturity except G45 at 4 dS/m (89%) salinity level.

Table 4. Mean and relative values of days to maturity of twelve wheat genotypes at five salinity levels

Genotype	Salt treatment – Electrical conductivity dS/m								
	Mean days to maturity					Relative days to maturity			
	0 dS/m	4 dS/m	8 dS/m	12 dS/m	16 dS/m	4 dS/m	8 dS/m	12 dS/m	16 dS/m
G1	104.7	100.0	102.0	102.0	99.33	95.54	97.45	97.45	94.89
G11	106.7	99.33	103.3	101.0	100.33	93.12	96.87	94.68	94.06
G15	103.3	101.7	105.3	103.7	95.67	98.39	101.9	100.3	92.59
G18	98.33	96.67	96.00	99.00	97.67	98.31	97.63	100.7	99.33
G22	106.3	98.67	105.3	100.0	100.00	92.80	99.06	94.05	94.05
G24	105.3	108.0	99.00	98.33	96.67	102.5	94.00	93.35	91.78
G26	102.7	98.67	101.0	98.67	100.00	96.10	98.37	96.10	97.40
G32	99.67	97.67	95.33	97.00	96.67	97.33	95.65	97.32	96.99
G33	105.0	98.00	106.0	99.33	97.67	93.33	100.9	94.60	93.02
G37	108.3	110.7	101.7	98.67	103.00	102.2	93.85	91.08	95.08
G40	104.3	98.33	100.7	98.33	102.33	94.25	96.49	94.25	98.08
G45	109.0	97.00	102.3	102.0	102.67	89.00	93.88	93.58	94.19
LSD (0.05)			5.01						

Plant height (Table 5)

The highest mean plant height was observed in G15 at control (86.67 cm) and at 4 dS/m (82.67 cm), in G37 at control (86.67 cm) and at 8 dS/m (82.67 cm), in G40 at 12 dS/m (80.00 cm), and in G33 at 16 dS/m (85.00 cm). Again, the lowest plant height was found in G26 at control (77.00 cm) and at 4 dS/m (65.67 cm), in G32 at 8 dS/m (68.00 cm), in G45 at 12 dS/m (60.67 cm) and at 16 dS/m (49.67 cm).

The relative plant height (% relative to control condition) shows that two genotypes namely G33 and G40 produced above 100% relative plant height at 16 dS/m and at 4 dS/m salinity, respectively. It means that these two genotypes are less affected at 16 dS/m and 4 dS/m salinity levels. At 4 dS/m G11, G15, G32, G33, G40 and G45 produced above 90% relative plant height. G1, G22, G24, G26, G33, G37 and G40 exhibited above 90% relative plant height at 8 dS/m salinity level. At 12 dS/m, above 90% relative plant height was found in G24, G33 and G40. Again, at 16 dS/m, G24, G33 and G40 had above 90% relative plant height.

Table 5. Mean and relative values of plant height (cm) of twelve wheat genotypes at five salinity levels

Genotype	Salt treatment – Electrical conductivity dS/m								
	Mean plant height (cm)					Relative plant height (cm)			
	0 dS/m	4 dS/m	8 dS/m	12 dS/m	16 dS/m	4 dS/m	8 dS/m	12 dS/m	16 dS/m
G1	82.67	71.33	76.67	72.33	67.33	86.28	92.74	87.49	81.44
G11	85.00	77.67	72.33	71.33	72.67	91.38	85.09	83.92	85.49
G15	86.67	82.67	76.00	71.00	66.67	95.38	87.69	81.92	76.92
G18	81.33	69.00	68.33	66.00	61.67	84.84	84.02	81.15	75.83
G22	78.33	69.00	74.33	63.00	67.67	88.09	94.89	80.43	86.39
G24	82.33	68.00	79.00	76.00	75.33	82.59	95.96	92.31	91.50
G26	77.00	65.67	71.33	64.33	63.67	85.29	92.64	83.55	82.69
G32	79.00	78.00	68.00	63.67	58.33	98.73	86.08	80.59	73.84
G33	82.67	79.00	82.33	79.67	85.00	95.56	99.59	96.37	102.8
G37	86.67	70.33	82.67	72.67	71.33	81.15	95.38	83.85	82.30
G40	82.00	82.33	79.00	80.00	80.00	100.4	96.34	97.56	97.56
G45	83.00	76.67	68.67	60.67	49.67	92.37	82.73	73.10	59.84
LSD (0.05)			7.04						

Table 6. Mean and relative values of number of spikes/plant of twelve wheat genotypes at five salinity levels

Genotype	Salt treatment – Electrical conductivity dS/m								
	Mean spikes/plant (no.)					Relative spikes/plant (no.)			
	0 dS/m	4 dS/m	8 dS/m	12 dS/m	16 dS/m	4 dS/m	8 dS/m	12 dS/m	16 dS/m
G1	5.67	5.50	4.67	3.67	2.84	97.00	82.36	64.73	50.08
G11	5.17	4.83	5.00	3.50	4.33	93.42	96.71	67.69	83.38
G15	4.33	3.67	4.33	3.17	2.83	84.76	100.00	73.21	65.36
G18	4.67	4.50	4.33	3.50	2.67	96.35	92.72	74.95	57.17
G22	5.33	5.17	3.83	3.17	4.17	96.99	71.85	59.47	78.24
G24	6.00	5.67	5.83	5.50	5.50	94.50	97.17	91.67	91.67
G26	4.67	4.34	4.33	3.17	3.17	92.94	92.72	67.88	67.88
G32	4.50	4.17	4.17	3.17	2.83	92.66	92.67	70.44	62.89
G33	5.67	5.67	5.33	5.17	4.84	100.0	94.00	91.18	85.36
G37	4.33	3.50	3.83	3.67	4.17	80.83	88.45	84.76	96.30
G40	6.34	5.87	5.50	5.33	5.51	92.59	86.75	84.07	86.91
G45	4.67	3.33	4.00	3.67	3.17	71.30	85.65	78.59	67.88
LSD (0.05)			1.07						

Number of spikes per plant (Table 6)

The highest number of spikes per plant was in G40 at control (6.34), at 4 dS/m (5.87) and at 16 dS/m (5.51). G24 showed the highest at 8 dS/m (5.83) and at 12 dS/m (5.50) salinity levels. The lowest number was observed in G15 and G37 at control (4.33), in G45 at 4 dS/m (3.33), in G22 and G37 at 8 dS/m (3.83). in G15, G22, G26 and G32 at 12 dS/m (3.17). Again G18 showed the lowest value at 16 dS/m (2.67). The relative number of spikes per plant showed that two genotypes G33 and G15 produced above 100% relative number of spikes per plant at 4 and 8 dS/m, respectively. G1, G11, G18, G22, G24, G26, G32 and G40 exhibited above 90% relative number of spikes per plant at 4 dS/m. At 8 dS/m salinity level, above 90% relative number of spikes per plant was observed in G11, G18, G24, G26, G32 and G33. G24 exhibited above 90% relative number of spikes per plant at 12 dS/m and 16 dS/m salinity levels. G33 and G37 produced above 90% relative number of spikes per plant at 12 and 16 dS/m salinity level, respectively. Only G1 exhibited below 50% relative number of spikes per plant at 16 dS/m salinity level.

Hundred grain weight (Table 7)

The highest mean 100-grain weight was found in G33 at all salt treatment that is at control (5.27g), at 4 dS/m (5.23g), at 8 dS/m (5.08g), at 12 dS/m (5.03g) and at 16 dS/m (4.51). The lowest 100-grain weight was observed in G1 at control (4.25g), in G22 at 4 dS/m (2.87g), in G32 at 8 dS/m (3.20g), at 12 dS/m (2.70g) and at 16 dS/m (2.31) salt treatments. The relative values of 100-grain weight shows that three genotypes G24, G33 and G40 produced above 90% relative weight at all salinity levels except G33 and G40 at 16 dS/m (85%) salinity level. Rest of these genotypes G1, G11, G18 and G26 exhibited above 90% relative value at 4 dS/m. Only G11 showed above 90% at 8 dS/m level. It was observed that G24, G33 and G40 genotypes were less affected in their grain weight under increased salinity.

Table 7. Mean and relative values of 100-grain weight (g) of twelve wheat genotypes at five salinity levels

Genotype	Salt treatment – Electrical conductivity dS/m								
	100-grain weight (g)					Relative 100-grain weight (g)			
	0 dS/m	4 dS/m	8 dS/m	12 dS/m	16 dS/m	4 dS/m	8 dS/m	12 dS/m	16 dS/m
G1	4.25	3.93	3.47	3.30	2.95	92.47	81.65	77.65	69.41
G11	5.07	4.95	4.63	4.22	3.96	97.63	91.32	83.23	78.11
G15	4.57	3.97	3.59	3.13	2.83	86.87	78.56	68.49	61.93
G18	4.56	4.24	3.45	2.92	2.74	92.98	75.66	64.04	60.09
G22	4.37	2.87	3.53	3.16	3.64	65.68	80.78	72.31	83.30
G24	5.02	4.98	4.92	4.80	4.53	99.20	98.01	95.61	90.24
G26	5.21	4.72	4.24	3.30	3.23	90.60	81.38	63.34	62.00
G32	4.51	4.02	3.20	2.70	2.31	89.14	70.95	59.87	51.22
G33	5.27	5.23	5.08	5.03	4.51	99.24	96.39	95.44	85.58
G37	4.95	4.14	4.26	3.76	3.64	83.64	86.06	75.96	73.54
G40	4.72	4.41	4.38	4.31	4.10	93.43	92.80	91.31	86.86
G45	4.97	4.40	4.09	3.69	3.13	88.53	82.29	74.25	62.98
LSD (0.05)			1.46						

Grain yield per plant (Table 8)

The highest mean grain yield per plant was produced in G40 at all salt treatments, that is at control (8.82 g/plant), at 4 dS/m (8.43 g/plant), at 8 dS/m (8.42 g/plant), at 12 dS/m (8.35 g/plant) and at 16 dS/m (7.70 g/plant). The lowest grain yield per plant was exhibited in G18 at control (6.06 g/plant) and at 8 dS/m (4.13 g/plant), in G22 at 4 dS/m (5.60 g/plant) and in G26 at 12 dS/m (2.55 g/plant) and at 16 dS/m (1.29 g/plant) salinity levels. Again, the relative grain yield per plant shows that four genotypes namely G11, G18, G24, G33 and G40 produced above 90% relative grain yield per plant at 4 dS/m but at 8 dS/m, three genotypes namely G24, G33 and G40 exhibited above 90% and at 12 dS/m, two genotypes G24 and G40 produced above 90%. It appears that these two genotypes were tolerant to salinity at different salt treatments. From the results it is clear that the increased salinity decreased the tolerance. 50%

relative grain yield per plant was observed in G15, G18, G26, G32 and G45 at 12 dS/m. G1, G15, G18, G26, G32 and G45 at 16 dS/m produced below 50% relative grain yield per plant.

Table 8. Mean and relative values of grain yield/plant (g) of twelve wheat genotypes at five salinity levels

Genotype	Salt treatment – Electrical conductivity dS/m								
	Mean grain yield/plant (g)					Relative grain yield/plant (g)			
	0 dS/m	4 dS/m	8 dS/m	12 dS/m	16 dS/m	4 dS/m	8 dS/m	12 dS/m	16 dS/m
G1	8.63	7.02	6.13	4.31	2.97	81.34	71.03	49.94	34.41
G11	8.17	7.48	7.08	5.62	4.51	91.55	86.66	68.79	55.20
G15	8.06	6.93	5.48	3.97	2.57	85.98	67.99	49.26	31.89
G18	6.06	5.88	4.13	2.97	1.53	97.03	68.15	49.01	25.25
G22	8.10	5.60	6.76	5.74	4.06	69.14	83.46	70.86	50.12
G24	7.71	7.50	7.40	7.15	6.50	97.28	95.98	92.74	84.31
G26	6.92	5.92	4.15	2.55	1.29	85.55	59.97	36.85	18.64
G32	8.23	6.56	5.28	2.99	1.86	79.71	64.16	36.33	22.60
G33	8.81	8.33	8.21	7.23	6.57	94.55	93.19	82.07	74.57
G37	7.61	6.27	6.08	4.58	3.01	82.39	79.89	60.18	59.55
G40	8.82	8.43	8.42	8.35	7.70	95.58	95.46	94.67	87.30
G45	8.50	6.77	5.84	4.13	2.31	79.65	68.70	48.59	27.18
LSD (0.05)			0.54						

From the discussion it was clear that increased salinity decreased tolerance. Considering grain yield per plant and other related parameters at different salinity levels, G40 performed the best in both absolute and relative values followed by G24 and G33. Salt tolerant genotype was expected to be less affected at high salinity level.

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