Project ID: 809

Competitive Research Grant

Sub-Project Completion Report

on

Selection of Salinity Tolerant Wheat Genotypes through Physiological and Biochemical Appraisal

Project Duration

May 2017 to September 2018

Department of Agronomy
Bangabandhu Sheikh Mujibur Rahman Agricultural University (BSMRAU)
Gazipur-1706

Submitted to
Project Implementation Unit-BARC, NATP-2
Bangladesh Agricultural Research Council
Farmgate, Dhaka-1215

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Acknowledgement

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Published in: September 2018

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Acronyms

ROS: Reactive oxygen species
PH: Plant height
TTPH: Total tiller per plant
ETPH: Effective tiller per plant
PL: Panicle length
PNPP: Spikelet no per spike
GPP: Grain per spike
TSW: 1000-Seed weight
GY: Grain yield per plant (g)
CAT: Catalase activity
APX: Ascorbic peroxidase activity
CMI: Cell membrane injury
PC: Proline content
SS: Soluble sugar
SP: Soluble protein
PR: Photosynthetic rate
SC: Stomatal conductance
TR: Transpiration rate
RWC: Relative water content
LWP: Leaf water potential

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Executive Summary

Soil salinity is considered as one of the most devastating environmental stresses. In coastal area, over 30 percent of the net cultivable lands are available. This land is not being fully utilized for crop production, mostly due to soil salinity. The cropping patterns followed in the coastal areas are mainly Fallow-Fallow-Transplanted aman rice. That's why the cropping intensity in saline area is very low. Most of the coastal areas are located over medium high lands. This category of land is suitable for minimum two crops where salt tolerant wheat can be fitted easily after transplant aman rice. Therefore, salt tolerant wheat varieties should be identified. To fulfill the above demand we conducted experiments to identify wheat genotypes that can tolerate salinity stress to a considerable extent and to understand the mechanisms of salt tolerance through yield performance and some physiological and biochemical parameters. In the first experiment 100 wheat genotypes were evaluated under 0, 5, 10 and 15 dS m-1 salinity level from 15 days after sowing and five genotypes showed better performance which was tested in further experiment. Based on the results of the 1st experiment best five salt tolerant, one susceptible genotypes and standard check variety was grown in plastic pots. The experiment containing four treatments was laid out in a complete randomized design with five replications. The treatments were four levels of saline water with electrical conductivities at control, 5, 10 and 15 dSm^{-1}. Salinity stress caused an overall reduction in morphological, yield and yield attributes but the reduction was very little under 5 dSm^{-1} salinity level compare to control in most of the cases. The lowest reduction percent of yield was maintained by genotype BU 2008-4 together with the lowest reduction percent of plant height, days to anthesis, highest tiller number per plant, the lowest spike length reduction, highest number of spikelet per spike, grain number per spike, 1000-grain weight at 15 dSm^{-1} salinity level. Genotypes BU 1370-7 and BU 2050-2 also expressed the better performance in all the characters under all the salinity levels. Genotypes BU 2413-1 was the most sensitive to increasing salinity level which reflected in the lowest relative values of all the characters. Salinity stress significantly influenced the physiological and biochemical traits of wheat. It was found that higher salinity tolerance in BU 2008-4, BU 1370-7 and BU 2050-2 was associated with better water relations probably due to higher accumulation of proline, soluble sugar and soluble protein than that of genotype BU 2413-1 under salinity stress conditions. Furthermore, the faster photosynthetic rate with higher stomatal conductance and least degradation of chlorophyll, minimum cell membrane injury with low H2O2 accumulation and high antioxidant enzyme activities in genotype BU 2008-4 followed by BU 1370-7 and BU 2050-2 contributed to their high salinity tolerance than the susceptible genotype BU 2413-1. However, further field trial of the selected saline tolerant wheat genotypes in saline-prone area is essential for adaptability test.

CRG Sub-Project Completion Report (PCR)

A. Sub-project Description

1. Title of the CRG sub-project: Selection of Salt Tolerant Wheat Variety through Physiological and Biochemical Appraisal

2. Implementing organization: Department of Agronomy, Bangabandhu Sheikh Mujibur Rahman Agricultural University (BSMRAU)

3. Name and full address with phone, cell and E-mail of PI/Co-PI (s):

Principal Investigator: Dr. Md. Moshiul Islam

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Cell Phone: +8801711908640; E-mail: moynul60@yahoo.com

4. Sub-project budget (Tk):

   Total: 15,00,000 (Fifteen lack taka only)
   Revised (if any): N/A

5. Duration of the sub-project:

   Start date (based on LoA signed): 11 May, 2017

   End date: 30 September 2018

6. Justification of undertaking the sub-project:

   In coastal area, over 30 per cent of the net cultivable lands are available (Haque, 2006; SRDI, 2010). This land is not being fully utilized for crop production, mostly due to soil salinity. The problem of salinity is severe in the winter though during summer the salt concentration decreases dramatically due to monsoon rains and the cropping patterns followed in the coastal areas are mainly Fallow-Fallow-Transplanted aman rice (Haque, 2006). That's why the cropping intensity in saline area is very low. Most of the coastal areas are located over medium high lands. This category of land is suitable for minimum two crops where salt tolerant wheat can be fitted easily after transplant aman rice. For the sake of national food security the costal area must be brought under intensive crop cultivation. Purposely salt tolerant varieties should be identified. Therefore, for expanding crops production in the southern part of Bangladesh, it is necessary to develop salt tolerant wheat variety.

7. Sub-project goal: The goal of the project is to identify salinity tolerant wheat genotypes which could be used to increase the productivity in the coastal areas of Bangladesh.

8. Sub-project objective (s):

   (i) to screen wheat genotypes against salinity tolerance
   (ii) to analyze morphological, physiological and biochemical changes of selected wheat genotypes against salinity tolerance

9. Implementing location (s):

   Experimental field of the department of Agronomy, BSMRAU

10. Methodology in brief:

Materials and methods:

Based on the results of the experiment in November 2016 and secondary data of the 300 wheat genotypes, best five salt tolerant, one susceptible genotypes and standard check variety were grown in plastic pots. Required number of experiment was conducted at the same time. The experiment was laid out in a complete randomized design (CRD) with four treatments where each treatment replicated five times. Two plants were allowed to grow in each pot. Three levels of saline water with electrical conductivities at 5, 10 and 15 dSm^{-1} and ordinary tap water as the control made up a total of four salinity treatments. The pots were irrigated with ordinary tap water until 35 days of sowing. Then saline water collected from the coastal areas and it was diluted at 5, 10 and 15 dSm^{-1}. After 35 days of seed sowing the treatment of saline water as control (0.3 dSm^{-1}), 5, 10 and 15 dSm^{-1} was added in the pots. Before application of such high concentrations of saline water, the plants were irrigated with a 2.5 dSm^{-1} solution for 5 days in order to protect the plants from osmotic shock. After application of saline water, the soil slowly absorbed the salt and the salinity was developed in the soil and finally attained an equilibrium condition between water and soil salinity.

Data to be taken: The following data were taken

i) Relative water content ii) Leaf water potential iii) Photosynthetic rate iv) Stomatal conductance v) Leaf chlorophyll content vi) Hydrogen peroxide (H_2O_2) vii) Percent injury in cell membrane

Biochemical attributes namely i) Proline content ii) Soluble sugar content iii) Soluble protein accumulation

Antioxidant exzymes activity

i) Catalase activity (CAT) ii) Ascorbic peroxidase (APX) activity

Yield and yield contributing characters was also taken.

Statistical analysis

Statistix 10 and SPSS version 12.0 was used to perform statistical analysis. Means will be separated by least significant difference (LSD).

11. Results and discussion:

Yield and yield attributes

Plant height reduction

The reduction percent of plant height of all the genotypes compared to control was higher at 15 dS m^{-1} than 5 and 10 dS m^{-1} salinity level (Fig. 1). At 5 and 10 dS m^{-1} salinity level, the lowest plant height reduction was observed in genotype BU 2050-2 (4.31% and 9.66%) followed by BU 2008-4 (4.55% and 10.12%) and the highest plant height reduction was found in genotype BU 2413-1 (10.88% and 19.23%). However, at 15 dS m^{-1} salinity level, the lowest plant height reduction was observed in genotype BU 2008-4 (12.91%) followed by BU 2050-2 (13.43%) and the highest plant height reduction was found in genotype BU 2413-1 (28.67%). The decrease in plant height of wheat genotypes might be due to decreased in growth for the presence of excessive salts in root zone (Singla and Garg, 2005).

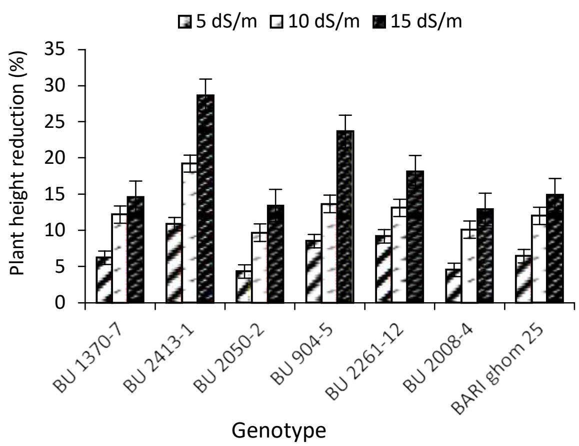


Fig. 1. Plant height reduction (%) of wheat genotypes as affected by variable salinity levels

Days to anthesis

Wheat genotypes varied significantly in anthesis which ranged from 70 to 72 days under control condition (Table 1). Anthesis showed 1 to 3 days at 5 dS m^{-1} and 2 to 7 days at 10 dS m^{-1} earliness in the genotypes compared to control. At 15 dS m^{-1} salinity level the anthesis was faster than earlier salinity level. Genotype BU 2413-1 showed earliest anthesis (11 days) followed by BU 2261-12 (9 days). Genotype BU 2008-4 showed the minimum (4 days) earliness followed by BU 1370-7 (5 days) and BU 2050-2 (5 days) under saline condition as compared to control. It has been reported that salinity stress accelerated reproductive growth and finally caused the wheat yield reduction (Mass and Grieve, 1990).

Total tiller/plant

Different salinity levels had an effect on number of total tiller per plant. Number of total tiller per plant of all genotypes decreased due to increasing salinity level. Total tiller per plant under control condition ranged between 6.58 and 6. The maximum number of total tiller per plant of all genotypes was found in control condition and the minimum was at 15 dSm^{-1} salinity levels (Table 2). Under 15 dSm^{-1} saline level, total tiller per plant exhibited a wide range of variation among the genotypes. At 15 dSm^{-1} salinity level, the maximum number of total tiller per plant (5.98) was found in BU 2008-4 and the minimum (4.22) was found in BU 2413-1.

Table 1. Days required for anthesis of wheat genotypes as affected by variable salinity levels

Genotype	Anthesis (No of days)			
	Salinity level (dS m^{-1})			
	0	5	10	15
BU 1370-7	71.33 bc	70.33 a	68.33 a	66.33 a
BU 2413-1	70.33 bc	66.67 c	62.67 c	58.67 d
BU 2050-2	70.33 bc	69.33 ab	67.67 ab	65.33 a
BU 904-5	72.67 a	70.33 a	68.33 a	62.67 bc
BU 2261-12	71.33 ab	69.67 ab	67.33 ab	61.67 c
BU 2008-4	70.33 bc	69.33 ab	68.33 a	66.33 a
BARI ghom 25	70.33 c	68.67 b	67.67 ab	63.67 b
CV (%)	2.35	2.83	2.68	2.91

Table 2. Total tiller/plant of wheat genotypes under different salinity levels

Genotype	Total tiller			
	Salinity level (dS m^{-1})			
	0	5	10	15
BU 1370-7	6.17	5.79 ab	5.65 abc	5.49 ab
BU 2413-1	6.00	5.57 b	4.80 d	4.22 c
BU 2050-2	6.50	6.19 ab	5.87 ab	5.59 ab
BU 904-5	6.27	5.81 ab	5.29 bcd	5.06 b
BU 2261-12	6.04	5.81 ab	5.00 cd	4.87 bc
BU 2008-4	6.58	6.38 a	6.19 a	5.98 a
BARI ghom 25	6.46	6.06 ab	5.86 ab	5.37 ab
CV (%)	7.91	7.52	8.49	8.77

Effective tiller/plant

Salinity significantly reduced the number of effective tiller per plant in wheat genotypes (Table 3). The reduction value of effective tiller per plant was more in 15 dS m^{-1} salinity stress compared to 5 and 10 dS m^{-1} salinity stress in all the genotypes (Fig. 2). Under control condition, the effective tiller per plant ranged from 5.41 to 5.83, whereas this range was 2.73 to 5.61 at 15 dS m^{-1} salinity level. Under 15 dS m^{-1} salinity condition the highest number of effective tiller per plant was observed in genotype BU 2008-4 (5.61) followed by genotypes BU 2050-2 (5.20) and BU 1370-7 (5.09). The minimum effective tiller producer was BU 2413-1 (2.73) followed by BU 2261-12 (3.70). The lowest reduction value of effective tiller per plant was also observed in genotype BU 2008-4 (3.83%) followed by BU 1370-7 (8.97%) and the highest was observed in genotype BU 2413-1 (49.91%). Under saline conditions salinity reduces the tiller number by delaying and reducing tiller emergence at the vegetative stage (Grieve et al. 2001).

Table 3. Effective tiller/plant of wheat genotypes under different salinity levels

Genotype	Effective tiller Salinity level (dS m^{-1})			
	0	5	10	15
BU 1370-7	5.59	5.43 ab	5.18 a	5.09 a
BU 2413-1	5.45	4.85 b	3.80 b	2.73 c
BU 2050-2	5.75	5.67 ab	5.32 a	5.20 a
BU 904-5	5.41	5.12 ab	4.15 b	3.99 b
BU 2261-12	5.36	5.01 ab	3.95 b	3.70 b
BU 2008-4	5.83	5.81 a	5.67 a	5.61 a
BARI ghom 25	5.79	5.73 ab	5.50 a	5.23 a
CV (%)	4.73	4.91	6.11	9.56

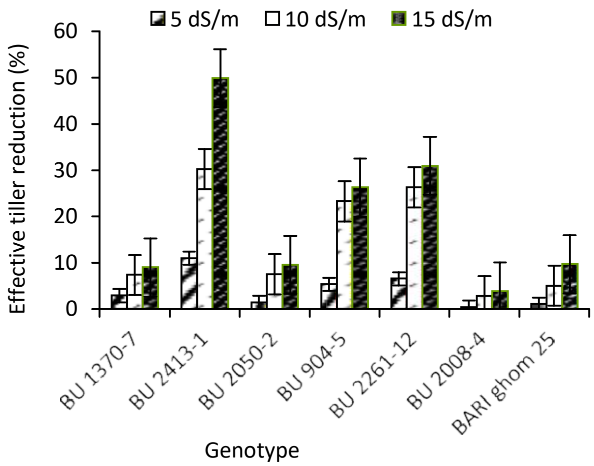


Fig. 2. Effective tiller reduction (%) of wheat genotypes as affected by variable salinity levels

Spike length

Spike length was not declined significantly at higher salinity levels (Table 4). But due to lower salinity level (5 and 10 dS m^{-1}) spike length reduction was very little in all the genotypes which were not significantly different from that of control (Fig. 3). Under 15 dS m^{-1} salinity the reduction of spike length was pronounced more which was significantly different from that of control. At 15 dS m^{-1} salinity level the highest spike length was obtained in genotype BU 2413-1 (10.49 cm) along with highest reduction value (15.83%). The lowest reduction value at 15 dS m^{-1} salinity was found in genotype BU 2008-4 (4%) followed by BU 2008-4 (5.22%) and BU 2050-2 (5.30%).

Spikelet number per spike

Salt stress significantly reduced the number of spikelet per spike irrespective of wheat genotypes (Table 5). Under control condition, the spikelet per spike ranged from 19.36 to 21.43, whereas this range was 15 to 19.68 at 15 dS m^{-1} salinity level. Under lower salinity level (5 and 10 dS m^{-1}) the trend of spikelet per spike was similar among the genotypes and the reduction of number of spikelet per spike was very small which was reflected in the reduction values (Fig. 4). However at higher salinity level (15 dS m^{-1}) the reduction of number of spikelet per spike was comparatively higher than the earlier treatments. At 15 dS m^{-1} salinity stress the highest number of spikelet per spike was observed in genotype BU 1370-7 (19.68) followed by BU 2008-4 (18.64) and the lowest number of spikelet per spike was found in genotype BU 2413-1 (15). On the other hand the lowest reduction value at 15 dS m^{-1} salinity stress was found in genotype BU 2008-4 (6.80%) followed by BU 1370-7 (7.43%) and the highest was found in genotype BU 2413-1 (23%). Shamsi and Kobraee (2013) reported that the fertile spikelet reduce under salt environment.

Table 4. Spike length of wheat genotypes under different salinity levels

Genotype	Spike length			
	Salinity level (dS m^{-1})			
	0	5	10	15
BU 1370-7	10.91	10.71	10.47	10.34
BU 2413-1	12.46	11.49	11.03	10.49
BU 2050-2	11.23	11.14	10.76	10.63
BU 904-5	11.32	10.61	10.22	9.97
BU 2261-12	11.58	10.70	10.48	10.12
BU 2008-4	10.46	10.25	10.16	10.04
BARI ghom 25	10.59	10.36	10.15	10.01
CV (%)	8.27	8.05	6.38	6.94

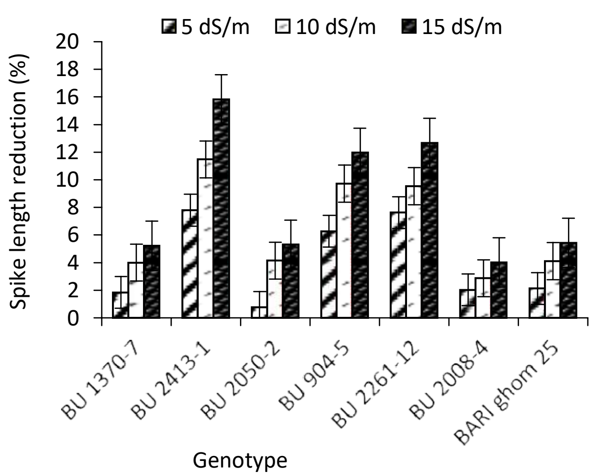


Fig. 3. Spike length reduction (%) of wheat genotypes as affected by variable salinity levels

Grain number per spike

The grain number per spike was also negatively changed due to salinity with genotypic variation (Table 6). In the control treatment the highest number of grain per spike was produced in genotype BU 2008-4 (60.83) and the lowest in BU 2261-12 (52.16). Like spikelet number per spike, grain per spike was also less influenced as compare to control in all the genotypes under 5 and 10 dS m^{-1}. Under 15 dS m^{-1} salinity level the highest number of grain per spike was found in genotype BU 2008-4 (56.90) and the lowest was found in genotype BU

2413-1 (38.80). At higher salinity (15 dS m^{-1}) the reduction progressed more in all the genotypes but the reduction was lowest in genotype BU 2008-4 (6.45%) and highest in BU 2413-1 (29.77) (Fig. 5).

Table 5. Spikelet number per spike of wheat genotypes under different salinity levels

Genotype	Spikelet number per spike			
	Salinity level (dS m^{-1})			
	0	5	10	15
BU 1370-7	21.26 a	20.80 ab	20.51 a	19.68 a
BU 2413-1	19.50 c	19.00 c	18.13 e	15.00 e
BU 2050-2	19.36 c	19.02 c	18.52 de	17.85 cd
BU 904-5	21.43 a	20.88 a	20.15 ab	18.71 bc
BU 2261-12	20.38 abc	19.85 abc	19.15 cd	17.41 d
BU 2008-4	20.00 bc	19.76 bc	19.46 bc	18.64 bc
BARI ghom 25	20.70 ab	20.32 ab	19.86 abc	18.83 ab
CV (%)	3.34	2.99	2.67	3.02

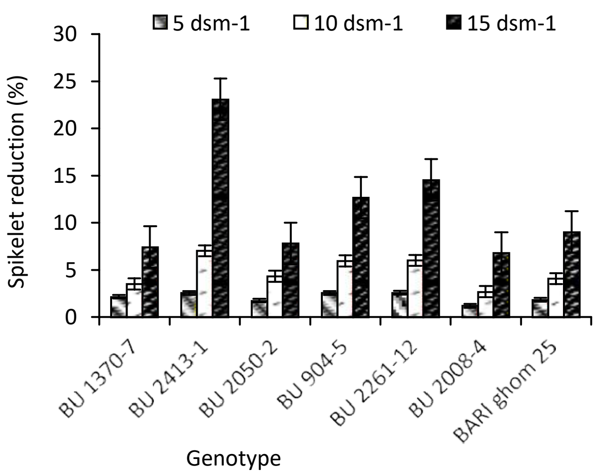


Fig. 4. Spikelet reduction (%) of wheat genotypes as affected by variable salinity levels

Table 6. Grain per spike of wheat genotypes under different salinity levels

Genotype	Grain number per spike			
	Salinity level (dS m^{-1})			
	0	5	10	15
BU 1370-7	58.83 ab	57.30 ab	56.16 ab	53.75 ab
BU 2413-1	55.25 bc	48.21 d	41.60 e	38.80 e
BU 2050-2	56.14 abc	54.40 ab	53.33 bc	50.94 bc
BU 904-5	55.70 bc	53.62 bc	49.70 cd	47.62 c
BU 2261-12	52.16 c	49.18 cd	46.16 d	42.88 d
BU 2008-4	60.83 a	59.40 a	57.96 a	56.90 a
BARI ghom 25	55.96 bc	54.18 bc	52.80 bc	50.65 bc
CV (%)	4.82	5.32	4.65	4.20

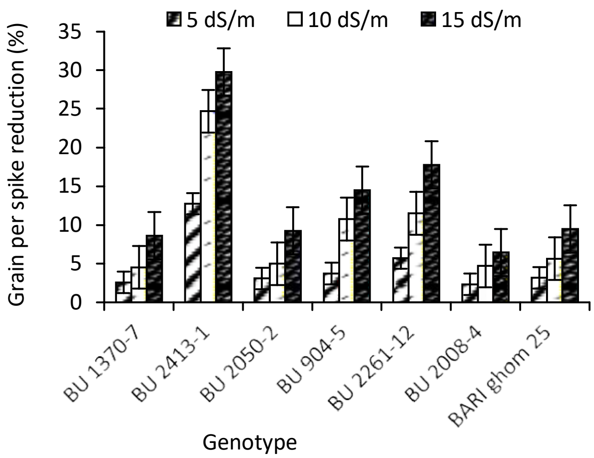


Fig. 5. Grain per spike reduction (%) of wheat genotypes as affected by variable salinity levels

Thousand grain weight

Salt stress condition significantly reduced the 1000-grain weight in all the genotypes with significant genotypic variations (Table 7). Under lower salinity level (5 and 10 dS m^{-1}) the reduction of 1000-grain weight was small which was reflected in the reduction values (Fig. 6). However at higher salinity level (15 dS m^{-1}) the reduction of 1000-grain weight was comparatively higher than the earlier treatments. At 15 dS m^{-1} salinity stress the maximum 1000-grain weight was observed in genotype BU 2050-2 (43.34 g) followed by BU 1370-7 (41.80) and BU 2008-4 (40.64 g). The lowest 1000-grain weight was found in genotype BU 2413-1 (27.89 g). On the other hand the lowest reduction value at 15 dS m^{-1} salinity stress was found in genotype BU 2008-4 (12.30%) followed by BU 1370-7 (14.44%) and the highest reduction value was found in genotype BU 2413-1 (39%).

Table 7. Thousand grain weight of wheat genotypes under different salinity levels

Genotype	Thousand grain weight			
	Salinity level (dS m^{-1})			
	0	5	10	15
BU 1370-7	48.85 abc	46.61 ab	44.05 ab	41.80 a
BU 2413-1	45.75 c	41.16 c	35.74 c	27.89 c
BU 2050-2	52.25 a	48.78 a	45.78 a	43.34 a
BU 904-5	47.43 bc	45.75 ab	40.98 b	35.99 b
BU 2261-12	49.45 ab	47.60 a	41.47 b	35.69 b
BU 2008-4	46.34 bc	44.25 bc	41.97 b	40.64 a
BARI ghom 25	48.03 bc	45.80 ab	41.92 b	40.52 a
CV (%)	4.33	4.12	4.50	4.41

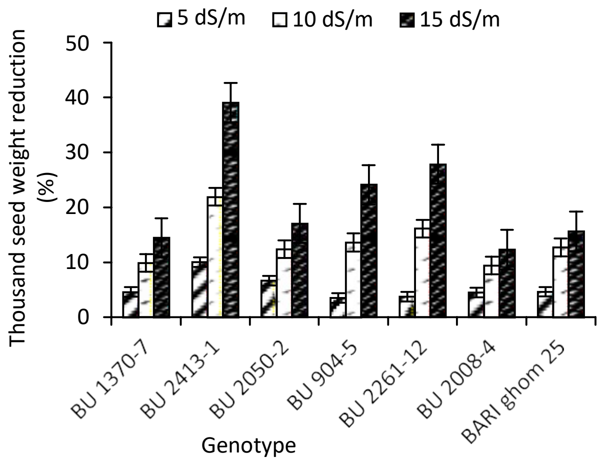


Fig. 6. Thousand grain weight reduction (%) of wheat genotypes as affected by variable salinity levels

Grain yield per plant

Grain yield of wheat showed a significant reduction in all the genotypes due to salt stress (Table 8). Under control condition the highest grain yield was recorded in genotype BU 1370-7 (10.09 g plant^{-1}) followed by BU 2413-1 (10.06 g plant^{-1}) and the lowest was obtained in BU 2261-12 (8.88 g plant^{-1}). Under 5 and 10 dS m^{-1} salinity level marked reduction in grain yield was found in all the genotypes. The highest grain yield per plant at 15 dS m^{-1} salinity level was found in genotype BU 2008-4 (8.92 g plant^{-1}) followed by BU 1370-7 (8.11 g plant^{-1}) and BU 2050-2 (7.92 g plant^{-1}) and the lowest was found in genotype BU 2413-1 (5.16 g plant^{-1}). At 15 dS m^{-1} salinity level the reduction was progressed more with drastic decline in genotype BU 2413-1 and moderate reduction in others genotypes (Fig.7). The reduction value at 15 dS m^{-1} salinity level was also lowest in genotype BU 2008-4 (9.38%) and highest in genotype BU 2413-1 (48.75). The decrease in yield an yield components under saline conditions might have occurred due to retarded growth of the plants as a result of the low uptake of water and nutrients as well as due to the ion-toxic effects of Na^+ and Cl^- (Munns et al. 1995; Aldesuquy and Ibrahim, 2001). The correlation matrix between yield contributing characters and yield of different wheat genotypes are presented in Table 9 and found that different yield contributing characters were also closely related to grain yield of wheat.

Table 8. Grain yield of wheat genotypes under different salinity levels

Genotype	Grain yield (g/plant)			
	Salinity level (dS m^{-1})			
	0	5	10	15
BU 1370-7	10.09 a	9.59 a	9.10 a	8.11 ab
BU 2413-1	10.06 a	9.08 abc	6.85 c	5.16 e
BU 2050-2	9.48 ab	9.10 abc	8.69 ab	7.92 abc
BU 904-5	9.21 ab	8.02 bc	7.75 bc	6.89 cd
BU 2261-12	8.88 b	7.94 c	7.35 c	6.20 de
BU 2008-4	9.84 ab	9.49 a	9.21 a	8.92 a
BARI ghom 25	9.59 ab	9.17 ab	8.56 ab	7.38 bcd
CV (%)	6.96	7.54	7.20	8.39

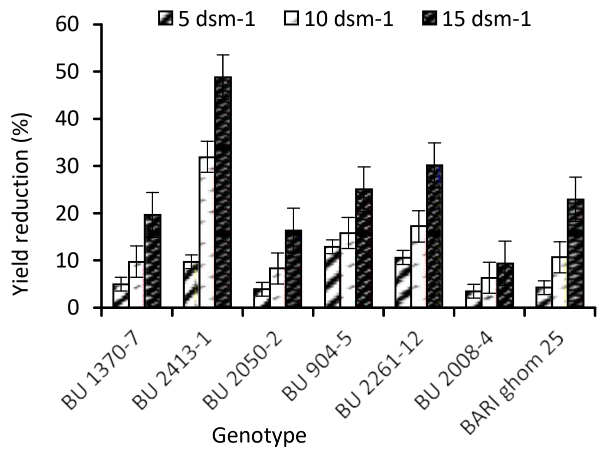


Fig. 7. Grain yield reduction (%) of wheat genotypes as affected by variable salinity levels

Table 9. Correlation coefficient of yield contributing characters and yield of seven white genotypes under saline condition

Traits	PH	TTPP	ETPP	PL	PNPP	GPP	TSW	GY
PH	1							
TTPP	0.79*	1						
ETPP	0.81*	0.97**	1					
PL	-0.17	-0.91**	-0.88**	1				
PNPP	0.63	0.79*	0.80*	-0.45	1			
GPP	0.66	0.97**	0.96**	-0.22	0.83*	1		
TSW	0.87**	0.92**	0.94**	-0.04	0.82*	0.87**	1	
GY	0.80*	0.99**	0.96**	-0.85*	0.80*	0.99**	0.89**	1

*Correlation is significant at the 0.05 level (2-tailed)

** Correlation is significant at the 0.01 level (2-tailed)

PH = Plant height (cm), TTPH = Total tiller per plant, ETPH = Effective tiller per plant, PL = Panicle length (cm), PNPP = Spikelet no per spike, GPP=Grain per spike TSW = 1000-Seed weight (g), GY = Grain yield per plant (g)

Plant water status

Relative water content

Relative water content (RWC) is considered as a measure of plant water status that reflects metabolic activity in tissues and used as a most meaningful index for dehydration tolerance (Anjum, 2011). Salt treatment caused a significant decrease in relative water content. Among the stages, irrespective of genotypes the RWC in flag leaves was the highest in booting stage (Fig. 8) and the lowest was obtained at anthesis stage (Fig. 9). It might be due to leaf development at early stage which delines as the dry matter accumulates and leaf mature. Under control condition the RWC varied from 90.77 to 92.68 and 84.91 to 86.95 at booting stage an anthesis stages respectively. In the treatment of 15 dS m^{-1} salt condition the RWC varied from 75.3 to 86.81 and 64.75 to 79.39 at booting stage an anthesis stages respectively. Katerji et al. (1997) reported that a decrease in RWC indicates a loss of turgor that results in limited water availability for cell extension processes. At different treatment the highest RWC was recorded in genotype BU 2008-4 with the lowest reduction reflected in relative value followed by BU 2050-2 (Fig. 8 and Fig. 9).

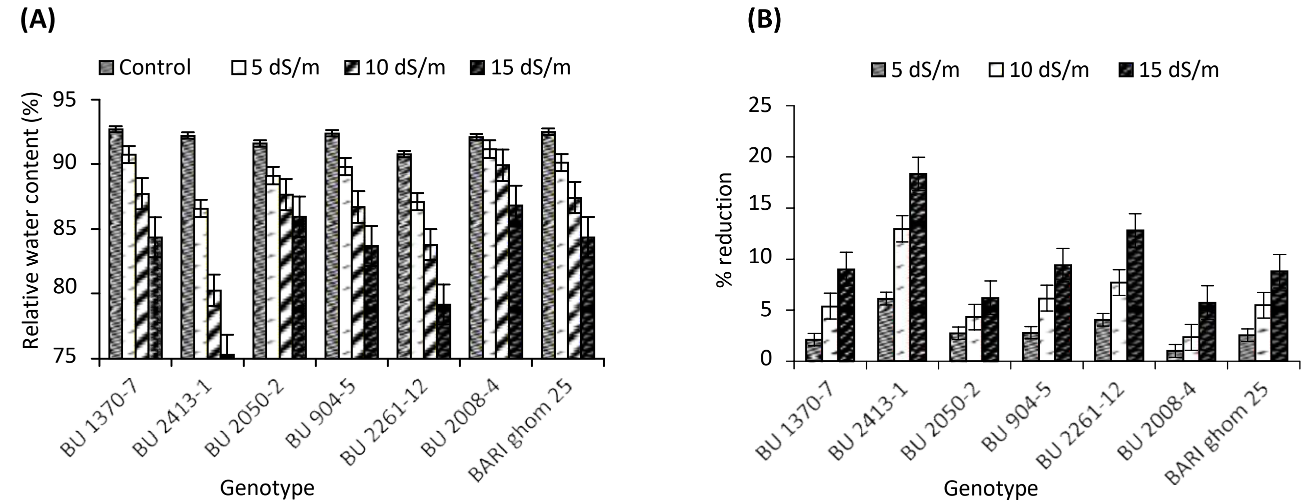


Fig. 8. Relative water content (%) (A) and its reduction (%) (B) at booting stage of wheat genotypes under variable salinity levels

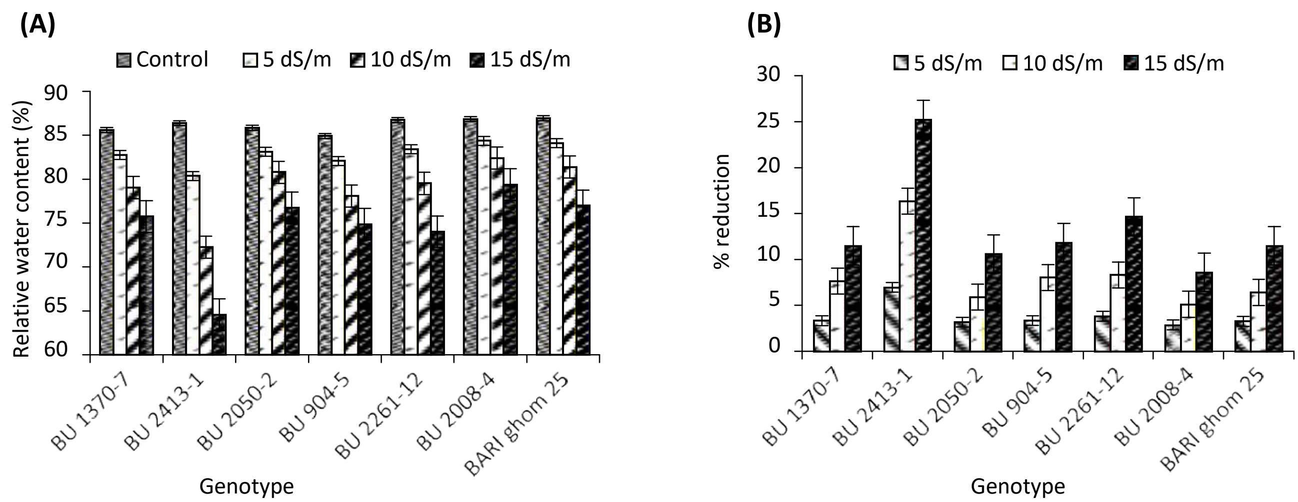


Fig. 9. Relative water content (%) (A) and its reduction (%) (B) at anthesis stage of wheat genotypes under variable salinity levels

Water saturation deficit

Water saturation deficit (WSD) is the deviation of water content from the leaf compared to the saturation level of that leaf at a particular situation. A high water saturation deficit indicates that the plants are subjected to a greater degree of water deficit. Water saturation deficit showed an inverse trend of relative water content (RWC). Salinity stress significantly increased the WSD in wheat (Fig. 10). Under control condition the highest WSD was observed in BU 2261-12 (7.96%) followed by BU 2050-2 (7.89) and the lowest was found in BU 1370-7 (7.37). However, at 15 dS m^{-1} salinity level the highest WSD was observed in BU 2413-1 (28.49) with the highest relative value (372%) and lowest was found in BU 2008-4 (13.01) also along with the lowest relative value (169) (Fig. 10). Hossain et al. (2006) reported that WSD increase with increasing salinity levels and lower WSD indicate tolerant to salinity.

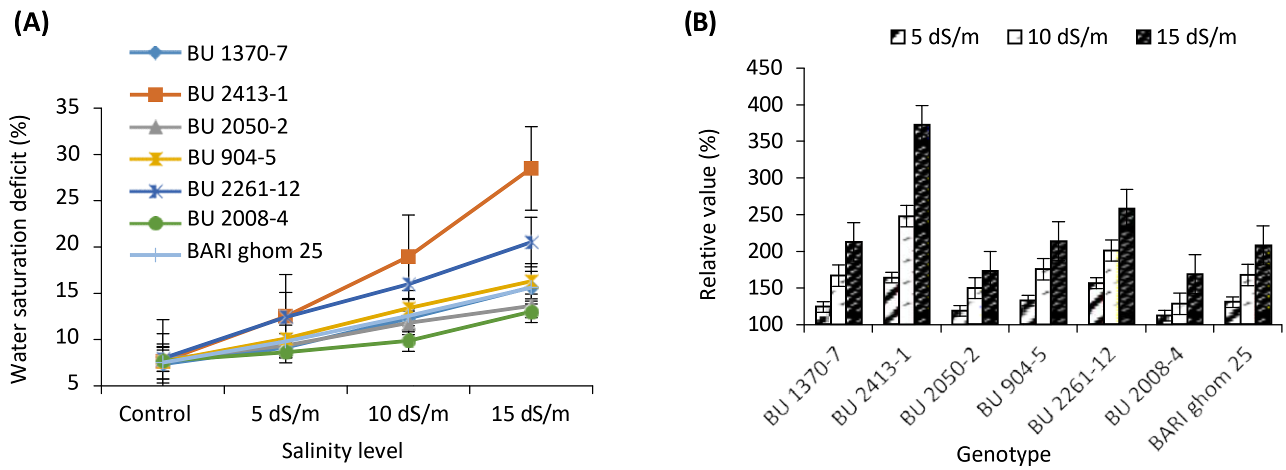


Fig. 10. Water saturation deficit (A) and its relative value (B) in leaf of wheat genotypes at anthesis stage as affected by variable salinity levels

Leaf Water Potential

Leaf water potential was decreased markedly in wheat flag leaf due to increase in salinity irrespective of genotypes (Fig. 11). Osmotic effects of salt on plants are the results of lowering of the soil water potential due to increase in solute concentration in the root zone. At very low soil water potentials, this condition interferes with plant's ability to extract water from the soil and maintain turgor. At anthesis the leaf water potential ranged from -0.64 to 0.66 MPa, -0.66-0.71 MPa, -0.70 to 0.78 MPa and from -0.72 to 0.83 MPa under control, 5 dS m^{-1}, 10 dS m^{-1} and 15 dS m^{-1} salinity level. However, the highest leaf water potential was recorded in BU 2008-4 genotype under the salt stress conditions with the lowest reduction followed by BU 2050-2 and BU 1370-7 (Fig. 11). As the salts within the plant tissues increased osmotic potential, the water potential is decreased (Ashraf and Foolad, 2005; Parida and Das, 2005). The correlation matrix between different physiological characters and yield of different wheat genotypes are presented in Table 10 and found that different biochemical characters were also closely related to grain yield of wheat.

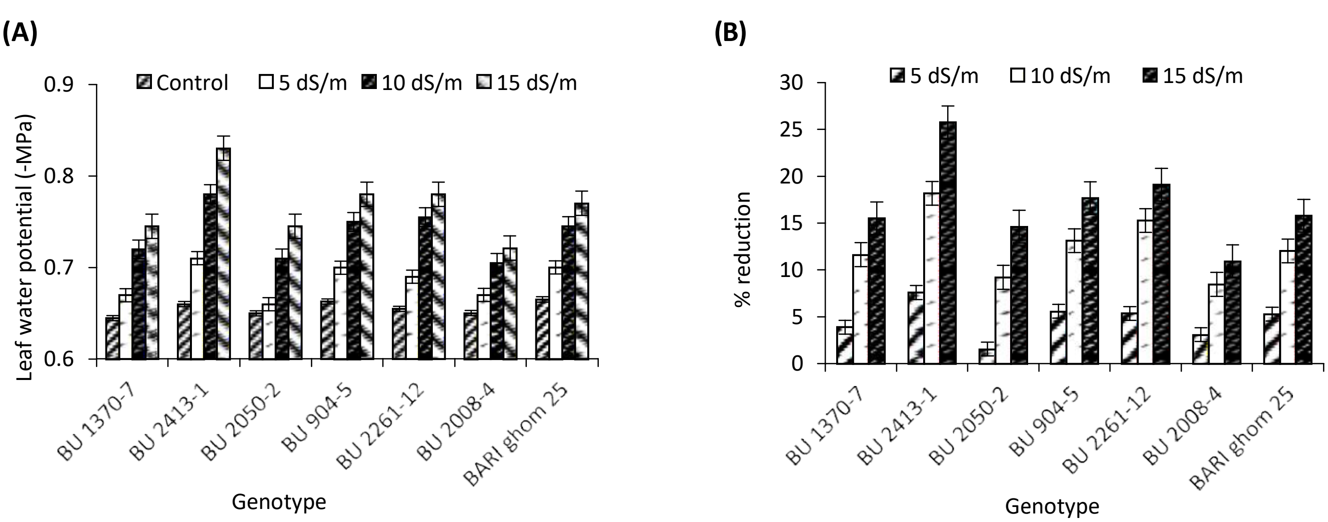


Fig. 11. Leaf water potential (A) and its reduction (%) (B) at anthesis stage of wheat genotypes as affected by variable salinity levels

Table 10. Correlation coefficient of oxidative, biochemical and morphological characters and grain yield of seven white genotypes under saline condition

Traits	CAT	AXP	ROS	MDA	CMI	PC	GB	SS	SP	PR	SC	TRA	RWC	LWP	GY
CAT	1														
AXP	0.96**	1													
ROS	-0.99**	-0.95**	1												
MDA	-0.98**	-0.94**	0.99**	1											
CMI	-0.95**	-0.94**	0.98**	0.98**	1										
PC	0.99**	0.95**	-0.99**	-0.99**	-0.97**	1									
GB	0.99**	0.96**	-1.00**	-0.99**	-0.99**	0.99**	1								
SS	0.98**	0.94**	-1.00**	-0.99**	-0.98**	0.99**	1.00**	1							
SP	0.99**	0.95**	-0.99**	-0.98**	-0.96**	0.99**	0.98**	0.97**	1						
PR	0.95**	0.89**	-0.89**	-0.90**	-0.82*	0.92**	0.89**	0.88**	0.93**	1					
SC	0.98**	0.97**	-0.96**	-0.93**	-0.92**	0.96**	0.96**	0.94**	0.97**	0.94**	1				
TR	-0.89**	-0.76*	0.86*	0.85*	0.78*	-0.87*	-0.83*	-0.83*	-0.91**	-0.93**	-0.87*	1			
RWC	0.95**	0.98**	-0.95**	-0.93**	-0.95**	0.94**	0.96**	0.94**	0.94**	0.85*	0.97**	-0.75*	1		
LWP	-0.98**	-0.90**	0.98**	0.96**	0.94**	-0.98**	-0.97**	-0.97**	-0.98**	-0.90**	-0.95**	0.91**	-0.92**	1	
GY	0.99**	0.95**	-0.98**	-0.96**	-0.93**	0.98**	0.97**	0.96**	0.99**	0.95**	0.99**	-0.92**	0.95**	-0.98**	1

*Correlation is significant at the 0.05 level (2-tailed)

** Correlation is significant at the 0.01 level (2-tailed)

CAT= Catalase activity, APX= Ascorbic peroxidase activity, ROS=Reactive oxygen species, CMI=Cell membrane injury, PC=Proline content, GB= Glycine-betaine content, SS=Soluble sugar, SP=Soluble protein, PR=Photosynthetic rate, SC=Stomatal conductance , TR=Transpiration rate, RWC=Relative water content, LWP= Leaf water potential, GY=Grain yield

Compatible solutes accumulation

Proline accumulation

Proline is one of the key osmolytes contributing toward osmotic adjustment (Iqbal et al. 2008) and it is a well-known adaptive mechanism in plants against salt stress conditions (Parida and Das, 2005; Ashraf and Foolad, 2007; Ahmad et al. 2010). Intracellular proline which is accumulated during salinity stress not only provides tolerance towards stress but also serves as an organic nitrogen reserve during stress recovery. Accumulation of proline in flag leaf of wheat was measured both under control and salt stress conditions but the accumulation was about 2-2.5 times higher at lower salt level and almost 3-5.5 times higher at higher salt stress condition than control condition. Different wheat genotypes exhibited different magnitude off proline accumulation both under control and salt stress conditions. However, the highest accumulation of proline was recorded in the genotype BU 2008-4 at 5 dS m^{-1} (3.12 µg g^{-1} FW), 10 dS m^{-1} (7.14 µg g^{-1} FW) and 15 dS m^{-1} (12.53 µg g^{-1} FW) salinity level followed by BU 1370-7 (3.11µg g^{-1} FW, 6.98 µg g^{-1} FW and 12.19 µg g^{-1} FW) and BU 2050-2 (2.95 µg g^{-1} FW, 6.65 µg g^{-1} FW and 11.37 µg g^{-1} FW) at all the salinity level (Fig. 12). Relative value was also highest in BU 2008-4, BU 1370-7 and BU 2050-2 (Fig. 12).The lowest proline accumulation was recorded in the genotype BU 2413-1 at 5, 10 and 15 dS m^{-1} salinity level (2.20 µg g^{-1} FW, 3.87 µg g^{-1} FW and 6.49 µg g^{-1} FW). Under all the salinity level the genotypes were significantly different from each other.

(A) (B)

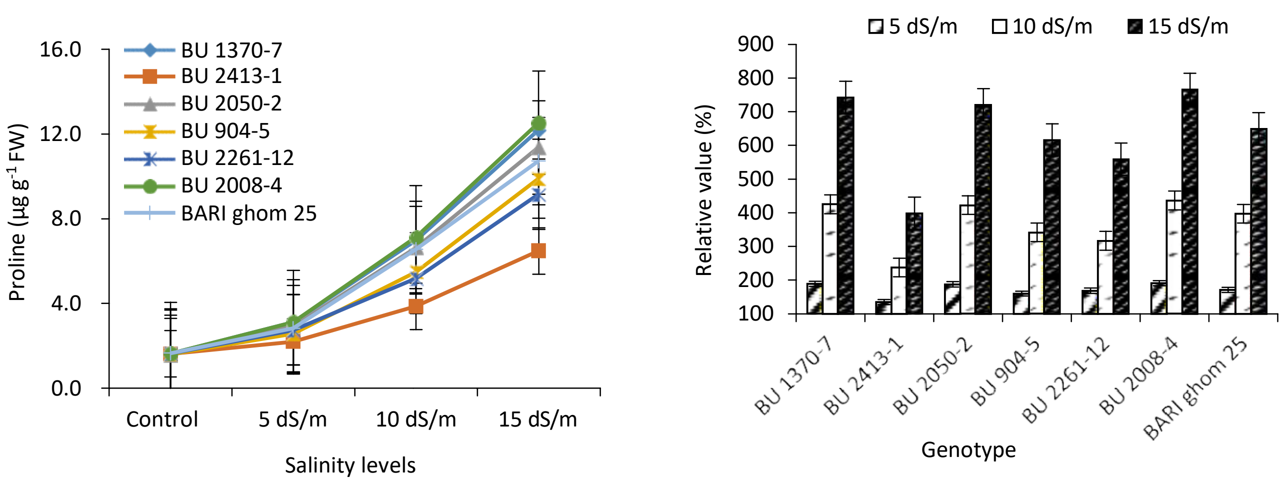


Fig. 12. Proline content (A) and its relative value (B) in leaf of wheat genotypes at anthesis stage as affected by variable salinity levels

Soluble sugar accumulation

Sugar is another important osmoprotectants which contributed up to 50% of the total osmotic potential in glycophytes subjected to saline conditions (Ashraf and Harris, 2004). Sugar accumulation in salinity stressed plants prevents structural and functional changes of membranes and destruction of soluble proteins. Increased accumulations of carbohydrates such as sugars and starch occur under salt stress (Parida et al. 2002). In this experiment it was observe that the soluble sugar content increased significantly in wheat genotypes at different proportion under all salt stress conditions (Fig. 13). Soluble sugar content at control condition ranged from 27.89 to 28.53 mg g^{-1} FW of which the highest soluble sugar was produced by the genotype BU 1370-7 (28.53 mg g^{-1} FW) and the lowest in genotype BU 2050-2 (27.89 mg g^{-1} FW). At higher salt stress condition (15 dS m^{-1}) a drastic positive change in soluble sugar content was occurred compared to control in all the wheat genotypes with significant genotypic variation from each other of which the highest soluble sugar was obtained in genotype BU 2008-4 (65.27 mg g^{-1} FW) along with the highest relative value (231%) following in BU 1370-7 (64.58 mg g^{-1} FW) with a relative value of 226% and in BU 2050-2 (62.89 mg g^{-1} FW) with a relative value of 225%. The lowest was found in genotype BU 2413-1 (41.22 mg g^{-1} FW) with the lowest relative value (145%).

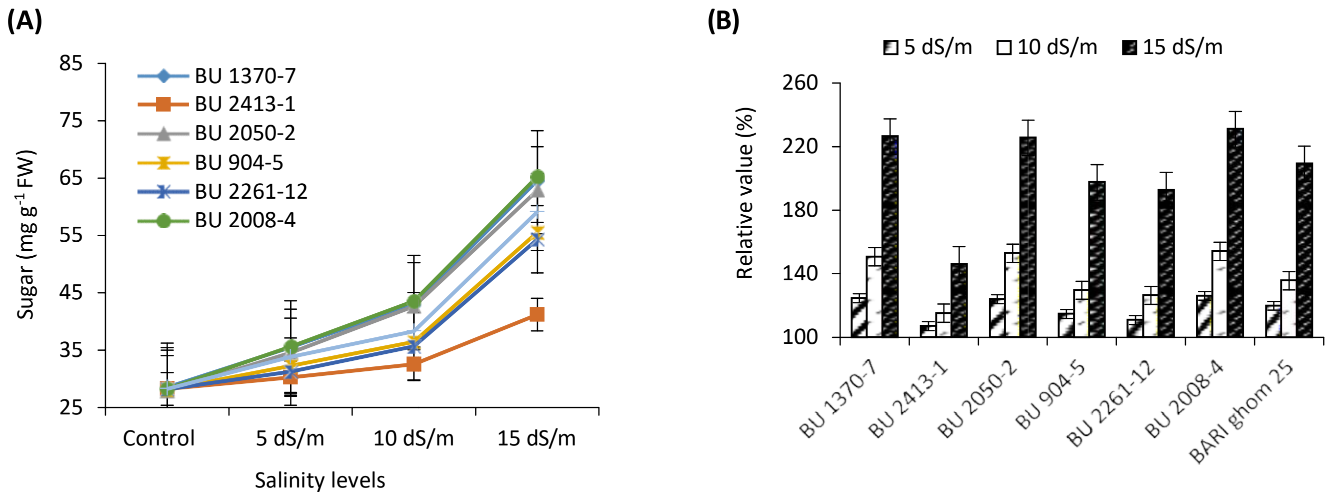


Fig. 13. Soluble sugar accumulation (A) and its relative value (B) in leaf of wheat genotypes at anthesis stage as affected by variable salinity levels

Soluble protein accumulation

Soluble protein also significantly increased with increased with increasing salt stress condition (Fig. 14). At control condition the highest soluble protein was produced by the genotype BARI ghom 25 (22.42 mg g^{-1} FW) and the lowest in genotype BU 2050-2 (21.35 mg g^{-1} FW). At higher salinity level (15 dS m^{-1}) BU 2008-4 produce the highest amount of soluble protein (45.35 mg g^{-1} FW) along with the highest relative value (203%) followed by BU 1370-7 (43.04 mg g^{-1} FW) with second highest relative value of 194% and in BU 2050-2 (41.23 mg g^{-1} FW) with third highest relative value of 193%. Genotype BU 2413-1 produced the lowest amount of soluble protein (31.27 mg g^{-1} FW) with the lowest relative value (145%). The correlation matrix between different biochemical characters and yield of different wheat genotypes are presented in Table 10 and found that different biochemical characters were also closely related to grain yield of wheat.

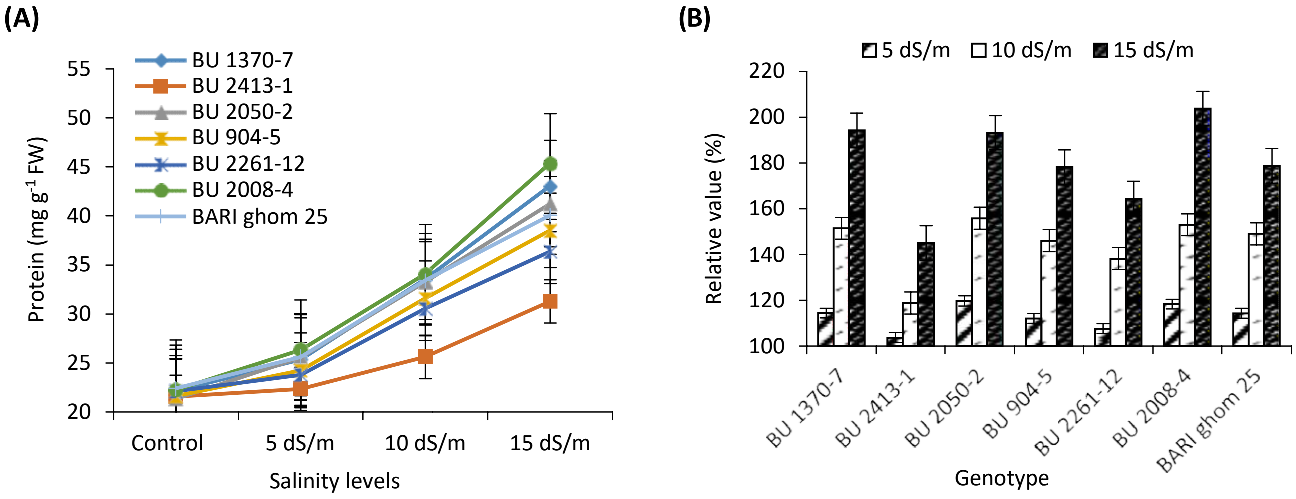


Fig. 14. Soluble protein accumulation (A) and its relative value (B) in leaf of wheat genotypes at anthesis stage as affected by variable salinity levels

Gas exchange activities

Photosynthetic rate (Pn)

Photosynthesis rate of wheat genotypes was reduced significantly when plants were exposed to salt stress (Fig. 15). Under control condition the maximum Pn was observed in genotype BU 1370-7 (17.04 µmol m^{-2} s^{-1}) and the lowest in genotype BU 2261-12 (15.10 µmol m^{-2} s^{-1}). Photosynthetic rate decreased sharply with increasing salinity level. However, the highest Pn was observed in BU 2008-4 (13.70 µmol m^{-2} s^{-1}) with lowest reduction value (17.58%) followed by BU 2008-4 (13.31 µmol m^{-2} s^{-1}) with second lowest reduction value (21.89%) at 15 dS m^{-1} salinity level and the lowest Pn was observed in genotype BU 2413-1 (11.11µmol m^{-2} s^{-1}) with highest reduction value (33.75%). The highest Pn at 15 dS m^{-1} salinity level was found in genotype BU 2008-4 (13.70 µmol m^{-2} s^{-1}) with lowest relative value (17.58%) followed by BU 2008-4 (13.31 µmol m^{-2} s^{-1}) with second lowest relative value (21.89%). It was reported that stomatal conductance which result in restriction the availability of CO2 for carboxylation reactions is the factor that reduced photosynthesis under stress (Brugnoli and Bjorkman, 1992).

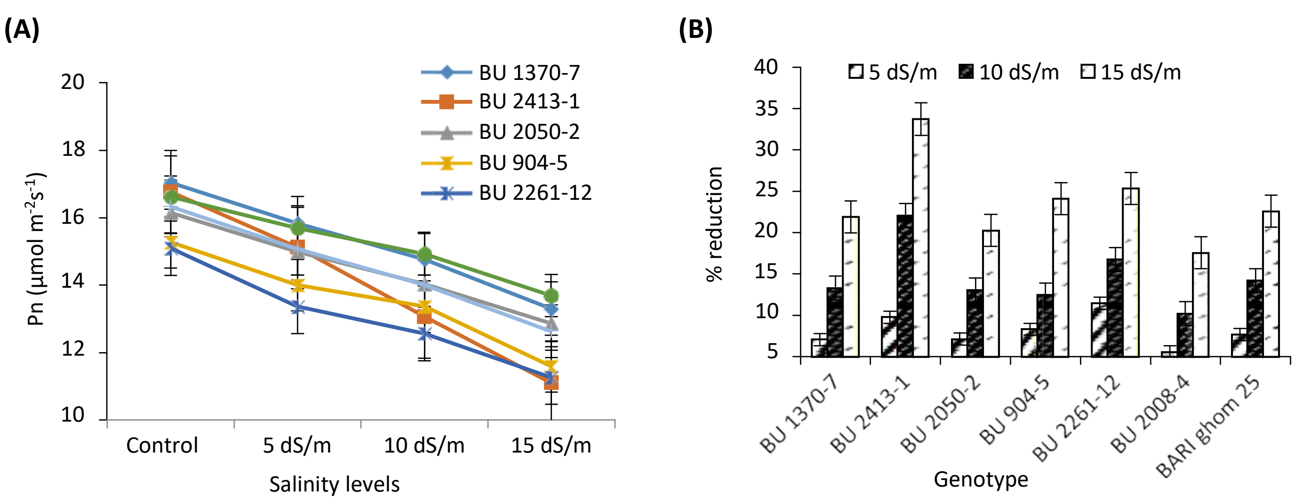


Fig. 15. Photosynthetic rate (Pn) (A) and its reduction (%) (B) in flag leaf of wheat genotypes at anthesis stage as affected by variable salinity levels

Stomatal conductance

Stomatal conductance of wheat genotypes was significantly reduced under salt tress conditions as compared to control in all the genotypes (Fig. 16). Under control, the highest stomatal conductance was found in genotypes BU 2413-1 and BU 1370-7 (0.267 mmol m^{-2} s^{-1}) and the lowest in BARI ghom 25 (0.247 mmol m^{-2} s^{-1}). Under 15 dS m^{-1} salinity level, the reduction of stomatal conductance was more where the maximum stomatal conductance was recorded in genotype BU 2008-4 (0.175 mmol m^{-2} s^{-1}) along with the lowest reduction value (34%) followed by BU 2050-2 (0.159 mmol m^{-2} s^{-1}) with reduction value (39%) (Fig. 16). The minimum stomatal conductance at 15 dS m^{-1} salinity level was observed in genotype BU 2413-1 (0.083 mmol m^{-2} s^{-1}) with highest reduction value (69%).

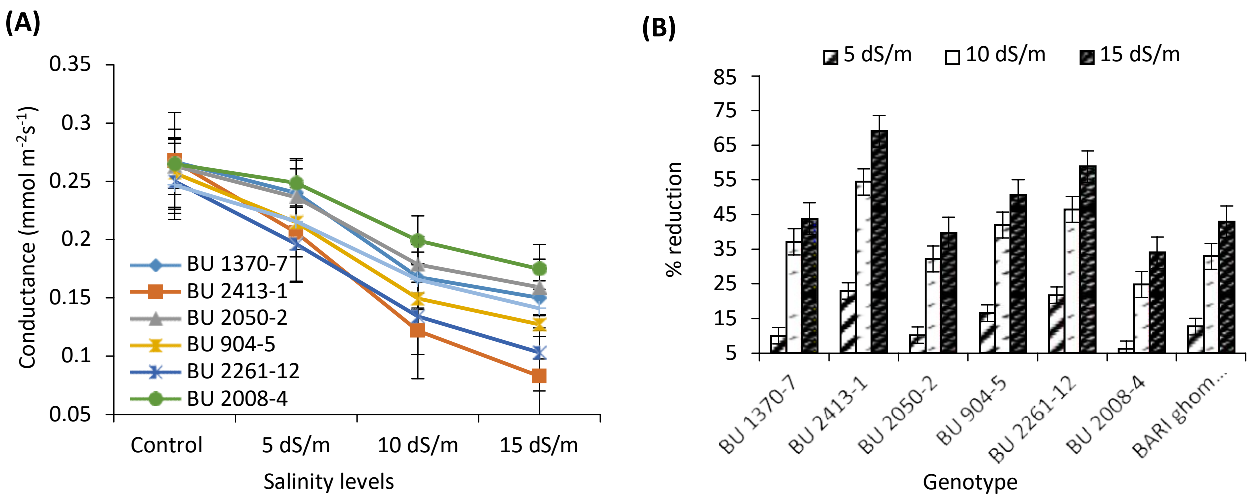


Fig. 16. Stomatal conductance (A) and its reduction (%) (B) in flag leaf of wheat genotypes at anthesis stage as affected by variable salinity levels

Leaf chlorophyll content

One of the most notable effects of salt stress is the alteration of photosynthetic pigment biosynthesis (Maxwell and Johnson, 2000). The decrease in chlorophyll content under salt stress is commonly reported and chlorophyll concentration was used as a sensitive indicator of the cellular metabolic state (Chutipaijite et al. 2011). Present study revealed that salt stress significantly reduced the chl a regardless of genotypes (Table 11) compared to control. At lower salinity level (5 dS m^{-1}) the content of chl a was less affected. Under 15 dS m^{-1} salt condition the content of chl a was more affected. However the highest content of chl a was found in genotype BU 2008-4 (1.33 mg g^{-1} FW) followed by genotype BU 1370-7 (1.29 mg g^{-1} FW) and the minimum was recorded in genotype BU 2413-1 (1.04 mg g^{-1} FW). Chlorophyll b content was also reduced due to salt stress compared to control irrespective of genotypes. The amount of chl b was lower than chl a irrespective of treatment. Salt treatment significantly decreased the total chl content at anthesis stage irrespective of wheat genotypes (Fig. 17). However, genotype BU 2008-4 maintained the maximum chl at all the salinity levels together with minimum reduction values (Fig. 17). The correlation matrix between different physiological characters and yield of different wheat genotypes are presented in Table 10 and found that different physiological characters were also closely related to grain yield of wheat.

Table 11. Chlorophyll content in flag leaf of wheat genotypes at anthesis stage as affected by variable salinity levels

Genotype	Chlorophyll a (mg g^{-1} FW)				Chlorophyll b (mg g^{-1} FW)			
	Salinity level (dS m^{-1})				Salinity level (dS m^{-1})			
	0	5	10	15	0	5	10	15
BU 1370-7	1.69	1.52 a	1.43 a	1.29 a	1.12	1.09 a	1.06 a	1.03 a
BU 2413-1	1.66	1.35 d	1.17 c	1.04 d	1.09	0.99 b	0.94 b	0.85 b
BU 2050-2	1.68	1.51 ab	1.42 a	1.28 a	1.11	1.08 ab	1.04 a	1.01 a
BU 904-5	1.61	1.44 bc	1.32 b	1.20 bc	1.11	1.04 ab	1.01 a	1.00 a
BU 2261-12	1.67	1.43 cd	1.31 b	1.19 c	1.13	1.03 ab	1.01 a	0.99 a
BU 2008-4	1.70	1.57 a	1.45 a	1.33 a	1.12	1.10 a	1.05 a	1.03 a
BARI ghom 25	1.67	1.49 abc	1.41 a	1.27 ab	1.11	1.05 ab	1.03 a	1.01 a
CV (%)	4.12	3.01	3.56	3.65	3.85	5.36	3.52	4.26

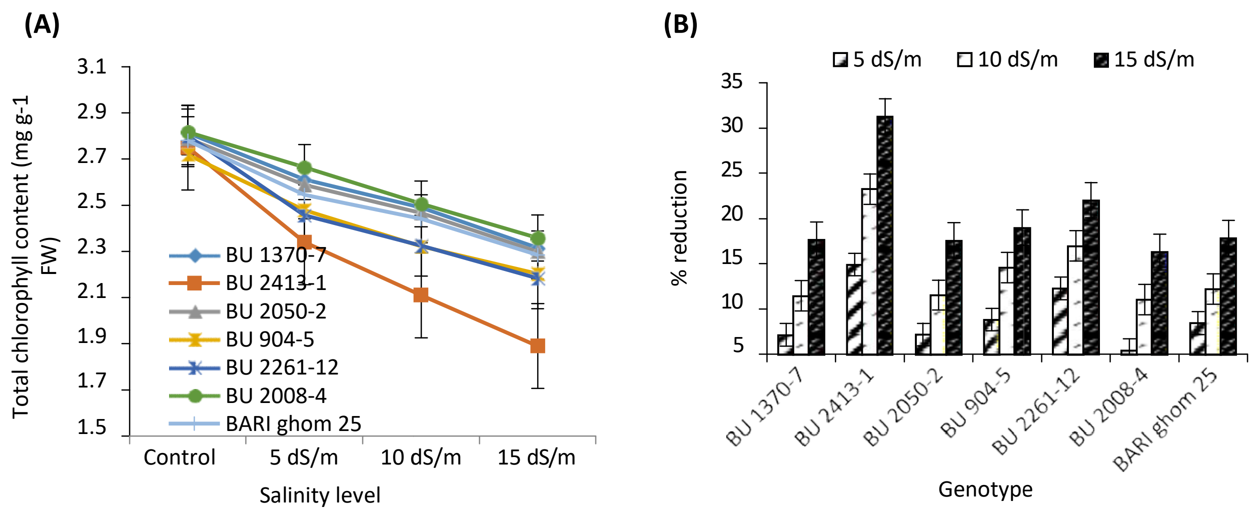


Fig. 17. Total chlorophyll content (A) and its reduction (%) (B) in flag leaf of wheat genotypes at anthesis stage as affected by variable salinity levels.

Oxidative stress

Salt stress can lead to stomatal closure, which reduces CO_2 availability in the leaves and inhibits carbon fixation, exposing chloroplasts to excessive excitation energy which in turn increase the generation of reactive oxygen species (ROS) such as superoxide ($O_2^{\cdot -}$), hydrogen peroxide (H_2O_2), hydroxyl radical (OH^-) and singlet oxygen ($^1O_2$) (Parida and Das, 2005; Ahmad and Sharma, 2008; Ahmad et al. 2010). ROS are highly reactive and may cause cellular damage through oxidation of lipids, proteins and nucleic acids (Aple and Hirt, 2004). Among them H_2O_2 is the most harmful ROS which causes oxidative stress.

Hydrogen peroxide (H_2O_2)

In the present study salinity significantly increased the content of H_2O_2 in the wheat plants regardless of genotype (Fig. 18 Under control condition the highest content of H_2O_2 was found in the genotype BU 904-5 (8.73µ mol g^{-1}FW). In the treatment of 15 dS m^{-1} salt condition the highest content of H_2O_2 was found in the genotype BU 2413-1 (13.28 µ mol g^{-1}FW) and the lowest was found in the genotype BU 2008-4 (9.60 µ mol g^{-1}FW). Due to lower salinity (5 dS m^{-1}) level the amount of H_2O_2 was increased very little, maintaining the similar trend among the genotypes, without significant difference as obtained in control. But the increasing rate at 15 dS m^{-1} was higher in BU 2413-1 followed by BU 2261-12 which were reflected in relative values 152% and 132% of BU 2413-1 and BU 2261-12 respectively (Fig. 18). The lowest amount of H_2O_2 was recorded in the genotype BU 2008-4 (9.60 µ mol g^{-1}FW) together with lowest relative value (114%).

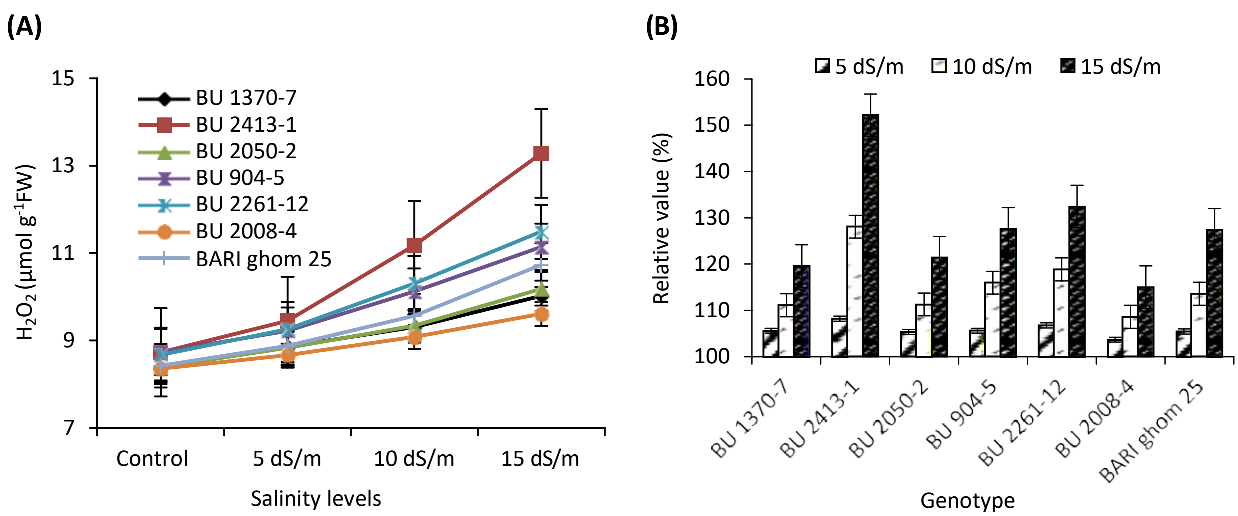


Fig. 18. H_2O_2 accumulation (A) and its relative value (B) in leaf of wheat genotypes at anthesis stage as affected by variable salinity levels

11.5.2 Percent injury in cell membrane

The cell membrane, being at the interface, is the first organelle to be affected by salt stress (Xu et al. 2010). Present study revealed that increase salt concentration cause an increase in cell membrane injury irrespective of genotypes (Fig. 20). Under control condition identical cell membrane injury was occurred with the highest in genotype BU 2261-12 (31.87%) following in BU 904-5 (31.44%) and the lowest percent of injury was recorded in BU 2050-2 (31.15%). Again the highest injury was found in genotype BU 2413-1 in both 10 (49.27%) and 15 dS m^{-1} salinity level (55.45%), while the lowest was found in genotype BU 2008-4 in both 10 (36.56%) and 15 dS m^{-1} salinity level (39.68%) followed by genotypes BU 1370-7 (37.97% and 41.07% at 10 and 15 dS m^{-1} salinity level) and BU 2050-2 (38.14% and 41.91% at 10 and 15 dS m^{-1} salinity level). The correlation matrix between oxidative characters and yield of different wheat genotypes are presented in Table 10 and found that different oxidative characters were also closely related to grain yield of wheat.

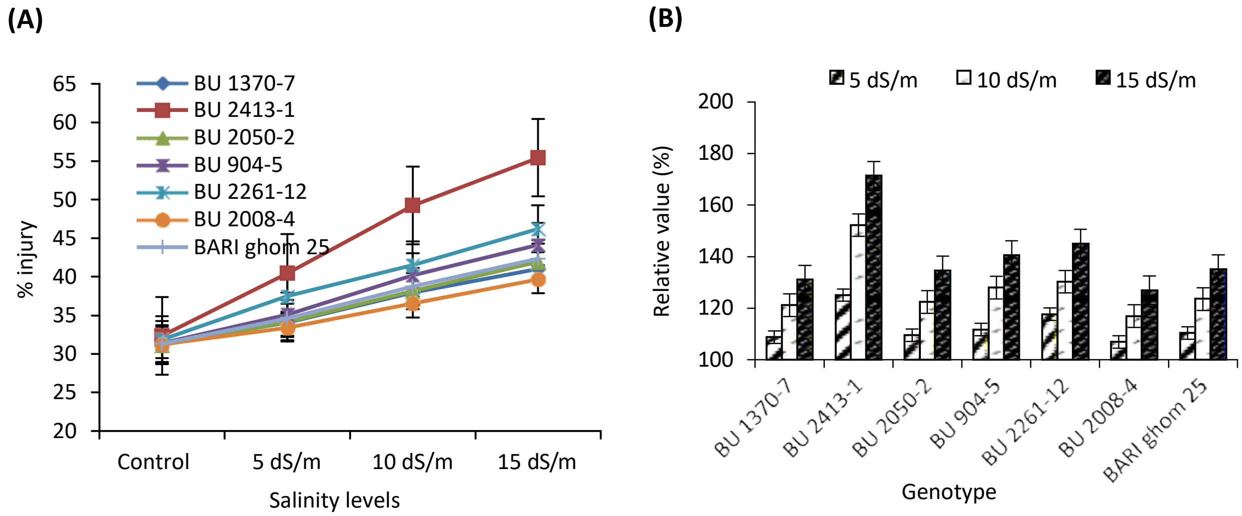


Fig. 20. Percent injury in cell membrane (A) and its relative value (B) in leaf of wheat genotypes at booting stage as affected by variable salinity levels

Antioxidant exzymes activity

Antioxidant metabolism, including antioxidant enzymes and non enzymatic compounds, play critical role in detoxifying ROS induced by salinity stress.

Catalase activity (CAT)

In the present study salinity significantly increased the catalase activity in all the genotypes (Fig. 21). Under control condition the highest catalase activity was observed in genotype BU 1370-7 (70.67 µ mol/min/mg protein) followed by BU 2050-2 (70.56 µ mol/min/mg protein) and the lowest was found in BU 2413-1 (69.26 µ mol/min/mg protein). In the treatment of 5 dS m^{-1} salinity level the increase of catalase activity was very small irrespective of genotypes. However, under 15 dS m^{-1} salinity level, a remarkable increase in catalase activity was observed in all the genotypes with the highest in genotype BU 2008-4 (93.56 µ mol/min/mg protein) with the highest relative value (133%) followed by BU 1370-7 (91.32 µ mol/min/mg protein) with the relative value of 129% and BU 2050-2 (90.31µ mol/min/mg protein) with the relative value of 128% in the same treatment (Fig. 21). The lowest catalase activity was recorded in genotype BU 2413-1 (74.3 µ mol/min/mg protein) with the lowest relative value (107%).

Ascorbic peroxidase (APX) activity

Like CAT salinity significantly increased the activity of APX regardless of genotypes (Fig. 23). The maximum APX activity was obtained in the genotype BU 2008-4 (0.4868 µ mol/min/mg protein) and the minimum activity was found in genotype BU 2261-12 (0.4801 µ mol/min/mg protein) at control. Under lower salinity level (5 dS m^{-1}) a little increase of APX was noticed in all the genotypes. At 15 dS m^{-1} salinity level, the activities of APX among the genotypes were progressed more with the maximum in genotype BU 2008-4 (0.64 µ mol/min/mg protein) with the highest relative value (131%) followed by BU 1370-7 (0.6332 µ mol/min/mg protein) with the relative value of 130% and BU 2050-2 (0.6306 µ mol/min/mg protein) with the relative value of 129% in the same treatment (Fig. 23). The lowest APX activity was recorded in genotype BU 2413-1 (0.5251µ mol/min/mg protein) with the lowest relative value (108%). The correlation matrix between antioxidant exzymes activity and yield of different wheat genotypes are presented in Table 10 and found that different oxidative characters were also closely related to grain yield of wheat.

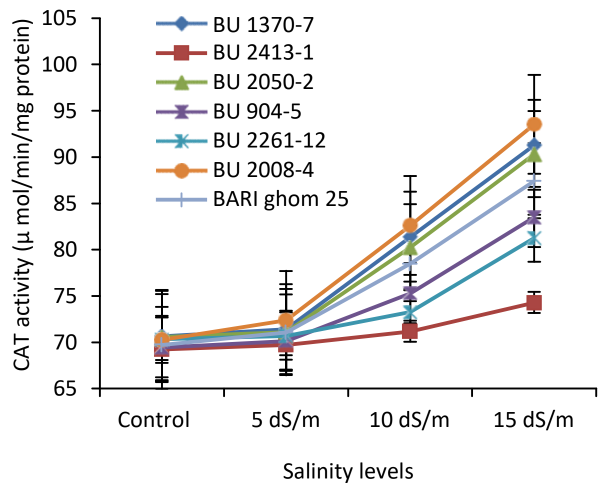


Fig. 21. Catalase (CAT) activity of wheat genotypes as affected by variable salinity levels

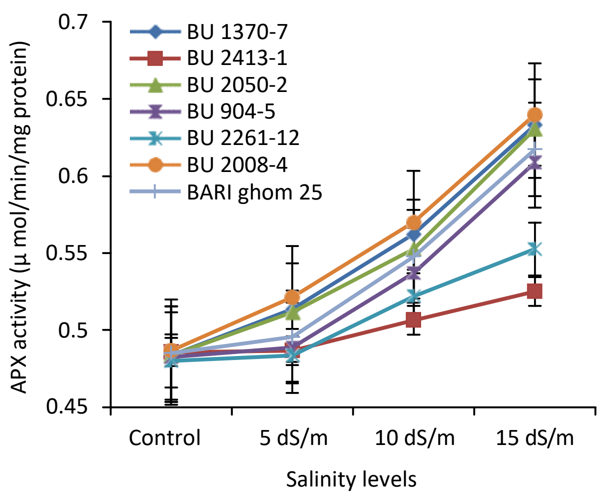
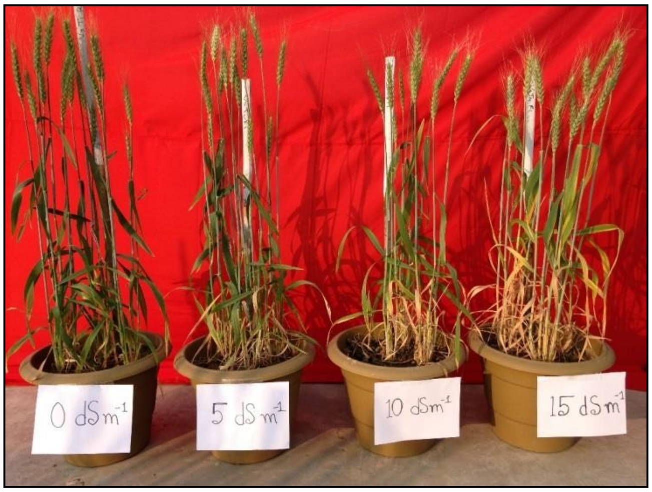


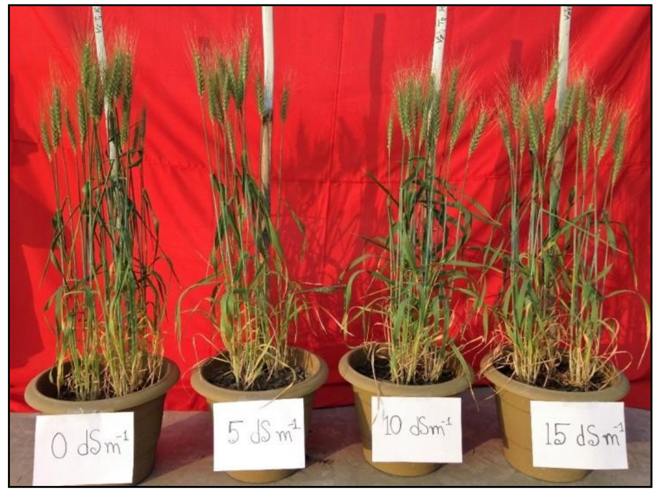
Fig. 22. Ascorbic peroxidase (APX) activity of wheat genotypes as affected by variable salinity levels

Pictorial view of the experiment

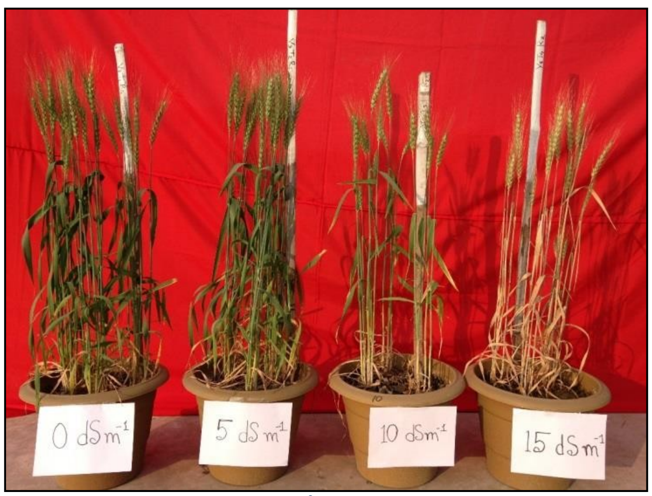
Fig. Field monitoring by different team and performing the research work



BARI Ghom 25 (CK)



Genotype BU-2008-4



Genotype BU-2413-1

Fig. Pictorial view of the performance of the genotypes

12 Research highlight/findings:

- A wide range of genotypic variation in wheat was found regarding physiological, biochemical and yield and yield attributes under salinity stress.
- The results showed that under salinity stress ROS (H_2O_2) production and cell membrane injury was lowest in genotype BU 2008-4, BU 1370-7 and BU 2050-2.
- The genotypes BU 2008-4, BU 1370-7 and BU 2050-2 showed the highest enzyme activity.
- Higher accumulation of different biochemical solutes such as proline, soluble sugar and soluble protein was found in genotypes BU 2008-4, BU 1370-7 and BU 2050-2 with faster photosynthetic rate with higher stomatal conductance and least degradation of chlorophyll.
- The lowest reduction in yield was maintained by the genotypes BU 2008-4, BU 1370-7 and BU 2050-2 together with the lowest reduction of yield attributes at different salinity level.
- Based on on-station results, it is recommended to validate results of the promising genotypes (BU 2008-4, BU 1370-7, BU 2050-2) in the farmers fields of coastal region of Bangladesh.

B. Implementation Position

1. Procurement:

Description of equipment and capital items	PP Target		Achievement		Remarks
	Phy (#)	Fin (Tk)	Phy (#)	Fin (Tk)	
(a) Office equipment	a) Desktop Computer 1 b) Laser Printer 1 c) UPS 1 d) Scanner 1 e) Digital Camera 1 f) Refrigerator 1	195000.00	a) Desktop Computer 1 b) Laser Printer 1 c) UPS 1 d) Scanner 1 e) Digital Camera 1 f) Refrigerator 1	195000.00	Completed
(b) Lab &field equipment	a) Plastic pot 300 b) Plastic tray 40	95000.00	a. Plastic pot 300 b. Plastic tray 40	95000.00	Completed
(c) Balance, Chemicals	a) Balance 1 b) Different Chemical	431080.00	a) Balance 1 b) Different Chemical	431080.00	Completed
(c) Other capital items	a) Executive Table 1 b)Executive Chair 1 c) File cabinet 1 d) Steel Almira 1 e) Front Chair 1 f) Computer Table 1 g)Computer Chair 1	86500.00	b) Executive Table 1 b)Executive Chair 1 g) File cabinet 1 h) Steel Almira 1 i) Front Chair 1 j) Computer Table 1 g)Computer Chair 1	86500.00	Completed

2. Establishment/renovation facilities: Not applicable

3. Training/study tour/ seminar/workshop/conference organized: Not applicable

C. Financial and physical progress

Fig in Tk

Items of expenditure/activities	Total approved budget	Fund received	Actual expenditure	Balance/ unspent/ **Required**	Physical progress (%)	Reasons for deviation
A. Contractual staff salary	412797	392356	397797	20441	95.05	Due of lack of fund
B. Field research/lab expenses and supplies	437580	423388	437580	14192	96.76	
C. Operating expenses	53123	51222	48315	1901	96.42	
D. Vehicle hire and fuel, oil & maintenance	40000	34782	40000	5218	86.96	
E. Training/workshop/seminar etc.	0	0	0	0	0	
F. Publications and printing	75000	40204	15000	34796	53.61	
G. Miscellaneous	35000	32805	32600	2195	93.73	
H. Capital expenses	446500	446500	446500	0	100	
Total	**1500000**	**1421257**	**1417792**	**78743**	**94.75**	

D. Achievement of Sub-project by objectives: (Tangible form)

Specific objectives of the sub-project	**Major technical activities performed in respect of the set objectives**	**Output(i.e. product obtained, visible, measurable)**	**Outcome(short term effect of the research)**
to screen wheat genotypes against salinity tolerance	We screened 300 wheat genotypes from the previous experiment conducted at Department of Agronomy, BSMRAU.	We selected five promising wheat genotypes against salinity	Salinity tolerant wheat genotypes
to analyze morphological, physiological and biochemical changes of selected wheat genotypes against salinity tolerance	2.1 Physiological data i) Relative water content ii) Leaf water potential iii) Photosynthetic rate iv) Stomatal conductance v) Leaf	2.1 The lowest reduction of stomatal conductance, leaf water potential, relative water content, leaf chlorophyll content was found in genotype BU-2008-4,	Physiological and biochemical mechanism related to salinity tolerant was detected

	chlorophyll content 2.2 Biochemical data i) Hydrogen peroxide (H_2O_2) content ii) Percent injury in cell membrane ii) Proline content iii) Soluble sugar content and v) Soluble protein content Antioxidant enzymes activity: i) Catalase activity (CAT) ii) Ascorbate peroxidase activity (APX) 2.3 Yield and yield contributing characters	followed by BU 1370-7 and BU 2050-2 which indicates tolerance against salinity. The highest accumulation of proline, soluble sugar, soluble protein, lowest H_2O_2 production, cell membrane injury and highest antioxidant enzyme activity was also recorded in BU-2008-4, BU 1370-7 and BU 2050-2 genotype. Lowest reduction value of yield was also maintained in genotype BU 2008-4, BU 1370-7 and BU 2050-2 together with the lowest reduction value of plant height, days to anthesis, highest tiller number per plant, the lowest spike length reduction, highest number of spikelet per spike, grain number per spike and 1000-grain weight at different salinity level.	

E. Materials Development/Publication made under the Sub-project:

Publication	Number of publication		Remarks (e.g. paper title, name of journal, conference name, etc.)
	Under preparation	Completed and published	
Technology bulletin/ booklet/leaflet/flyer etc.	Leaflet		
Journal publication	Two scientific paper under preparation		Physiology and Molecular Biology of Plants; Springer

F. Technology/Knowledge generation/Policy Support (as applied):

i. Generation of technology (Commodity & Non-commodity)

Salinity tolerant wheat genotype was identified

G. Information regarding Desk and Field Monitoring

i) Desk Monitoring [description & output of consultation meeting, monitoring workshops/seminars etc.):

a) Training program in BARC on 17 June 2017
b) Research review workshop in BARC on 21 December 2017
c) Monitoring workshops in BARC on 26 February 2018
d) Monitoring workshops in BARC on 15 May 2018
e) Monitoring workshops in BARC on 9 September 2018
f) Research review workshop in BSMRAU on 29 November 2018

ii) Field Monitoring (time& No. of visit, Team visit and output):

a) Field monitoring was done by Director Research, BSMRAU
b) Field monitoring was done by the Department of Agronomy, BSMRAU
c) Field monitoring was done by the Department of Soil Science, BSMRAU

I. Lesson Learned (if any)

i) Physiological and biochemical analysis
ii) Financial management and procurement system
iii) Operation of donor funded research project

J. Challenges (if any)

i) Fund release was not timely

Prof. Dr. Md. Moshiul Islam

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Signature of the Principal Investigator
Date ....

Seal Dr. Md. Moshiul Islam
Professor
Department of Agronomy
Bangabandhu Sheikh Mujibur Rahman
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Prof. Dr. A. K. M. Aminul Islam

....

Counter signature of the Head of the organization/authorized representative
Date 3/12/2019

Seal Prof. Dr. A. K. M. Aminul Islam
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