Bangladesh Agron. J. 2017, 20 (2): 53-66

SEEDLING GROWTH OF WHEAT AS AFFECTED BY SOIL SALINITY

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(**Received:** 29 May 2017, **Accepted:** 23 August 2017)

Keywords: Wheat genotypes, artificially developed soil salinity and seedling growth

Abstract

An experiment was conducted to evaluate seedling growth of wheat under saline condition. Thirty wheat genotypes were grown in trays containing different levels of salinity (Control, 6 and 12 dSm^{-1}) during October to December, 2013. Seedling emergence index, shoot and root length, shoot and root dry weight were found to be reduced with the increases of soil salinity level but the degree of reduction were not similar for all wheat genotypes. Salt tolerance index (STI) also indicated a wide difference in salt tolerance among the wheat genotypes. Sourav, Gourav, Shatabdi, BAW 1185, BAW 1186, BAW 1187, BAW 1189 and BAW 1193 were more salt tolerance while BAW 1177, BAW 1190 and BAW 1198 showed greater salt sensitivity than the other wheat genotypes at 6 dS m^{-1}. However, at 12 dS m^{-1}, Sourav, Gourav, Shatabdi, Sufi and BAW 1184 showed more salt tolerance and BAW 1183, BAW 1190, BAW 1192, BAW 1194 and BAW 97 provided greater stress sensitivity among the testing wheat genotypes. Considering both saline stress Sourav, Gourav and Shatabdi were found to be salt tolerant and BAW 1190 was saline sensitive wheat genotypes.

Introduction

Salt stress affects seedling growth in different ways depending on plant species (Gul and Weber 1999). Salinity affects the seedling growth of plants (Tezara *et al.,* 2003, Rahman and Kayani, 1988) by slow or less mobilization of reserve foods (Kayani *et al*., 1990) suspending the cell division, enlargement (Meiri and Poljakoff – Mayber, 1970) and injuring hypocotyls (Assadian and Miyamoto, 1987). Generally, Salinity can inhibit plant growth by three major ways (Greenway and Munns, 1980): a) Water deficit arising from the more negative water potential (elevated osmotic pressure) of the soil solution; b) Specific ion toxicity usually associated with either excessive chloride or sodium uptake; and c) Nutrient ion imbalance when the excess of Na+ or Cl- leads to a diminished uptake of K^+, Ca^{2+}, NO_3^- or P, or to impaired internal distribution of one or another of these ions. Therefore, Boubaker (1996) showed that seedling characteristics are also viable criteria for selecting salt tolerance in wheat in a screening experiment of wheat cultivars. The relation of various seedling growth parameters to seed yield and yield component under saline conditions are important for the development of salt tolerant cultivar. The screening of salt tolerant lines/cultivars has been attempted by many researchers on various species at seedling growth stage (Ashraf, 1999). Therefore, the present study was conducted to evaluate the response of wheat genotypes to artificially developed saline soil at seedling stage.

Materials and Methods

The experiment was conducted on tray at the research field of the department of Crop Physiology and Ecology, Hajee Mohammad Danesh Science and Technology University (HSTU), Dinajpur during October 2013 to December 2013. The top soil (0-15 cm depth) was collected from research field of HSTU, Dinajpur. The soil was sandy loam and Cation Exchange Capacity (CEC) and pH value of the soil were 5.60 meq/100g and 5.45 respectively. The soil contained 1.19 % organic matter, 0.69 % organic carbon, 0.07 % total Nitrogen, 16.75 ppm available Phosphorous and 0.17 me/100g exchangeable Potassium (The soil was analysed at SRDI, Dinajpur). Each of 21 plastic bowl (diameter 18 cm) was filled with 10 kg of air dried soil. Different amount (0, 0.2, 0.4, 0.6, 0.8, 1.0, and 1.2 % W/W) of NaCl and Na_2SO_4 in a ratio of 1:1 was added in different plastic bowl. Each treatment was replicated thrice. Before adding, the calculated amount of salt was dissolved in 1 litre of tap water. The plastic bowl were then kept under shade for air drying and pulverized every day. After complete air drying the soil in each bowl was mixed properly. The soil samples were collected from each plastic bowl for determining the soil salinity level (Rhoades *et al.*, 1999). The soil salinity level was plotted against the salt concentration and a standard curve was prepared which is shown in Fig.1. Artificial saline soil of different dSm $^{-1}$ (0, 6 and 12 dS m $^{-1}$) was developed by adding calculated amount of NaCl and Na_2SO_4 in a ratio of 1:1 with the help of standard curve (Fig.1).

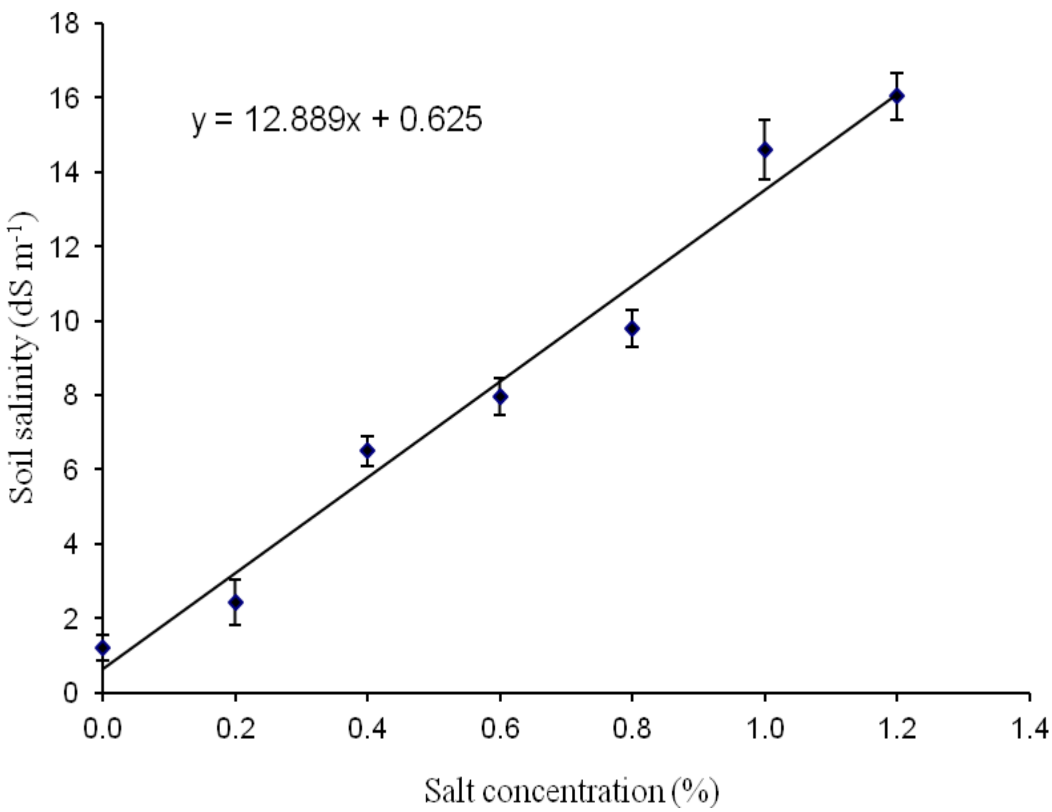

Fig.1. Relationship between soil salinity and salt concentration added in the soil.

Eighteen try of 1.5m x 0.6m size was filled with artificially developed saline soil of different dS m $^{-1}$ (0, 6 and 12 dS m $^{-1}$). For the placement of seeds of thirty wheat genotypes in different artificially developed (0, 6 and 12 dS m $^{-1}$) saline soil seeds were sown in the respective saline soil containing trays at the depth of 3cm. Fifty seeds were sown in each line and there were 15 lines in each tray and every line contained single genotype. For thirty wheat genotypes two trays were required to complete a single treatment the experiment was replicated thrice having eighteen trays. Growing of seedlings were allowed up to 30 days under an artificial shade or net house.

Intercultural operation like weeding was done to maintain normal growth of the crop. Normal irrigation was given in each tray in every alternate day until harvesting. At 30 days after sowing, five seedlings from each treatment combinations were sampled. Shoot and root length of individual seedling were recorded manually with scale. Then the seedlings were dried separately at 70 C for 72 h in an electric oven (Model- 03-54639, Binder, Germany) and weight were recorded with an electrical balance (Model- AND EK-300 i).

Salt Tolerance Index was calculated using following formula as Goudarzi and Pakniyat (2008)

$$\text{STI} = \frac{\text{Performance under salt stress condition}}{\text{Performance under normal stress condition}}$$

The data were analyzed by partitioning the total variance with the help of computer using MSTATC program. The treatment means were compared using Tukey's Test.

Results and Discussion

Emergence index

Emergence index which indicates the speed of emergence was significantly influenced by interaction effect of salinity levels and wheat genotypes (Table 1). Emergence index was higher at control (with a range from 54.61 in Gourav to 71.44 in BAW-1182 and a mean of 63.70) moderate at moderate stress (with a range from 40.78 in BAW 1199 to 62.11 in BAW 1182 and a mean of 49.43) and lower at higher saline stress (with a range from 4.46 in BAW 1199 to 29.16 in BARI Gom 25 and a mean of 19.03). The results showed that the speed of emergence was reduced with the increment of soil salinity stress but the degree of reduction in emergence index was not similar for all wheat genotypes at moderate and higher salinity stress compared to control. At moderate soil salinity stress, wheat genotypes- Sourav,Sufi, Bijoy, Prodip, BARI Gom 25, BARI Gom 26, BARI Gom 27, BARI Gom 28, BAW 1184, BAW 1185, BAW 1187, BAW 1189, BAW 1190, BAW 1191, BAW 1192, BAW 1194, BAW 1196, BAW 1197, BAW 1198, BAW 1199, BAW 1200 and BAW 1201 showed more than 20% reduction and wheat genotypes- Gourov, BAW 1177, BAW 1182, BAW 1183, BAW 1186, BAW 1193 and BAW 1195 showed less than 20% reduction in emergence index compared to control except in Shatabdi in which emergence index was even increased. At higher soil salinity stress, only wheat genotypes Shatabdi showed less than 50% reduction and all others genotypes showed more than 50% reduction in emergence index compared to control.

Table 1. Emergence index of different wheat genotypes as influenced by salinity levels

Wheat genotypes	Emergence index			% change over control at 6 dS m^{-1}	% change over control at 12 dS m^{-1}
	Control	Saline (6 dS m^{-1})	Saline (12 dS m^{-1})		
Sourav	63.87	50.79	10.75	-20.47	-83.17
Gourav	54.61	50.79	18.50	-6.99	-66.12
Shatabdi	56.65	59.58	28.84	+5.17	-49.09
Sufi	66.60	49.69	28.91	-25.39	-56.59
Bijoy	67.63	46.54	22.19	-31.18	-67.19
Prodip	64.43	48.81	14.03	-24.24	-78.22
BARI Gom-25	66.43	51.23	29.16	-22.88	-56.10
BARI Gom-26	65.22	46.70	27.90	-28.39	-57.22
BARI Gom-27	63.87	50.41	23.14	-21.07	-63.77
BARI Gom-28	69.11	53.77	16.34	-22.19	-76.36
BAW 1177	65.79	53.71	22.09	-18.36	-66.42
BAW 1182	71.44	62.11	27.82	-13.05	-61.06
BAW 1183	66.12	58.19	29.56	-11.99	-55.29
BAW 1184	69.11	51.61	24.08	-25.32	-65.16
BAW 1185	64.79	45.27	6.38	-30.12	-90.15
BAW 1186	61.21	58.77	28.80	-3.98	-52.95
BAW 1187	60.37	45.63	15.90	-24.41	-73.66
BAW 1189	60.55	42.28	9.20	-30.17	-84.81
BAW 1190	63.64	42.48	10.71	-33.25	-83.17
BAW 1191	66.34	46.94	28.47	-29.24	-57.08
BAW 1192	62.06	46.91	6.89	-24.41	-88.90
BAW 1193	58.11	50.81	24.55	-12.56	-57.75
BAW 1194	60.38	46.68	11.05	-22.69	-81.69
BAW 1195	64.06	51.87	14.11	-19.03	-77.97
BAW 1196	66.77	50.51	16.61	-24.35	-75.12
BAW 1197	67.24	46.59	17.29	-30.71	-74.29
BAW 1198	59.34	45.56	6.26	-23.22	-89.45
BAW 1199	56.16	40.78	4.46	-27.39	-92.06
BAW 1200	62.24	46.98	28.94	-24.52	-53.50
BAW 1201	66.94	36.90	18.23	-44.88	-72.77
Range	54.61-71.44	40.78-62.11	4.46-29.16		
Mean	63.70	49.43	19.03		
$LSD_{(0.01)}$		6.25			
CV (%)		8.81			

Shoot length

Shoot length of 30 days old seedling was significantly influenced by influenced by the interaction effect of soil salinity levels and wheat genotypes (Table 2). The shoot length was found to be higher at control (with a range from 33.30 cm in BAW 1193 to 53.00 cm in BAW 1182 and a mean of 41.54 cm), moderate at moderate stress (ranging from 24.20 cm in BARI Gom 25 to 38.97 cm Sourav with a mean of 29.92 cm) and lower at higher soil salinity stress (with a range from 17.50 cm in BAW 1197 to 38.90 cm in Sourav and a mean of 23.63 cm). The shoot length was found to be reduced with the increment of soil salinity stress but the degree of reduction was not similar for all wheat genotypes.

Table 2. Shoot length of different wheat genotypes as influenced by salinity levels

Wheat genotypes	Shoot length (cm)			% change over control at 6 dS m^{-1}	% change over control at 12 dS m^{-1}
	Control	Saline (6 dS m^{-1})	Saline (12 dS m^{-1})		
Sourav	40.50	38.97	38.90	-3.77	-3.95
Gourav	38.00	34.03	30.80	-10.44	-18.94
Shatabdi	35.40	32.13	26.80	-9.24	-24.29
Sufi	36.60	28.70	24.50	-21.58	-33.06
Bijoy	36.60	25.40	22.00	-30.60	-39.89
Prodip	36.80	24.60	21.00	-33.15	-42.93
BARI Gom-25	40.17	24.20	21.90	-39.75	-45.48
BARI Gom-26	39.07	26.20	21.70	-32.94	-44.45
BARI Gom-27	40.50	27.40	22.10	-32.34	-45.43
BARI Gom-28	45.50	29.00	22.20	-36.26	-51.20
BAW 1177	44.50	31.40	27.40	-29.43	-38.42
BAW 1182	53.00	35.40	24.60	-33.20	-53.58
BAW 1183	42.90	34.20	22.90	-20.27	-46.62
BAW 1184	41.80	30.30	28.10	-27.51	-32.77
BAW 1185	43.20	36.60	28.20	-15.27	-34.72
BAW 1186	47.37	38.30	27.80	-19.14	-41.31
BAW 1187	39.40	31.67	23.00	-19.61	-41.62
BAW 1189	44.30	32.90	20.50	-25.73	-53.72
BAW 1190	43.50	29.50	24.60	-32.18	-43.44
BAW 1191	40.50	26.80	19.60	-33.82	-51.60
BAW 1192	41.67	27.20	19.50	-34.72	-53.20
BAW 1193	33.30	26.13	18.80	-21.53	-43.54
BAW 1194	37.70	28.00	18.70	-25.72	-50.39
BAW 1195	40.50	30.10	21.10	-25.67	-47.90
BAW 1196	50.57	29.10	24.77	-42.45	-51.01
BAW 1197	42.60	28.80	17.50	-32.39	-58.92
BAW 1198	42.00	25.50	23.90	-39.28	-43.09
BAW 1199	42.10	27.63	17.70	-34.37	-57.95
BAW 1200	42.70	29.50	23.30	-30.91	-45.43
BAW 1201	43.70	28.10	25.10	-35.70	-42.56
Range	33.30-53.00	24.60-38.97	17.50-38.90		
Mean	41.54	29.92	23.63		
LSD $_{(0.01)}$		1.52			
CV (%)		8.35			

At moderate soil salinity stress, wheat genotypes-Sufi, Bijoy, Prodip, BARI Gom 25, BARI Gom 26, BARI Gom 27, BARI Gom 28, BAW 1177, BAW 1182, BAW 1183, BAW 1184, BAW 1189, BAW 1190, BAW 1191, BAW 1192, BAW 1194, BAW 1195, BAW 1196, BAW1197, BAW 1198, BAW1199, BAW 1200 and BAW1201 showed more than 20% reduction and wheat genotypes- Sourav, Gourav, Shatabdi, BAW 1185, BAW 1186 and BAW 1187 showed less than 20% reduction in shoot length compared to control. At higher soil salinity stress, wheat genotypes- BARI Gom 28, BAW 1182, BAW 1189, BAW 1191, BAW 1192, BAW 1194, BAW 1196, BAW 1197 and BAW 1199 showed more than 50% reduction and others wheat genotypes showed less than 50% reduction in shoot length compared to control.

Root length

Root length of 30 days old seedling was significantly influenced by the interaction effect of soil salinity levels and wheat genotypes (Table 3). The root length was found to be higher at control (with a range from 12.57 cm in Sufi to 23.20 cm in BAW 1185 and a mean of 17.03 cm), moderate at moderate stress (ranging from 8.03 cm in BAW 1194 to 16.23 cm in Gourov with a mean of 12.99 cm) and lower at higher soil salinity stress (with a range from 6.33 cm in BAW 1200 to 13.70 cm in Shatabdi and a mean of 9.44 cm).

Table 3. Root length of different wheat genotypes as influenced by salinity levels

Wheat genotypes	Root length (cm)			% change over control at 6 dS m^{-1}	% change over control at 12 dS m^{-1}
	Control	Saline (6 dS m^{-1})	Saline (12 dS m^{-1})		
Sourav	14.13	13.70	11.50	-3.04	-18.61
Gourav	14.00	16.23	11.20	+15.93	-20.00
Shatabdi	12.84	13.20	13.70	+2.80	+6.70
Sufi	12.57	12.70	8.33	+1.03	-33.73
Bijoy	18.00	14.60	8.43	-18.89	-53.17
Prodip	18.00	14.50	12.20	-19.44	-32.22
BARI Gom-25	17.80	12.60	11.28	-29.21	-36.62
BARI Gom-26	16.10	13.00	11.60	-19.25	-27.95
BARI Gom-27	17.30	13.80	9.60	-20.23	-44.51
BARI Gom-28	16.30	12.70	11.50	-22.09	-29.45
BAW 1177	19.00	14.00	12.00	-26.32	-36.84
BAW 1182	14.80	12.80	9.70	-13.51	-34.46
BAW 1183	19.60	14.50	11.10	-26.02	-43.37
BAW 1184	18.00	10.40	11.70	-42.22	-35.00
BAW 1185	23.20	16.10	12.00	-30.60	-48.28
BAW 1186	18.50	8.30	6.73	-55.14	-63.62
BAW 1187	21.30	11.40	7.83	-46.48	-63.24
BAW 1189	16.00	8.13	7.20	-49.19	-55.00
BAW 1190	18.60	9.83	8.50	-47.15	-54.30
BAW 1191	17.30	13.10	6.90	-24.27	-60.12
BAW 1192	18.03	13.30	6.53	-26.23	-63.78
BAW 1193	16.40	14.40	7.60	-12.19	-53.66
BAW 1194	16.30	8.03	7.30	-50.74	-55.21
BAW 1195	16.30	14.30	8.00	-12.27	-50.92
BAW 1196	17.30	11.40	10.20	-34.10	-41.04
BAW 1197	14.90	15.00	8.80	+0.67	-40.94
BAW 1198	17.20	11.50	9.53	-33.14	-44.59
BAW 1199	18.00	15.60	7.70	-13.33	-57.22
BAW 1200	16.00	14.50	6.33	-9.38	-60.44
BAW 1201	17.40	16.10	8.30	-7.47	-52.30
Range	12.57-23.20	8.03-16.23	6.33-13.70		
Mean	17.03	12.99	9.44		
$LSD_{(0.01)}$		2.68			
CV (%)		12.71			

The root length was found to be reduced with the increment of soil salinity stress but the degree of reduction was not similar for all wheat genotypes. At moderate soil salinity stress, wheat genotypes- BARI Gom 25, BARI Gom 27, BARI Gom 28, BAW 1177, BAW 1183, BAW 1184, BAW 1185, BAW 1186, BAW 1187, BAW 1189, BAW 1190, BAW 1191, BAW 1192, BAW 1194, BAW 1196 and BAW 1198 showed more than 20% reduction and wheat genotypes- Sourav, Bijoy, Prodip, BARI Gom 26, BAW 1182, BAW 1193, BAW 1195, BAW 1199, BAW 1200 and BAW 12001 showed less than 20% reduction in germination index compared to control except Gourov, Sufi and BAW 1197 in which root length was even increased. At higher soil salinity stress, wheat genotypes- Bijoy, BAW 1186, BAW 1187, BAW 1189, BAW 1190, BAW 1191, BAW 1192, BAW 1193, BAW 1194, BAW 1195, BAW 1199, BAW 1200 and BAW 1201 showed more than 50% reduction and others wheat genotypes showed less than 50% reduction in root length compared to control.

Shoot dry weight

Shoot dry weight of 30 days old seedling was significantly influenced by influenced by the interaction effect of soil salinity levels and wheat genotypes (Table 4). The shoot dry weight was found to be higher at control (with a range from 2.34 mg in Sufi to 5.01 mg in BAW 1200 and a mean of 3.33 mg), moderate at moderate stress (ranging from 0.64 mg in BARI Gom 26 to 3.18 mg in Sourav with a mean of 1.40 mg) and lower at higher soil salinity stress (with a range from 0.32 mg in BAW 1197 to 1.31 mg in BAW 1201 and a mean of 0.67 mg). Shoot dry weight was found to be reduced with the increment of soil salinity stress but the degree of reduction was not similar for all wheat genotypes.

Table 4. Shoot dry weight of different wheat genotypes as influenced by salinity levels

Wheat genotypes	Shoot dry weight (mg)			% change over control at 6 dSm^{-1}	% change over control at 12 dSm^{-1}
	Control	Saline (6 dSm^{-1})	Saline (12 dSm^{-1})		
Sourav	2.73	3.18	1.27	+16.48	-53.47
Gourav	2.70	1.41	0.93	-47.77	-65.55
Shatabdi	2.62	1.45	1.03	-44.65	-60.68
Sufi	2.34	1.13	0.70	-51.70	-70.08
Bijoy	3.29	1.30	0.63	-60.48	-80.85
Prodip	3.17	0.88	0.60	-72.24	-81.07
BARI Gom-25	3.23	0.82	0.48	-74.61	-85.13
BARI Gom-26	2.68	0.64	0.45	-76.11	-83.21
BARI Gom-27	2.73	0.78	0.38	-71.42	-86.08
BARI Gom-28	2.72	1.01	0.32	-62.86	-88.23
BAW 1177	3.44	1.46	0.65	-57.55	-81.10
BAW 1182	3.73	1.29	0.58	-65.42	-84.45
BAW 1183	4.46	1.45	0.49	-67.48	-89.01
BAW 1184	2.86	1.23	1.17	-56.99	-59.09
BAW 1185	2.57	1.41	1.31	-45.14	-49.02
BAW 1186	3.99	2.84	1.02	-28.82	-74.43

Wheat genotypes	Shoot dry weight (mg) Control	Saline ($6\ dSm^{-1}$)	Saline ($12\ dSm^{-1}$)	% change over control at $6\ dSm^{-1}$	% change over control at $12\ dSm^{-1}$
BAW 1187	2.86	1.74	0.76	-39.16	-73.42
BAW 1189	2.50	1.78	0.35	-28.80	-86.00
BAW 1190	3.79	1.03	0.44	-72.82	-88.39
BAW 1191	2.80	1.22	0.41	-56.43	-85.35
BAW 1192	3.37	1.27	0.36	-62.31	-89.31
BAW 1193	3.13	1.65	0.40	-47.28	-87.22
BAW 1194	3.98	1.36	0.36	-65.83	-90.95
BAW 1195	2.77	1.27	0.49	-54.15	-82.31
BAW 1196	3.32	1.30	0.82	-60.84	-75.30
BAW 1197	3.68	1.37	0.32	-62.77	-91.30
BAW 1198	3.88	1.40	0.75	-63.92	-80.67
BAW 1199	4.49	1.27	0.56	-71.71	-87.53
BAW 1200	5.01	1.59	0.91	-68.26	-81.83
BAW 1201	5.23	1.50	1.13	-71.32	-78.39
Range	2.34-5.01	0.64-3.18	0.32-1.13		
Mean	3.33	1.40	0.67		
LSD $_{(0.01)}$		0.087			
CV (%)		8.35			

At moderate soil salinity stress, wheat genotypes-Sufi, Bijoy, Prodip, BARI Gom 25, BARI Gom 26, BARI Gom 27, BARI Gom 28, BAW 1177, BAW 1182, BAW 1183, BAW 1184, BAW 1190, BAW 1191, BAW 1192, BAW 1194, BAW 1195, BAW 1196, BAW1197, BAW 1198, BAW1199, BAW 1200 and BAW1201 showed more than 50% reduction and wheat genotypes- Gourav, Shatabdi, BAW 1185, BAW 1186, BAW 1187, BAW 1189 and BAW 1193 showed less than 50% reduction in shoot dry weight compared to control except Sourav, in which shoot dry weight was even increased.At higher soil salinity stress, wheat genotypes- Bijoy, Prodip, BARI Gom 25, BARI Gom 26, BARI Gom 27, BARI Gom 28, BAW 1177, BAW 1182, BAW 1183, BAW 1189, BAW 1190, BAW 1191, BAW 1192, BAW 1193, BAW 1194, BAW 1195, BAW 1197, BAW 1198, BAW 1199 and BAW 1200 showed more than 80% reduction and others wheat genotypes showed less than 80% reduction in shoot dry weight compared to control.

Root dry weight

Root dry weight of 30 days old seedling was significantly influenced by influenced by the interaction effect of soil salinity levels and wheat genotypes (Table 5). The Root dry weight was found to be higher at control (with a range from 0.55 mg in BAW 1196 to 1.64 mg in BAW 1201 and a mean of 0.95 mg), moderate at moderate stress (ranging from 0.24 mg in BAW 1177 to 0.93 mg in BAW 1185 with a mean of 0.39 mg) and lower at higher soil salinity stress (with a range from 0.05 mg in BAW 1194 to 0.30 mg in BAW 1186 and a mean of 0.20 mg).

Table 5. Root dry weight of different wheat genotypes as influenced by salinity levels

Wheat genotypes	Root dry weight (mg)			% change over control at 6 dSm^{-1}	% change over control at 12 dSm^{-1}
	Control	Saline (6 dSm^{-1})	Saline (12 dSm^{-1})		
Sourav	0.67	0.69	0.46	+2.98	-31.34
Gourav	0.77	0.42	0.29	-45.45	-62.34
Shatabdi	0.79	0.36	0.47	-54.43	-40.51
Sufi	0.64	0.26	0.26	-59.37	-59.37
Bijoy	1.14	0.35	0.24	-69.29	-78.94
Prodip	0.88	0.26	0.23	-70.45	-73.86
BARI Gom-25	0.77	0.28	0.17	-63.63	-77.92
BARI Gom-26	0.82	0.25	0.27	-69.51	-67.07
BARI Gom-27	0.73	0.25	0.12	-65.75	-83.56
BARI Gom-28	0.75	0.26	0.15	-65.33	-80.00
BAW 1177	1.28	0.24	0.28	-81.25	-78.12
BAW 1182	1.08	0.33	0.09	-69.44	-91.66
BAW 1183	1.15	0.45	0.16	-60.87	-86.08
BAW 1184	1.27	0.40	0.32	-68.50	-74.80
BAW 1185	1.71	0.93	0.27	-45.61	-84.210
BAW 1186	1.59	0.90	0.30	-43.39	-81.13
BAW 1187	0.92	0.40	0.19	-56.52	-79.34
BAW 1189	0.71	0.52	0.09	-26.76	-87.32
BAW 1190	1.02	0.29	0.16	-71.56	-84.31
BAW 1191	0.94	0.43	0.12	-54.25	-87.23
BAW 1192	0.72	0.31	0.12	-56.94	-83.33
BAW 1193	0.81	0.47	0.09	-41.97	-88.88
BAW 1194	0.85	0.25	0.05	-70.58	-94.11
BAW 1195	0.72	0.33	0.12	-54.16	-83.33
BAW 1196	0.55	0.34	0.20	-38.18	-63.63
BAW 1197	0.86	0.33	0.09	-61.62	-89.53
BAW 1198	0.90	0.27	0.17	-70.00	-81.11
BAW 1199	1.09	0.45	0.12	-58.71	-88.99
BAW 1200	0.87	0.50	0.15	-42.52	-82.75
BAW 1201	1.64	0.45	0.18	-72.56	-89.02
Range	0.55-1.64	0.24-0.93	0.05-0.30		
Mean	0.95	0.39	0.20		
$LSD_{(0.01)}$		0.025			
CV (%)		7.76			

Shoot dry weight was found to be reduced with the increment of soil salinity stress but the degree of reduction was not similar for all wheat genotypes. At moderate soil salinity stress, wheat genotypes- Shatabdi, Sufi, Bijoy, Prodip, BARI Gom 25, BARI Gom 26, BARI Gom 27, BARI Gom 28, BAW 1177, BAW 1182, BAW 1183, BAW 1184, BAW 1187, BAW 1190, BAW 1191, BAW 1192, BAW 1194, BAW 1195, BAW1197, BAW 1198, BAW 1199 and BAW1201 showed more than 50% reduction and wheat genotypes- Gourav, BAW 1185, BAW 1186, BAW 1187, BAW 1189, BAW 1193, BAW 1196 and BAW 1200 showed less than 50% reduction in root dry weight compared to control except Sourav, in which root dry weight was even increased. At higher soil salinity stress, wheat genotypes- BARI Gom 27, BARI Gom 28, BAW 1182, BAW 1183, BAW 1185, BAW 1186, BAW 1189, BAW 1190, BAW 1191, BAW 1192, BAW 1193, BAW 1194, BAW 1195, BAW 1197, BAW 1198, BAW 1199, BAW 1200 and BAW 1201 showed more than 80% reduction and others wheat genotypes showed less than 80% reduction in root dry weight compared to control.

Seedling dry weight

Seedling dry weight of 30 days old seedling was significantly influenced by influenced by the interaction effect of soil salinity levels and wheat genotypes (Table 6). The seedling dry weight was found to be higher at control (with a range from 3.00 mg in Sufi to 6.87 mg in BAW 1201 and a mean of 4.34 mg), moderate at moderate stress (ranging from 0.94 mg in BARI Gom 26 to 4.34 mg in BAW 1185 with a mean of 1.84 mg) and lower at higher soil salinity stress (with a range from 0.41 mg in BAW 1194 to 1.73 mg in Sourav and a mean of 0.89 mg). Seedling dry weight was found to be reduced with the increment of soil salinity stress but the degree of reduction was not similar for all wheat genotypes. At moderate soil salinity stress, wheat genotypes- Sufi, Bijoy, Prodip, BARI Gom 25, BARI Gom 26, BARI Gom 27, BARI Gom 28, BAW 1177, BAW 1182, BAW 1183, BAW 1184, BAW 1190, BAW 1191, BAW 1192, BAW 1194, BAW 1195, BAW 1196, BAW1197, BAW 1198, BAW 1199, BAW 1200 and BAW1201 showed more than 50% reduction and wheat genotypes- Gourav, BAW 1185, BAW 1186, BAW 1187, BAW 1189 and BAW 1193 showed less than 50% reduction in seedling dry weight compared to control except Sourav, in which seedling dry weight was even increased. At higher soil salinity stress, wheat genotypes- Prodip, Bijoy, BARI Gom 25, BARI Gom 26, BARI Gom 27, BARI Gom 28, BAW 1177, BAW 1182, BAW 1183, BAW 1189, BAW 1190, BAW 1191, BAW 1192, BAW 1193, BAW 1194, BAW 1195, BAW 1197, BAW 1198, BAW 1199, BAW 1200 and BAW 1201 showed more than 80% reduction and others wheat genotypes showed less than 80% reduction in seedling dry weight compared to control. At higher soil salinity stress Sourov, Shatabdi, Sufi, BAW1184, BAW1186, BAW1187 and BAW11896 showed comparatively lower reduction in seedling dry weight.

In the present study, all parameters were affected due to salt stress. With increasing salt concentration in the environment for germination, shoot and root length and dry weight were reduced significantly. Garciarrubio *et al.* (2003) and Datta *et al.* (2009) were also found the same result. 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). Salinity affects the seedling growth of plants (Tezara *et al.*, 2003, Rahman and Kayani, 1988) by slow or less mobilization of reserve foods (Kayani *et al.*, 1990), suspending the cell division, enlargement (Meiri and APoljakoff-Mayber, 1970) and injuring hypocotyls (Assadian and Miyamoto, 1987).

Table 6. Seedling dry weight of different wheat genotypes as influenced by salinity levels

Wheat genotypes	Seedling dry weight (mg)			% change over control at 6 dSm^{-1}	% change over control at 12 dSm^{-1}
	Control	Saline (6 dSm^{-1})	Saline (12 dSm^{-1})		
Sourav	3.40	3.87	1.73	+13.82	-49.12
Gourav	3.49	1.83	1.27	-47.56	-63.61
Shatabdi	3.42	1.87	1.50	-45.32	-56.14
Sufi	3.00	1.36	0.97	-54.66	-67.66
Bijoy	4.43	1.66	0.90	-62.52	-79.68
Prodip	4.05	1.15	0.84	-71.60	-79.25
BARI Gom-25	3.68	1.10	0.66	-70.11	-82.07
BARI Gom-26	3.50	0.94	0.72	-73.14	-79.43
BARI Gom-27	3.47	1.04	0.50	-70.03	-85.59
BARI Gom-28	3.47	1.28	0.68	-63.11	-80.40
BAW 1177	4.73	1.20	0.94	-74.63	-80.13
BAW 1182	4.83	1.63	0.68	-66.25	-85.92
BAW 1183	5.61	1.91	0.65	-65.95	-88.41
BAW 1184	4.13	1.63	1.50	-60.53	-63.68
BAW 1185	5.95	4.34	1.58	-27.06	-73.45
BAW 1186	5.50	3.75	1.32	-31.82	-76.00
BAW 1187	3.79	2.15	0.95	-43.27	-74.93
BAW 1189	3.22	2.31	0.44	-28.26	-86.33
BAW 1190	4.70	1.32	0.61	-71.91	-87.02
BAW 1191	3.83	1.65	0.54	-56.92	-85.90
BAW 1192	4.29	1.58	0.49	-63.17	-88.57
BAW 1193	3.95	2.12	0.50	-46.33	-87.34
BAW 1194	4.84	1.61	0.41	-66.74	-91.53
BAW 1195	3.50	1.60	0.62	-54.28	-82.28
BAW 1196	3.88	1.64	1.02	-57.73	-73.71
BAW 1197	4.57	1.71	0.41	-62.58	-91.03
BAW 1198	4.78	1.18	0.92	-75.31	-80.75
BAW 1199	5.53	1.73	0.68	-68.72	-87.70
BAW 1200	5.89	2.09	1.07	-64.52	-81.83
BAW 1201	6.87	1.95	1.31	-71.62	-80.93
Range	3.00-6.87	0-94-4.34	0.41-1.73		
Mean	4.34	1.84	0.89		
$LSD_{(0.01)}$		0.025			
CV (%)		2.28			

The same authors found that the reduction in root and shoot deve-lopment may be due to toxic effects of the higher level of NaCl concentration as well as unbalanced nutrient uptake by the seedlings. High level of salinity may have also inhibit the root and shoot elongation due to slowing down the water uptake for overall osmotic adjustments of the plant body under high salt stress condition. Salt stress result in a considerable decrease in the fresh and dry weights of root and shoot (Chartzoulakis & Klapaki 2000, Parida and Das, 2005). 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.

Salt tolerance index based on seedling dry weight grown at 6 dS m^{-1} artificial saline soil

Salt tolerance index (STI) of thirty wheat genotypes based on seedling dry weight (30 days old) at 6 dS m^{-1} artificial saline soil is presented in Fig. 2. These STI values indicated a wide difference in salt tolerance among the wheat genotypes. Wheat genotypes- Sourav, Gourav, Shatabdi, BAW 1185, BAW 1186, BAW 1187, BAW 1189 and BAW 1193 showed more than 0.5 STI and Sufi, Bijoy, Prodip, BARI Gom 25, BARI Gom 26, BARI Gom 27, BARI Gom 28, BAW 1177, BAW 1182, BAW 1183, BAW 1184, BAW 1190, BAW 1191, BAW 1192, BAW 1194, BAW 1195, BAW 1196, BAW 1197, BAW 1198, BAW 1199 and BAW 1201 provided less than 0.50 STI.

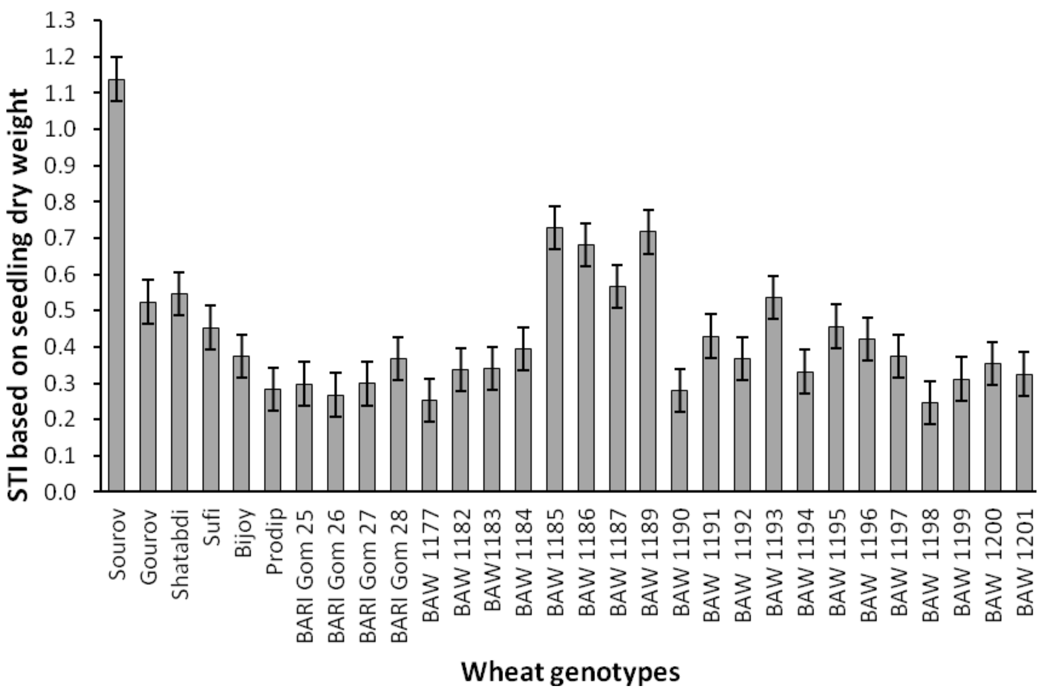

Fig. 2. Salt tolerance index of different wheat genotypes based on seedling dry weight grown at 6 dS m-1 artificial saline soil (Vertical bar indicates LSD value).

Salt tolerance index based on seedling dry weight grown at 12 dS m^{-1} artificial saline soil

Salt tolerance index (STI) of thirty wheat genotypes based on seedling dry weight (30 days old) at 12 dS m^{-1} artificial saline soil is presented in Fig.3. These STI values indicated a wide difference in salt tolerance among the wheat genotypes. Wheat genotypes- Sourav, Gourav, Shatabdi, Sufi and BAW 1184 showed more than 0.3 STI and Bijoy, Prodip, BARI Gom 25, BARI Gom 26, BARI Gom 27, BARI Gom 28, BAW 1177, BAW 1182, BAW 1183, BAW 1185, BAW 1186, BAW 1187, BAW 1189, BAW 1190, BAW 1191, BAW 1192, BAW

1193, BAW 1194, BAW 1195, BAW 1196, BAW 1197, BAW 1198, BAW 1199 and BAW 1201 provided less than 0.3.

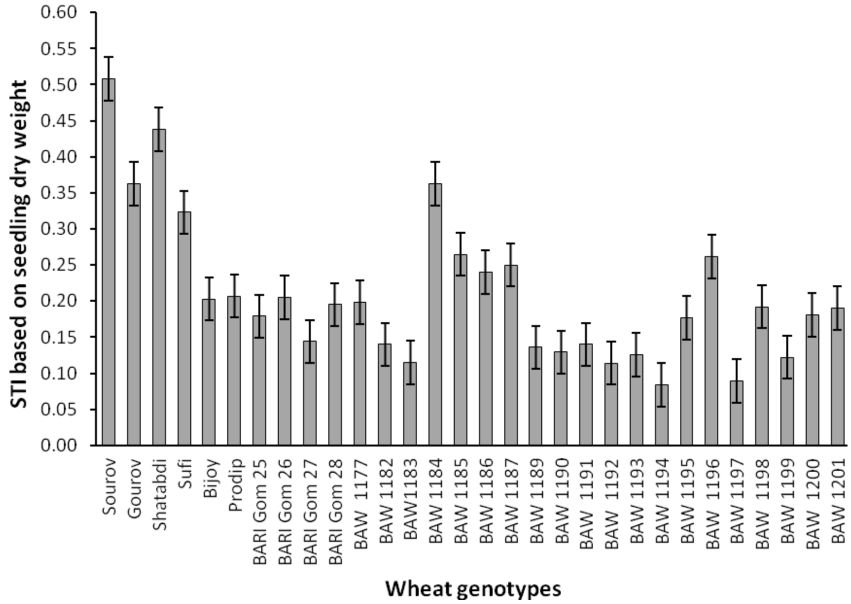

Fig.3. Salt tolerance index of different wheat genotypes based on seedling dry weight grown at 12 dS m^{-1} artificial saline soil (Vertical bar indicates LSD value).

Conclusion

Salt tolerance index (STI) also indicated a wide difference in salt tolerance among the wheat genotypes. Sourav, Gourav, Shatabdi, BAW 1185, BAW 1186, BAW 1187, BAW 1189 and BAW 1193 were more salt tolerance while BAW 1177, BAW 1190 and BAW 1198 showed greater salt sensitivity than the other wheat genotypes at 6 dS m^{-1}. However, at 12 dS m^{-1}, Sourav, Gourav, Shatabdi, Sufi and BAW 1184 showed more salt tolerance and BAW 1183, BAW 1190, BAW 1192, BAW 1194 and BAW 97 provided greater stress sensitivity among the testing wheat genotypes. Considering both saline stress Sourav, Gourav and Shatabdi were found to be salt tolerant and BAW 1190 was saline sensitive wheat genotypes.

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