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PHOTOSYNTHESIS, YIELD ATTRIBUTES AND YIELD OF BORO RICE GENOTYPES UNDER DIFFERENT SALINITY LEVELS

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ABSTRACT

Munni SA, Islam MT, Nahar BS, Rahman MS, Haque MA (2017) Photosynthesis, yield attributes and yield of boro rice genotypes under different salinity levels. *Int. J. Expt. Agric.* 7(2), 9-14.

A pot experiment was conducted at the Bangladesh Institute of Nuclear Agriculture (BINA), Mymensingh, during December 2015 to May, 2016 to study the salt tolerance in Boro rice genotypes *viz*. Binadhan-10, Binadhan-8, B-10 and B-11. The plants were grown under four salinity levels *viz*. control, 6 dS/m, 9 dS/m and 12 dS/m. Plant height, number of total tillers/plant, length of panicle, straw weight/plant, number of panicle/plant, filled grain/plant, 1000-grain weight, yield/plant, photosynthesis, chlorophyll, nitrate reductase activity and soluble protein decreased with the increase in salinity levels as compared to the control. Only unfilled grain/plant increased at 9 dS/m. Binadhan-10 showed the highest plant height, filled grains/plant, 1000-grain weight and yield/plant and the lowest soluble protein. The genotype B-10 showed the highest photosynthesis, total tillers and moderate yield/plant. Binadhan-8 showed the highest number of unfilled grains/plant, soluble protein, 1000-granin weight and grain yield/plant. B-11 showed the highest chlorophyll, nitrate reductase activity, 1000-grain weight, and grain yield/plant. Length of panicle and number of panicles/plant was not significant among the studied genotypes. Binadhan-10 and Binadhan-8 showed more tolerance to salinity stress compared to B-10 and B-11.

Key words: *salinity, photosynthesis, yield attributes, rice*

INTRODUCTION

Salinity is one of the major impediments to enhancing production in rice growing areas worldwide. One-fifth of irrigated arable lands in the world have been reported to be adversely influenced by high soil salinity (Negrao *et al.* 2011). As per the report of FAO 2010 (Food and Agriculture Organization, 2010), over 800 million ha of worldwide land are severely salt affected and approximately 20% of irrigated areas (about 45 million ha) are estimated to suffer from salinization problems by various degrees. This is more serious since irrigated areas are responsible for one-third of world's food production. In Asia, 21.5 million hectares of land areas are affected by salinity and estimated to cause the loss of up to 50% fertile land by the 21st midcentury (Nazar 2011).

Rice is moderately sensitive to salt in the field as almost all the other crop species. The extent of damage for salinity depends on the severity of stress, growth conditions and plant sensitivity to salinity (Mishra and Bhattacharya, 1980). Rice (*Oryza sativa* L.), the staple food for two-thirds of world's population, plays an important role in world economy. In Asia, more than two billion people are getting 60-70 percent of their energy requirement from rice and its derived products (Thiyagarajan and Selvaraju, 2001). Although salinity affects all stages of growth and development of rice, it depresses grain yield the most seriously at the reproductive stage (Akbar and Ponnamperuma, 1982). Among the rice seasons, rice varieties are succumbing to salinity stresses at reproductive phase in T. Aman season. But in Boro and Aus season, primarily the vegetative phase is affected by salinity stresses. BRRI dhan40 and BRRI dhan41, Binadhan-8 and Binadhan-10 have been developed to combat the problem of salinity stress at the vegetative and reproductive phase. Rice is considered to be sensitive to salinity and tolerant to alkalinity, and some traditional salt tolerant varieties can withstand high pH up to 10.0 under irrigated conditions (Mishra and Bhattacharya, 1980). As a result, it is necessary to find out some salt tolerant rice varieties which can be grown in acute saline condition. Therefore this study was undertaken to find out some salt tolerant rice varieties. Bearing the above views in mind, the present work was undertaken to observe the effect of salinity on Boro rice genotypes and to find out salt tolerant rice genotype.

MATERIALS AND METHODS

A pot experiment was conducted at the yard of Bangladesh Institute of Nuclear Agriculture, Mymensingh during 10 December to 3 May 2016. Four genotypes of rice namely Binadhan-8, Binadhan-10, B-10 and B-11 were included in the study to assess their performance on morphological yield attributes, photosynthesis and yield under different saline levels. The two factor experiment was laid out in a Completely Randomized Design (CRD) with three replications. The one factor was salinity and another was genotype. To establish the experiment perforated pots were filled up with 8 kg well mixed soil with cow dung and fertilizer @ 50 N, 25 P and 25 mg/Kg of soil. The soil of this experiment was sandy loam in texture. The soil was collected from the BINA farm. A polythene shade was established above the experiment area to avoid the rain water. Six filled pots were placed in each tray and the tray was filled with water upto the neck of the pot. The total no of pots used in this study was 48 genotypes (4 cultivars*4 salinity levels*3 replications). Salinity treatment *viz*. control, 6, 9 and 12 dS/m were imposed at maximum tillering stage and continued up to harvest. The commercial salt (NaCl) was used to achieve the EC in the experiment. The salt was dissolved in pure water in the tray according to the treatment. Electrical conductivity meter was used to measure the EC of the salt solution. Four levels of

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salinity *viz.* control, 6, 9 and 12 dSm^{-1} were imposed at maximum tillering stage and remained up to the harvest. Data on photosynthesis, chlorophyll content and nitrate reductase activity in leaves were recorded at booting stage. Data on yield, yield attributes, yield and soluble protein in grains were also recorded at maturity. Data were collected and analyzed statistically and the means were adjudged by DMRT.

RESULTS AND DISCUSSION

Results revealed that the effect of different levels of salinity was significant on plant height, number of total tillers/plant, length of panicle, straw weight/plant, number of panicle/plant, filled grains/plant, unfilled grains/plant, 1000-grain weight, yield/plant, photosynthesis, chlorophyll content, nitrate reductase activity in leaves and soluble protein in grains. All the parameters decreased with increasing salinity except number of unfilled grains/plant and number of unfilled grains/plant increased with increased salinity. The highest plant height, number of total tillers/plant, length of panicle, straw weight/plant, panicles/plant, filled grain/plant, 1000-grain weight, yield/plant, photosynthesis, chlorophyll, nitrate reductase activity and soluble protein were observed in control plant. The lowest values of the above parameters were observed at 12 dS/m. The results are in conformity with Sen *et al.* 2004; Sultana *et al.* 2002; Islam *et al*. 1998 who found decrease in morpho-physiological and yield characters in rice under salinity stress. Exposure of plants to soil salinity during various developmental stages appears to induce various physiological and developmental changes (Islam *et al*. 2004). Salinity has three potential effects on plants: a) lowering of the water potential b) direct toxicity of any Na and Cl absorbed c) interference with the uptake of essential nutrients. Specific effects of stress include decreased germination and seedling growth (Zeng and Shannon, 2000) plant metabolism, especially on leaf senescence, have been related to the accumulation of toxic Na^+ and Cl^- ions and to K^+ and Ca^{2+} depletion (Al-Karaki, 2000) and suppressed leaf expansion which ultimately reduces photosynthetic area and dry matter production (Mansour and Salama, 2004). Many reports show salt induced reduction in photosynthetic pigments in rice (Cha-um *et al*. 2007). These plants also show the high chlorophyll degradation symptom, chlorosis, as a common morphological and physiological characteristic in response to salt stress (Harinasut *et al*. 2000). The response of plants to excess NaCl is complex and involves changes in their morphology, physiology and metabolism (Hilal *et al*. 1998). Translocation of salt into roots and to shoots is an outcome of the transpirational flux required to maintain the water status of the plant and unregulated transpiration may cause toxic levels of ion accumulation in the shoot (Yeo 1998). Lower transpiration rate, coupled with reduced ion uptake by the roots, or reduced xylem loading, may cause poor supply via the xylem. So, it is possible that an inadequate supply of ions to the expanding region may restrict cell division and/or expansion when plants are grown at high levels of NaCl (Berstein *et al*. 1995). Salinity also reduces the growth of plant through osmotic effects, reduces the ability of plants to take up water and this causes reduction in growth. There may be salt specific effects. Na^+ and Cl^- are the principal ions in majority of salt affected soils, which mainly affect plants growth. The roots of rice plants readily absorb Na^+ which is distributed in all plant organs to pose ion damage, osmotic stress and imbalance nutrition (Siringam *et al*. 2011). If excessive amount of salt enters the plant, the concentration of salt will eventually rise to a toxic level in order transpiring leaves causing premature senescence and reduce the photosynthetic leaf area of a plant to a level that cannot sustain growth (Munns 2002; Shereen *et al*. 2005).

Plant height, number of total tillers/plant, number of panicle/plant, filled grains/plant, unfilled grains/plant, 1000-grain weight, yield/plant, photosynthesis, chlorophyll sontent, nitrate reductase activity and soluble protein were significant among the studied varieties. Length of panicle and straw weight/plant were not significant among the studied genotypes. Binadhan-10 showed the highest plant height, length of panicle, filled grains/plant, 1000-grain weight and yield/plant and lowest soluble protein. The genotype B-10 showed the highest photosynthesis, number of panicle/plant and lowest unfilled grains/plant. Binadhan-8 showed the highest straw weight/plant, unfilled grains and soluble protein and lowest plant height, number of panicle/plant, photosynthesis and chlorophyll. B-11 showed the highest chlorophyll and nitrate reductase activity and lowest length of panicle, filled grains/plant, 1000-grain weight, yield/plant, chlorophyll content and nitrate reductase activity.

Interaction between salinity and genotypes had significant effect on plant height, number of total tillers/plant, length of panicle, straw weight/plant, number of panicle/plant, filled grains/plant unfilled grains/plant, chlorophyll content, nitrate reductase activity, soluble protein and photosynthesis. Photosynthesis, plant height, length of panicle, filled grains/plant, 1000-grain weight showed the highest result in the treatment combination of B-10×control. Unfilled grain/plant and soluble protein was highest in Binadhan-8×9 dS/m combination. Straw weight/plant, chlorophyll and nitrate reductase activity was highest in B-11×control combination. Plant height, length of panicle, straw weight/plant and nitrate reductase activity was lowest in the treatment combination of B-10×12 dS/m. Number of total tillers/plant, number of panicle/plant, filled grains/plant, unfilled grains/plant, 1000-grain weight and photosynthesis was lowest in the treatment combination of B-11×12 dS/m. Chlorophyll content and soluble protein were the lowest in the treatment combination of Binadhan-10×12 dS/m.

Table 1. Effect of different salinity levels on plant height (cm), number of total tillers/plant, length of panicle (cm) and straw weight/plant (gm) of rice genotypes

Treatments	**Plant height (cm)**	**No. of total tillers/plant**	**Length of panicle (cm)**	**Straw weight /plant (g)**
Control	90.92 a	14.92 a	24.92 a	21.46 a
6 dS/m	84.42 b	11.50 b	23.55 b	15.77 b
9 dS/m	80.25 c	10.33 b	20.38 c	12.65 b
12 dS/m	67.00 d	8. 08 c	19.34 d	7.79 c

Values having common letters or without letters in a column of specific treatment do not differ significantly at 5% level as per DMRT

Table 2. Plant height, number of total tillers/plant, length of panicle (cm) and straw weight/plant of rice genotypes under salinity

Genotypes	**Plant height (cm)**	**No. of total tillers/plant**	**Length of panicle (cm)**	**Straw weight /plant (g)**
Binadhan-10	87.25 a	10.00 b	22.36 a	14.14 a
B-10	78.25 b	13.25 a	22.13 a	13.69 a
Binadhan-8	77.33 b	11.17 b	22.10 a	15.72 a
B-11	79.75 b	10.42 b	21.61 a	14.12 a

Values having common letters or without letters in a column of specific treatment do not differ significantly at 5% level as per DMRT

Table 3. Interaction effect of genotype×salinity on plant height (cm), no of total tillers/Plant, length of panicle (cm) and straw weight/plant

Genotypes × Salinity (Interaction)	**Plant height (cm)**	**No. of total tillers/plant**	**Length of panicle (cm)**	**Straw weight /plant (g)**
V_1T_o (Binadhan-10×control)	99.33 a	11.67 cde	25.40 a	20.39 ab
V_1T_1 (Binadhan-10×6 dS/m)	91.67 b	11.00 cde	23.30 bc	16.44 abcd
V_1T_2 (Binadhan-10×9 dS/m)	87.67 bcd	10.00 cde	21.37 d	12.71 bcdef
V_1T_3 (Binadhan-10×12 dS/m)	70.33 hi	7.33 ef	19.37 ef	7.02 f
V_2T_o (B-10×control)	89.00 bc	17.67 a	24.67 ab	17.89 abc
V_2T_1 (B-10×6 dS/m)	86.33 bcde	12.67 bcd	25.00 a	17.55 abcd
V_2T_2 (B-10×9 dS/m)	80.00 defg	12.33 bcd	20.20 def	12.87 bcdef
V_2T_3 (B-10×12 dS/m)	57.67 j	10.33 cde	18.67 f	6.46 f
V_3T_o (Binadhan-8×control)	84.67 bcde	14.00 abc	24.40 abc	23.77 a
V_3T_1 (Binadhan-8×6 dS/m)	78.33 efgh	10.67 cde	22.93 c	15.13 bcde
V_3T_2 (Binadhan-8×9 dS/m)	74.00 fghi	10.67 cde	20.43 de	14.06 bcdef
V_3T_3 (Binadhan-8×12 dS/m)	72.33 ghi	9.33 def	20.64 de	9.94 def
V_4T_o (B-11×Control)	90.67 b	16.33 ab	25.23 a	23.79 a
V_4T_1 (B-11×6 dS/m)	81.33 cdef	11.67 cde	22.97 c	13.94 bcdef
V_4T_2 (B-11×69dS/m)	79.33 defg	8.33 def	19.53 ef	10.99 cdef
V_4T_3 (B-11×12dS/m)	67.67 i	5.33 f	18.70 f	7.75 ef

Values having common letters or without letters in a column of specific treatment do not differ significantly at 5% level as per DMRT

Table 4. Effect of different levels of salinity on number of panicle/plant, filled grains/plant, unfilled grains/plant, 1000-grain weight and yield/plant of rice genotypes

Treatments	**Panicles /plant (no.)**	**Filled grains/ plant (no.)**	**Unfilled grains/plant (no.)**	**1000-grain weight (g)**	**Yield/plant (g)**
Control (T_o)	12.83 a	477 a	114 b	23.23 a	26.22 a
6 dS/m	9.08 b	378 b	106 b	21.90 b	17.01 b
9 dS/m	6.58 c	213 c	169 a	19.92 c	5.53 c
12 dS/m	2.58 d	68 d	47.83 c	19.21 d	0.61 d

Values having common letters or without letters in a column of specific treatment do not differ significantly at 5% level as per DMRT

Table 5. Number of panicle/plant, filled grains/plant, unfilled grains/plant, 1000-grain weight, and yield/plant of rice genotypes under salinity

Genotypes	Panicles /plant (no.)	Filled grains/ plant (no.)	Unfilled grains/ plant (no.)	1000-grain weight (g)	Yield/plant (g)
Binadhan-10	8.25 a	326 a	90.83 b	22.53 a	13.55 ab
B-10	8.50 a	285 b	87.00 b	19.67 b	12.48 b
Binadhan-8	7.08 a	270 bc	173.3 a	22.47 a	14.79 a
B-11	7.25 a	255 c	88.00 b	19.60 b	8.57 c

Values having common letters or without letters in a column of specific treatment do not differ significantly at 5% level as per DMRT

Table 6. Interaction effect of genotype×salinity on number of panicle/plant, filled grains/plant, unfilled grains/plant, 1000-grain weight and yield/plant

Genotypes × Salinity (Interaction)	Panicle /plant (no.)	Filled grains/ plant (no.)	Unfilled grains/plant (no.)	1000-grain weight (g)	Yield/plant (g)
V_1T_o (Binadhan-10×control)	11.00 bcd	513 a	93.00 cdef	25.49 a	29.07 a
V_1T_1 (Binadhan-10×6 dS/m)	9.33 de	315 d	95 cdef	23.81 b	21.59 b
V_1T_2 (Binadhan-10×9 dS/m)	7.66 ef	341 d	123 bcde	20.50 cde	2.78 f
V_1T_3 (Binadhan-10×12 dS/m)	5.00 f	135 f	52 ef	20.31 cde	0.74 f
V_2T_o (B-10×control)	15.33 a	472 ab	96 cdef	21.16 cd	26.85 a
V_2T_1 (B-10×6 dS/m)	9.33 cde	438 bc	74.33 def	19.42 e	15.14 c
V_2T_2 (B-10×9 dS/m)	7.33 ef	194 e	142 bcd	18.94 ef	7.20 e
V_2T_3 (B-10×12 dS/m)	2.00 g	35.67 hi	35 f	19.14 ef	0.72 f
V_3T_o (Binadhan-8×control)	12.33 bc	482 ab	175 b	24.92 ab	28.18 a
V_3T_1 (Binadhan-8×6 dS/m)	8.00 def	416 c	158 bc	23.96 b	19.22 b
V_3T_2 (Binadhan-8×9 dS/m)	6.00 f	106 fg	280 a	21.30 c	11.10 d
V_3T_3 (Binadhan-8×12 dS/m)	2.00 g	75.67 gh	80.33 def	19.69 de	0.65 f
V_4T_o (B-11×Control)	12.67 ab	442 bc	95.67 cdef	21.35 c	20.80 b
V_4T_1 (B-11×6 dS/m)	9.66 cde	342 d	98.67 cdef	20.39 cde	12.07 cd
V_4T_2 (B-11×69dS/m)	5.33 f	211 e	133 bcd	18.95 ef	1.06 f
V_4T_3 (B-11×12dS/m)	1.33 g	25.33 i	24 f	17.70 f	0.35 f

Values having common letters or without letters in a column of specific treatment do not differ significantly at 5% level as per DMRT

Table 7. Effect of different levels of salinity on photosynthesis, chlorophyll, nitrate reductase activity and soluble protein in grains of rice genotypes

Treatments	Photosynthesis (µmol CO_2 $m^{-2}s^{-1}$)	SPAD Reading (Chlorophyll)	Nitrate reductase activity (NO_2 $g^{-1}fwh^{-1}$)	Soluble Protein (mgg^{-1})
Control	44.47 a	41.60 a	0.57 a	1.42 a
6 dS/m	42.03 b	40.28 b	0.43 b	1.33 b
9dS/m	36.15 c	39.85 c	0.35 c	1.27 c
12dS/m	34.05 d	39.02 d	0.26 d	1.17 d

Values having common letters or without letters in a column do not differ significantly at 5% level as per DMRT

Table 8. Effect of different levels of salinity on photosynthesis, chlorophyll content, nitrate reductase activity and Soluble Protein in grains of rice genotypes

Genotypes	Photosynthesis (µmol CO_2 $m^{-2}s^{-1}$)	SPAD Reading (Chlorophyll)	Nitrate reductase activity (NO_2 $g^{-1}fwh^{-1}$)	Soluble Protein (mgg^{-1})
Binadhan-10	40.19 a	36.92 c	0.37 b	1.18 d
B-10	40.43 a	42.91 b	0.36 b	1.23 c
Binadhan-8	37.92 b	36.90 c	0.40 b	1.42 a
B-11	38.16 b	44.03 a	0.48 a	1.36 b

Values having common letters or without letters in a column do not differ significantly at 5% level as per DMRT

Table 9. Interaction effect of genotyeps × salinity on photosynthesis, chlorophyll content, nitrate reductase activity in leaves and soluble proteins in grains

Genotypes × Salinity (Interaction)	**Photosynthesis (µmol CO_2 $m^{-2}s^{-1}$)**	**SPAD Reading (Chlorophyll)**	**Nitrate reductase activity (NO_2 $g^{-1}fwh^{-1}$)**	**Soluble protein (mgg^{-1})**
V_1T_o (Binadhan-10×control)	45.67 a	38.30 f	0.56 b	1.33 cd
V_1T_1 (Binadhan-10×6 dS/m)	42.27 bc	36.30 g	0.41 cd	1.20 ef
V_1T_2 (Binadhan-10×9 dS/m)	37.63 ef	36.73 g	0.29 efg	1.17 f
V_1T_3 (Binadhan-10×12 dS/m)	35.20 efg	36.33 g	0.23 g	1.00 g
V_2T_o (B-10×control)	45.60 a	45.23 ab	0.46 bc	1.42 ab
V_2T_1 (B-10×6 dS/m)	42.43 bc	43.03 cd	0.41 cd	1.28 d
V_2T_2 (B-10×9 dS/m)	38.17 de	42.70 cd	0.34 def	1.17 f
V_2T_3 (B-10×12 dS/m)	35.53 efg	40.67 e	0.21 g	1.02 g
V_3T_o (Binadhan-8×control)	41.97 bc	37.27 g	0.53 b	1.44 ab
V_3T_1 (Binadhan-8×6 dS/m)	40.93 cd	37.13 g	0.43 cd	1.39 abc
V_3T_2 (Binadhan-8×9 dS/m)	34.90 fg	36.53 g	0.38 cde	1.44 ab
V_3T_3 (Binadhan-8×12 dS/m)	33.87 gh	36.67 g	0.26 fg	1.38 bc
V_4T_o (B-11×Control)	44.67 ab	45.60 a	0.74 a	1.47 a
V_4T_1 (B-11×6 dS/m)	42.47 bc	44.67 b	0.47 bc	1.42 ab
V_4T_2 (B-11×69dS/m)	33.90 gh	43.43 c	0.37 cde	1.30 d
V_4T_3 (B-11×12dS/m)	31.60 h	42.40 d	0.34 def	1.26 de

Values having common letters or without letters in a column of specific treatment do not differ significantly at 5% level as per DMRT

CONCLUSION

Yield and yield attributes of Boro rice genotypes were the highest at control and those were decreased with increasing salinity. Binadhan-10 and Binadhan-8 showed more tolerance to salinity stress than B-10 and B-11.

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