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EFFECT OF NaCl INDUCED SALINITY ON SOME PHYSIOLOGICAL AND AGRONOMIC TRAITS OF WHEAT

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Abstract

Wheat genotypes were evaluated for salt stress at early seedling stage (solution culture) and maturity (pot culture) at Crop Physiology and Ecology Laboratory, Hajee Mohammad Danesh Science and Technology University, Dinajpur, Bangladesh. Shoot length, root length, root to shoot length ratio and seedling dry weight of 15 days old seedlings were found to be reduced at 12 dS m^{-1} salinity level compared to control condition. Based on seedling dry weight Shatabdi, BARI Gom 25, BARI Gom 26, BAW 1111, BAW 1146, BAW 1154 and BAW 1156 were identified as salt tolerant (STI = >0.70); BAW 1130, BAW 1135 and BAW 1142 were salt sensitive (STI = <0.60) and other ten were screened as moderately salt tolerant (STI = 0.60 to 0.70) wheat genotypes. Out of twenty genotypes, two salt tolerant (Shatabdi and BARI Gom 25) and two salt sensitive (BAW 1130 and BAW 1142) wheat genotypes were grown in pot irrigated with three levels of saline water (control, 6 dS m^{-1} and 12 dS m^{-1}). Salt tolerant wheat genotypes maintained lower level of leaf Na, higher level of leaf K, greater K to Na ratio, increased level of flag leaf proline and greater flag leaf SPAD value in saline condition than the sensitive ones. Salt sensitive genotypes affected more in spikes plant^{-1}, grains spike^{-1}, grain dry weight spike^{-1}, 100 grain weight and grain yield plant^{-1} under saline condition than salt tolerant genotypes.

Key words: Salinity stress, K/Na, Root/shoot length, Physiological traits and wheat.

Introduction

Wheat (*Triticum aestivum* L.) is the 1st ranking cereal crop globally and major staple food for more than one third of the world population rather than the main staple food for Asia (Shirazi *et al*., 2001). In Bangladesh, wheat is cultivated as a 2nd important cereal crop in the north and north-west parts of the country but a vast coastal salty area of southern parts remains fallow (seasonal or complete) and introduction of wheat cultivation in these areas may become a worthy effort to utilize these lands to meet up the food and nutritional deficit of the ever increasing population of Bangladesh. Due to climate change the area affected by soil salinity in Bangladesh increased from about 0.83 million ha in 1973 to 1.02 million ha in 2000, and 1.05 million ha in 2009 (Anon., 2010). Soil salinity is one of the major environmental stresses affecting plant growth and productivity (Allakhverdiev *et al*., 2000). Salt stress results in a considerable decrease in the fresh and dry weights of leaves, stems, tillers, fertile tillers and roots (Chartzoulakis & Klapaki, 2000). Increased NaCl salinity increases Na^+ and Cl^- and decreases in Ca^{2+}, Mg^{2+} and K^+ levels in number of plant (Khan *et al*., 1999). There is a negative relationship between Na^+ and K^+ concentration in roots and leaves which indicates that a greater degree of salt tolerance in plant is associated with a more efficient system for selective uptake of K^+ over Na^+ (Noble & Roger, 1992). Selection of salt tolerant wheat genotypes may be a feasible and economical approach for utilizing the salt affected areas. 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). Therefore, considering the above facts the present studies were taken to find out the effect of salinity on seedling growth, physiological traits, yield attributes and yield of wheat.

Materials and Methods

The investigation was conducted in two separate experiments at laboratory of Crop Physiology and Ecology Department, Hajee Mohammad Danesh Science and Technology University, Dinajpur, Bangladesh. The first experiment was performed at laboratory to screen the salinity tolerant genotypes in hydroponic culture during the period from October to November 2010. This experiment was carried out in two factors completely randomized design with three replications. The treatment factors were two salinity levels (Control i.e. 1.5 dS m^{-1} and 12 dS m^{-1}) and twenty wheat genotypes (Shatabdi, Prodip, BARI Gom 26, BARI Gom 25, BAW 1111, BAW 1118, BAW 1130, BAW 1135, BAW 1138, BAW 1140, BAW 1122, BAW 1142, BAW 1143, BAW 1146, BAW 1147, BAW 1148, BAW 1150, BAW 1153, BAW 1154 and BAW 1156). The germinated seeds were transferred just after two days to styrofoam stage suspended over 30 liters of Steiner nutrient solution in plastic bowls which was prepared according to the method of Steiner (1984). The solution was aerated with air compressor (Model-SB 248 A) during the day time at least for 8 hours. After 2 days required amount of NaCl was added to salinize the medium in increment of 2 dS m^{-1} per day up to the final salinity (12 dS m^{-1}) in one bowl while the other bowl NaCl was treated as non saline (Control 1.5 dS m^{-1}). Fifteen days old seedlings were harvested after the application of salinity levels. Shoot length and root length of seedlings were recorded manually. Seedling dry weight was taken by digital balance (Model- AND EK- 300 i) after drying the samples in drying oven (Model- E28# 03-54639, Binder, Germany) at 70ºC for 72 hours. The Salt tolerance index (STI = Variable measured under stress condition/Variable measured under normal condition) based on seedling dry weight was calculated as Goudarzi & Pakniyat (2008).

The second experiment was conducted in earthen pot inside the net house for studying the physiological traits, yield attributes and yield of wheat genotypes under different salinity levels during December 2010 to April 2011. The experiment was carried out in two factors completely randomized design with four replications. The treatment factors were three salinity levels (control- 1.5 dS m^{-1}, moderate- 6 dS m^{-1} and high- 12 dS m^{-1}) and four wheat genotypes (two salt tolerant viz., Shatabdi and BARI Gom 25, and two salt sensitive viz. BAW 1130 and BAW 1142) selected from first experiment. Each pot (25×30 cm^2) was filled with 10 kg of air dried soil mixed with cowdung and a fertilizer dose of N-P-K-S-Zn-B (140-35-75-18-2-0.5 kg ha^{-1}) was applied in the form of urea, triple supper phosphate, muriate of potash, gypsum, zinc sulphate and boric acid, respectively. Ten wheat seeds were sown in each earthen pot and finally five uniform, healthy plants were maintained. Intercultural operations like weeding and normal irrigation were done as per requirement. Twelve days after sowing, sufficient quantities of salt solution was applied in each treated pot. Salt solution was prepared artificially by dissolving calculated amount of commercially available NaCl with tap water. Tap water was used as control. Two liter of salt solution was applied in each pot. Salt solution was applied once in a week. Spikes $plant^{-1}$, grains $spike^{-1}$, grain dry weight $spike^{-1}$, 100 grain weight and grain yield $plant^{-1}$ were recorded properly. The SPAD value was taken from middle portion of the flag leaf of five main shoot at anthesis using SPAD meter (Model: Minolta, Chlorophyll Meter, SPAD-502, JAPAN). Proline content of flag leaf at 16 days after anthesis was estimated according to Bates *et al.* (1973) and the flag leaves were analyzed for soluble salts (Na^+, K^+ and K^+/Na^+ ratio) after extraction with 0.1 M Acetic acid as described by Ansari & Flowers (1986). Salt susceptibility index (SSI) was calculated based on grain yield as Fischer and Maurer (1978). The data were analyzed statistically i.e. analysis of variance (ANOVA) and treatment means were compared by Duncan's New Multiple Range Test (DMRT) with the help MSTAT computer program.

Results

Growth parameters: In hydroponic culture, the growth parameters like shoot length, root length, root to shoot length ratio and dry weight of 15 days old seedlings and STI based on root to shoot length ratio of twenty wheat genotypes as influenced by salinity levels is presented in Table 1. The shoot length and root length of seedlings were found significantly higher at normal saline condition (18.007 to 24.183 cm and 11.113 to 22.233 cm, respectively) compared to 12dSm^{-1} salinity level (12.933 to 18.740 cm and 6.293 to 11.507 cm, respectively). There were 6.45 to 36.80% shoot length and 19.67 to 62.93% root length reduction. The root to shoot length ratio was found higher at control for all the wheat genotypes except in BARI Gom 25 (-9.29) in which the ratio even increased in saline condition. Dry weight of seedlings also higher at control (ranging 23.66 to 37.66 mg $seedling^{-1}$ and mean 30.86 mg $seedling^{-1}$) compared to 12 dSm^{-1} salinity level (ranging 18.00 to 26.66 mg $seedling^{-1}$ and mean 20.58 mg $seedling^{-1}$). Due to salt sensitivity Prodip, BAW 1118, BAW 1130, BAW 1135, BAW 1138, BAW 1140, BAW 1122, BAW 1142 and BAW 1147 showed more than 35% reduction in dry weight of seedling. Shatabdi, BARI Gom 25, BARI Gom 26 and BAW 1156 showed less than 25% reduction in dry weight of seedling, whereas the other wheat genotypes affected moderately by salinity. Based on seedling dry weight Shatabdi, BARI Gom 25, BARI Gom 26, BAW 1111, BAW 1146, BAW 1154 and BAW 1156 showed more than 0.70 STI value were screened as salt tolerance (ST) genotypes, the wheat genotypes (BAW 1130, BAW 1135 and BAW 1142) provided less than 0.60 STI value were classified as salt sensitive (SS) genotypes and the other wheat genotypes (Prodip, BAW 1148, BAW 1138, BAW 1140, BAW 1122, BAW 1143, BAW 1147, BAW 1148, BAW 1150, BAW 1153) showed 0.60 to 0.70 STI value and were treated as moderately salt tolerance (MST) genotypes.

Physiological parameters: The SPAD values, flag leaf proline, leaf Na, leaf K and leaf K/Na ratio were significantly influenced by the interaction effect of salinity level and wheat genotypes in pot culture (Table 2). The SPAD value was increased in different wheat genotypes at moderate salinity level and the increment was 7.92, 1.23, 1.20 and 5.11% for Shatabdi, BARI Gom 25, BAW 1130 and BAW 1142, respectively over control. At high salinity level the SPAD value was reduced more in salt sensitive BAW 1142 and BAW 1130 (11.82 and 11.65%, respectively) than salt tolerant Shatabdi and BARI Gom 25 (1.67, and 3.69%, respectively). Under normal condition, the highest amount of proline was found in Shatabdi (2.13 μ mole g fresh $weight^{-1}$) followed by BAW 1130 and BAW 1142 (1.91 and 1.85 μ mol/g fresh weight, respectively), whereas BARI Gom 25 produced the lowest amount of proline (1.82 μ mol g fresh $weight^{-1}$). Both moderate and higher salinity level, proline content was increased in Shatabdi (21.13 and 63.38%, respectively) and BARI Gom 25 (31.86 and 56.59%, respectively), but decreased in BAW 1130 (9.95 and 25.65%, respectively) and BAW 1142 (40.54 and 42.16%, respectively). Due to salinization percent Na content of leaf markedly increased over normal condition for Shatabdi, BARI Gom 25, BAW 1130 and BAW 1142 (5.71, 5.88, 5.55 and 23.53%, respectively at moderate salinity and 14.29, 11.76, 33.33 and 64.71%, respectively at high salinity). There was no difference in leaf K content among the four wheat genotypes under control condition but at moderate and high salinity level, the most significant reduction was found in BAW 1130 (9.82 and 12.50%, respectively) followed by BAW 1142 (7.40 and 11.11%, respectively), whereas Shatabdi and BARI Gom 25 showed lower reduction in both cases. At control, the highest K/Na found in BARI Gom 25 (3.29) and the lowest K/Na showed by Shatabdi (3.09). The most K/Na reduction was found in BAW 1142 (46.23%) followed by BAW 1130 (34.41%) at high salinity and the least K/Na reduction was shown by BARI Gom 25 and Shatabdi (8.81and 9.06 %, respectively) under moderate salinity over control.

Table 1. Growth parameters of 15 days old seedling of different wheat genotypes as influenced by salinity levels in hydroponic culture.

Genotype	Shoot length (cm)			Root length (cm)			Root to shoot length ratio			Seedling dry weight (mg seedling^{-1})			STI based on seedling dry weight
	Control (1.5 dS m^{-1})	Saline (12 dS m^{-1})	Relative decrease (%)	Control (1.5 dS m^{-1})	Saline (12 dS m^{-1})	Relative decrease (%)	Control (1.5 dS m^{-1})	Saline (12 dS m^{-1})	Relative decrease (%)	Control (1.5 dS m^{-1})	Saline (12 dS m^{-1})	Relative decrease (%)	
Shatabdi	20.333 cd	14.493 jm	-28.72	13.153 h	7.767 km	-40.94	0.647	0.536	-17.16	34.33 ac	26.66 fj	-22.34	0.776
Prodip	21.907 bc	14.113 lm	-35.58	18.887 bc	9.320 jl	-50.65	0.862	0.659	-23.54	34.00 ac	21.66 jm	-36.29	0.637
BARI Gom 25	19.480 df	14.320 km	-26.49	11.113 ij	8.927 kl	-19.67	0.570	0.623	+9.29	27.00 ei	23.00 im	-14.81	0.851
BARI Gom 26	19.647 df	15.147 jl	-22.90	22.233 a	8.980 kl	-59.60	1.132	0.593	-47.61	25.33 gk	20.33 km	-19.74	0.802
BAW 1111	18.893 df	16.520 gk	-12.56	20.827 a	11.507 i	-44.74	1.102	0.697	-36.75	29.33 cg	21.00 km	-28.40	0.715
BAW 1118	20.013 ce	15.007 jm	-25.01	17.147 cg	7.787 km	-54.58	0.857	0.519	-39.44	28.66 dh	18.00 m	-37.19	0.627
BAW 1130	20.213 ce	14.580 jm	-27.86	18.587 bd	7.460 lm	-59.86	0.920	0.512	-44.35	35.00 ab	19.33 lm	-44.74	0.552
BAW 1135	21.893 bc	17.513 fi	-20.00	16.300 fg	8.553 kl	-47.52	0.745	0.488	-34.49	34.00 ac	18.00 m	-47.06	0.529
BAW 1138	19.040 df	15.780 il	-17.12	16.327 fg	8.680 kl	-46.83	0.858	0.550	-35.89	31.00 bf	20.00 lm	-35.48	0.645
BAW 1140	20.313 cd	18.000 eh	-11.39	16.453 eg	9.440 jl	-42.62	0.810	0.524	-35.30	29.66 cg	18.00 m	-39.31	0.606
BAW 1122	19.793 ce	15.140 jl	-23.50	17.567 bf	7.907 km	-54.98	0.888	0.522	-41.22	32.00 be	19.66 lm	-38.56	0.614
BAW 1142	18.007 eh	12.933 m	-28.18	16.980 cg	6.293 m	-62.93	0.943	0.487	-48.36	35.29 ac	18.66 lm	-47.12	0.529
BAW 1143	23.067 ab	16.127 hl	-30.08	18.887 dg	8.027 km	-52.46	0.732	0.498	-31.96	34.00 ac	23.00 im	-32.35	0.676
BAW 1146	18.813 df	15.200 jl	-19.20	17.067 cg	8.060 km	-52.77	0.907	0.530	-41.56	27.00 ei	19.66 lm	-27.18	0.728
BAW 1147	24.160 a	15.267 jl	-36.80	19.140 b	8.573 kl	-55.20	0.792	0.562	-29.04	37.66 a	23.00 im	-38.93	0.610
BAW 1148	24.183 a	15.307 jl	-36.70	18.553 bd	9.380 jl	-49.44	0.767	0.613	-20.07	33.00 ad	23.00 im	-30.30	0.696
BAW 1150	23.360 ab	18.580 dg	-20.46	15.253 g	8.747 kl	-42.65	0.653	0.471	-27.87	27.66 ei	19.00 lm	-31.31	0.686
BAW 1153	20.033 ce	18.740 df	-6.45	18.347 be	8.620 kl	-53.01	0.916	0.460	-49.78	31.66 bf	21.33 km	-32.63	0.673
BAW 1154	19.340 df	16.340 hl	-15.51	17.447 bf	9.647 jk	-44.70	0.902	0.590	-34.58	27.00 ei	19.66 lm	-27.18	0.728
BAW 1156	19.193 df	16.573 gj	-13.65	16.107 fg	8.933 kl	-44.53	0.839	0.539	-35.76	23.66 hl	18.66 lm	-21.13	0.788
Mean	20.584	15.784	-	17.218	8.630	-	0.842	0.548	-	30.86	20.58	-	-
Level of significance	**		-	**		-	-	-	-	**		-	-
CV (%)	6.31		-	7.78		-	-	-	-	10.53		-	-

Values followed by the different letter(s) are significantly different from each other by DMRT at 5% level

Table 2. Physiological parameters of different wheat genotypes as influenced by salinity levels in pot culture.

Genotypes	Salinity level	SPAD reading		Proline content		Na content of leaf at anthesis		K content of leaf at anthesis		Leaf K to Na ratio	
		Value	Relative increase /decrease (%)	µ mole g fresh weight^{-1}	Relative increase (%)	Na (%)	Relative increase (%)	K (%)	Relative decrease (%)	K/Na	Relative decrease (%)
Shatabdi	Control	48.0 de		2.13 e		0.35 gh		1.08 ab		3.09 bc	
	Moderate	51.8 ab	+ 7.92	2.58 c	+ 21.13	0.37 ef	+ 5.71	1.04 bc	- 3.70	2.81 d	- 9.06
	High	47.2 e	- 1.67	3.48 a	+ 63.38	0.40 d	+ 14.29	1.02 cd	- 5.55	2.55 e	- 17.48
BARI Gom 25	Control	48.8 cde		1.82 fg		0.34 h		1.12 a		3.29 a	
	Moderate	49.4 cd	+1.23	2.40 d	+ 31.86	0.36 fg	+ 5.88	1.08 ab	- 3.57	3.00 c	- 8.81
	High	47.0 e	- 3.69	2.85 b	+ 56.59	0.38 e	+ 11.76	1.04 bc	- 7.14	2.74 d	- 16.72
BAW 1130	Control	49.8 bcd		1.91 f		0.36 fg		1.12 a		3.11 bc	
	Moderate	50.4 bc	+1.20	1.72 g	- 9.95	0.38 e	+ 5.55	1.01 cd	- 9.82	2.66 de	- 14.47
	High	44.0 f	- 11.65	1.42 h	- 25.65	0.48 b	+33.33	0.98 de	- 12.50	2.04 g	- 34.41
BAW 1142	Control	49.9 bcd		1.85 fg		0.34 h		1.08 ab		3.18 ab	
	Moderate	52.6 a	+5.41	1.10 i	- 40.54	0.42 c	+ 23.53	1.00 ce	- 7.40	2.38 f	- 25.16
	High	44.0 f	- 11.82	1.07 i	- 42.16	0.56 a	+ 64.71	0.96 e	- 11.11	1.71 h	- 46.23
Level of significance		**	-	**	-	**	-	**	-	**	-
CV (%)		2.58	-	5.81	-	4.85	-	2.83	-	3.68	-

Values followed by the different letter(s) are significantly different from each other by DMRT at 5% level

Salinity level: Control 1.5 dS m^{-1}, Moderate 6.0 dS m^{-1} and High 12.0 dS m^{-1}

Table 3. Yield attributes and yields of different wheat genotypes as influenced by salinity levels in pot culture.

Genotypes	Salinity level	Spikes plant^{-1}		Grains spike^{-1}		Grain dry weight spike^{-1}		100 grain weight		Grain yield		SSI based on grain yield
		Number plant^{-1}	Relative decrease (%)	Number spike^{-1}	Relative decrease (%)	g spike^{-1}	Relative decrease (%)	g weight	Relative decrease (%)	g plant^{-1}	Relative decrease (%)	
Shatabdi	Control	5.2 ab		38.6 d		1.72 ab		4.52 a		6.67 b		
	Moderate	5.0 abc	- 3.85	37.2 de	- 3.62	1.65 c	- 4.06	4.02 de	- 11.06	4.76 cd	- 28.63	0.958
	High	3.2 e	- 38.46	32.6 g	- 15.54	1.43 e	- 16.86	3.99 de	- 11.72	3.41 e	- 48.87	0.831
BARI Gom 25	Control	4.4 cd		42.4 c		1.77 a		4.34 b		6.38 b		
	Moderate	4.2 d	- 4.54	38.2 de	- 9.90	1.57 d	- 11.29	4.22 bc	- 2.76	4.94 cd	-22.57	0.758
	High	2.8 ef	- 36.36	36.0 ef	- 15.09	1.41 e	- 20.33	4.10 cd	- 5.53	3.36 e	- 47.33	0.805
BAW 1130	Control	5.0 bc		41.4 c		1.66 bc		4.33 b		6.76 b		
	Moderate	4.4 d	- 12.00	34.2 fg	- 17.39	1.58 d	- 4.82	4.02 de	- 7.15	4.21 d	-37.72	1.262
	High	2.2 g	- 56.00	30.0 h	- 27.53	1.32 f	- 20.48	3.77 f	- 12.93	2.18 f	- 67.75	1.152
BAW 1142	Control	5.6 a		48.8 a		1.63 cd		3.87 ef		7.65 a		
	Moderate	5.0 bc	- 10.71	47.8 ab	- 2.04	1.58 d	- 3.06	3.44 g	- 11.11	5.34 c	-30.19	1.010
	High	2.4 fg	- 57.14	46.0 b	- 5.73	1.40 e	- 14.11	3.40 g	- 12.14	2.37 f	- 69.01	1.174
Level of significance		**	-	**	-	**	-	*	-	**	-	-
CV (%)		9.23	-	3.99	-	2.66	-	2.89	-	10.75	-	-

Values followed by the different letter(s) are significantly different from each other by DMRT at 5% level

Salinity level: Control 1.5 dS m^{-1}, Moderate 6.0 dS m^{-1} and High 12.0 dS m^{-1}

Yield attributes and yield: The yield attributes and yield for wheat genotypes under different salinity level is presented in Table 3. Wheat genotypes produced more spikes plant^{-1} (4.4 to 5.6) under control than under salt stress condition (2.2 to 5.0). Comparatively higher reduction was observed in salt sensitive BAW 1142 (57.14%) and BAW 1130 (56.00%) than salt tolerant varieties Shatabdi (38.46%) and BARI Gom 25 (36.36%) under high salinity level over control. The grains spikes^{-1} was also reduced significantly ranging from 5.73 to 27.53% and 2.04 to 17.39% in high and moderate saline condition, respectively. The reduction was inconsistent between tolerant and sensitive genotypes. Under control conditions BARI Gom 25 produced maximum grain weight spike^{-1} (1.77 g) followed by Shatabdi (1.72 g), whereas minimum grain weight spike^{-1} was recorded in BAW 1142 (1.63 g). At moderate and high salinity level the grain weight spike^{-1} was reduced (Shatabdi- 4.06 and 16.86%, BARI Gom 25- 11.29 and 20.33%, BAW 1130- 4.82 and 20.48%, and BAW 1142- 3.06 and 14.11%, respectively) than control. The reduction in 100 grain weight was more in salt sensitive BAW 1130 (12.93%) and BAW 1142 (12.14%) than salt tolerant BARI Gom 25 (5.53%) and Shatabdi (11.72%) under high salinity stress condition. At control condition, significantly the highest grain yield was produced by BAW 1142 (7.65 g plant^{-1}) and the lowest grain yield obtained from BARI Gom 25 (6.38 g plant^{-1}) which was at par BAW 1130 and Shatabdi (6.76 and 6.67 g plant^{-1}, respectively). Due to salinity the grain yield was decreased over normal condition both in salt sensitive and salt tolerant genotypes. But more reduction in grain yield plant^{-1} was found in salt sensitive BAW 1130 and BAW 1142 (37.72 and 30.19%, respectively) than salt tolerant BARI Gom 25 and Shatabdi (22.57 and 28.63%, respectively) under moderate saline condition. Similar results were also found at high salinity level (BAW 1142, BAW 1130, BARI Gom 25 and Shatabdi showed 69.01, 67.75, 47.33 and 48.87% reduction in grain yield plant^{-1}, respectively). Under moderate and high saline condition, the lowest SSI based on grain yield showed by BARI Gom 25 (0.758 and 0.805, respectively) followed by Shatabdi (0.958 and 0.831, respectively), whereas the highest SSI found in BAW 1130 (1.262 and 1.152, respectively) followed by BAW 1142 (1.01 and 1.174, respectively).

Discussion

It was found that the shoot length, root length and seedling dry weight decreased due to salinity stress. These findings are in agreement with Mujeeb *et al*. (2008), Al-Saady (2015) and Khatun *et al.* (2013) who observed that the increase in NaCl concentrations decreased the shoot and root length and biomass of all the wheat cultivars tested in their study. The SPAD value which indicated the greenness of leaf was increased at moderate salinity level but decreased at high saline condition. The reduction of SPAD value was higher in salt tolerant Shatabdi and BARI Gom 25 than salt sensitive BAW 1130 and BAW 1142. The results are in agreement with Hasan *et al*. (2015). Ashraf & McNeilly (1988) also stated that the salinity significantly reduces the total chlorophyll content and the degree of reduction in total chlorophyll depends on salt tolerance of plant species and salt concentrations. It was observed that the salt tolerant wheat genotypes accumulated more proline as compared to sensitive ones both at moderate and high salinity level. The results are in agreement with Ashraf *et al.* (1998) who reported that proline is an important osmolyte to adjust the plant under drought or saline condition. Khan *et al.* (2009) and Hasan *et al*. (2015) also narrated that proline accumulation may play a vital role in the salinity tolerance. Significantly higher increase in leaf Na and less leaf K and K/Na ratio was observed in sensitive genotypes compared to tolerant ones. Similar results were reported earlier (Blum, 1988; Essa, 2002; Zheng *et al*., 2008; Hasan *et al*., 2015; Shamsi & Kobraee, 2013) who stated that salt susceptible cultivars accumulate larger amount of toxic ion (Na^+) in leaf caused a sharp decrease in K^+ content and K/Na ratios, may cause physiological injuries from ion poisoning. In the present study, grain yield plant^{-1} of wheat was reduced under saline condition due to reduction in spikes plant^{-1}, grains spike^{-1} and 100 grain weight. The SSI based on grain yield was higher in sensitive genotypes (BAW 1130 and BAW 1142) than tolerant ones (Shatabdi and BARI Gom 25). These findings are in agreement with Kamkar *et al.* (2004) and Hasan *et al*. (2015), they showed that salinity reduces yield primarily by a severe reduction in spike number, grain number and 1000 grain weight in wheat. Higher reduction in number of grains and mean grain size under saline conditions resulted in considerable decrease in grain yield plant^{-1} was also reported by Grhassemi-Golezani *et al.* (2009). The observation of Goudarzi & Pakniyal (2008) and Hasan *et al*. (2015) were also parallel with our result as they mentioned salt tolerant wheat cultivars having lower Na^+ content, produced higher grain and biological yield under saline conditions. Mass & Poss (1989) also stated that soil salinity decreased more grain yield when plants were affected by stress condition at maximum tillering stage than when stressed at later stages. There was a highly significant negative correlation between grain yield and Na content and also a highly significant negative correlation between grain yield and K : Na content of the wheat genotypes under saline environments (Hasan *et al*., 2015), this findings also supported the present investigation.

Conclusion

Salt tolerant wheat genotypes as screened using STI based on seedling dry weight showed lower level of leaf Na, higher level of leaf K, greater K to Na ratio, more flag leaf proline and higher SPAD value in saline condition than the sensitive one. All these physiological traits contributed to better yield and yield attributes of salt tolerant genotypes under saline condition.

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