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Effect of salinity stress on growth and yield attributes in transplanted aman rice genotypes

M.S. Islam, K.M. Rahman[1], M.M. Rahman[2] , M.T.Islam[3] and M. M. Mashrafi[4]
Department of Crop Botany, [1]Department of Agroforestry, [4]Department of Agricultural Chemistry, Bangladesh Agricultural University, Mymensingh. [2]Supreme Seed Co.Ltd., and [3]Crop physiology Division, BINA.

Abstract: A pot experiment was conducted during July 15 to December 6, 2003 using three advanced lines of transplanting Aman rice viz. PNDB - 100, PR -26305-M-2 and PNR-166 at the Bangladesh Institute of Nuclear Agriculture (BINA), Mymensingh to assess their performance on morphological Parameters under different salinity levels. The salinity levels were control (0.27dSm^{-1}), 6 d sm^{-1} and 8 dsm^{-1}. Plant height, number of tillers, leaves and leaf area hill^{-1}, stem, leaf and total dry matter (TDM) hill^{-1}, length of panicles, number of filled grains,1000-grain weight, grain yield hill^{-1} were gradually decreased with the increase level of salinity compared to control. Among the three advanced lines, PNR -166 showed the best performance in most of the above parameters and showed tolerance to salinity, PNDB - 100 was intermediate and PR-26305-M-2 showed less tolerance to Salinity.

Key words: Rice, salinity stress, tolerant genotype.

Introduction

Rice (Oryza sativa) is the staple food crop in Bangladesh. It has been growing over 25 million hectares of land under irrigated and rain fed condition which covers about 80% of the total cropped area in Bangladesh (BBS, 2002). Sixty percent of the world population directly depends on rice. Salinity largely reduces the yield of rice in the coastal areas of the country mainly in Khulna. Patuakhali , Noakhali and Chittagong districts and in the Island of Bay of Bengal like Bhola, Hatiya and Sandip (Brammer, 1971). The salinity of these soils is either derived from tidal flooding with saline water at high spring tides or from sporadic inundation with salt water during cyclonic storms. Rice is moderately salt sensitive crop species (Mass and Hoffman, 1977). It can tolerate salt concentration up to 3 dsm^{-1}. Venkateswarlu et al (1970) and Kapp (1947) stated that rice at critical salinity level 4 dSm^{-1}, may give normal straw yield. Rice exhibits considerable intra-specific variability in resistant to NaCl salinity (Flowers and Yeo 1981). The national policy is to develop some rice cultivars that will be adopted in this region for increasing the production of rice. So far, no promising salinity tolerant rice cultivar has been developed in Bangladesh but salinity tolerant rice cultivar is needed to enhance the national production of rice. Research activities on the response of rice to salinity stress may be helpful in breeding of salt tolerant advanced lines by identifying physiological mechanisms related to salt tolerance. In this context the present work was undertaken to assess the effect of salinity stress at different growth stages of rice genotypes, and to find out the tolerant genotype to salinity stress.

Materials and Methods

A pot experiment was conducted under varying levels of soil salinity with three rice cultivars in the pot yard of BINA, Mymensing. The experiment was conducted in plastic pots and the soil was used as a growth medium which was collected from BINA farm. The soil was collected from 0-15 cm depth from the BINA farm. Seedlings for plant materials were produced on pots. The collected soil was dried under the sun and then the soil was crushed. A total of 3 pots were prepared and each pot contained 8 kg soil. The advanced lines were used as planting materials - (i) PNDB - 100 (v_1) (ii) PR-26305-M-2 (v_2) (iii) PNR-166 (v_3) . These advanced lines are under the process to be released as varieties in future at the BINA, Mymensingh. Soils of 8 kg/pot were fertilized with 40g/pot cow dung, 1.72g Urea/pot, 1.44g TSP/pot, 0.8g MP/ pot. Each plastic pot was 21cm deep with 24cm diameter at the top. The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications. The total number of pots used in this study was 81 (3cultivars x 3 salinity levels Ý 3 replications Ý 3 harvests). One of 25 days old seedling was transplanted in each earthen pot on August 10, 2003. The commercial salt (Nacl) 13.06g and 17.41g were added to each pot for imposition of two saline treatments . These amounts of salt dissolved in 100 ml of water and this solution was then poured uniformly into the pots. The saline treatments were begun at 45 days after transplanting (DAT). After impositions of saline treatments, soil samples were analyzed and the following EC values were found. So = Control, no salt was added (Average EC value was 0.27 dSm^{-1}), S_1 = Average EC value was 6 dSm^{-1}, S_2 = Average EC value was 8 dSm^{-1}.

The plant height of rice plant was considered from the top surface level of the pot to the tip of the longest leaf at booting stage and flowering stag. At maturity Stage the plant height of rice plant count from the top surface level of the pot to the tipper end of the longest panicle. Number of tillers per hill was counted at booting (80 DAT), flowering (95 DAT) and maturity stages. Leaf area of the plant was measured in cm^2 by an automatic leaf area mater (model - LI -3000-LI COR INC, Nebrasea, USA). The total dry mater, harvest index was calculated. The collected data on various characteristics of the advanced lines under this study were statistically analyzed to find out the levels of significance, using the MSTAT -C package developed by Russel (1986). The mean differences were compared by Duncan’s Multiple Range test (DMRT).

Results and Discussion

In the present experiment, efforts were made to find out salinity tolerant advanced lines of T. aman rice depending on morphological characters and their relation with yield. The experiment was designed with three salinity levels such as 0.27 dSm^{-1} (control), 6 dSm^{-1} and 8 dSm$^{-1.}$ The results are presented in Table 1 to 3 under the following head lines.

Morpho-Physiological characters of T. aman rice

Plant height (cm): The interaction effect of salinity and advanced lines in relation to plant height was found significant at 5% level (Table 1) at 80 DAT and maturity. The highest plant height was found in PNR - 166 at control treatment and the lowest was found in PNDB -100 at 8 dSm^{-1} soil salinity. At different DAT, statistically similar plant height was found in PNDB-100 and PR-26305-M-2 at 6 dSm^{-1} and PNR - 166 at 6 and 8 dSm^{-1} salinity levels. The salinity levels distinctly influenced the plant height. Salinity stress might result in lower turgidity in cell and ultimately produced shorter plants.

Table 1. Interaction between salinity levels and the T. aman rice genotypes on morphological parameters

Genotypes x Salinity levels (dS/m)		Plant height (cm)			No. of tillers per hill			No. of leaves per hill			Leaf area (cm²)		
		80 DAT	95 DAT	At maturity	80 DAT	95 DAT	At maturity	80 DAT	95 DAT	At maturity	80 DAT	95 DAT	At maturity
PNDB-100	0.27	104.50 a	116.00 ab	102.33 e	38.00 a	40.67 a	33.00 a	191.50 a	142.67 a	58.00 b	4110.19 a	3305.55 a	1951.71 c
	6	91.00 b	109.00b-d	113.33 bc	37.00 ab	39.00 a	32.60 a	184.00 a	129.33 b	58.00 b	3903.54 a	3291.22 a	1783.38 d
	8	83.50 c	103.33 d	97.00 e	34.00 bc	38.00 a	27.00 b	172.00 b	114.63 c	43.33 d	3455.78 b	3015.67 ab	1576.72 e
PR-26305-M-2	0.27	106.50 a	112.00 a-c	117.33 ab	34.00 bc	31.00 b	24.00 c	160.00 c	118.67 c	64.67 a	4087.24 a	3222.30 a	2005.35 bc
	6	97.00 b	109.67 b-d	110.00 c	31.00 c	31.00 b	22.67 cd	150.00 cd	116.57 c	56.67 b	4041.32 a	2862.60 b	2181.39 a
	8	104.00 a	107.33 cd	103.00 de	26.67 d	24.00 c	19.67 f	113.00 f	101.63 d	50.33 c	3949.47 a	2548.78 c	1760.42 d
PNR-166	0.27	109.00 a	119.00 a	120.00 a	32.33 c	29.66 b	21.66 de	140.00 de	106.00 d	56.33 b	3995.30 a	3214.68 a	2147.81 ab
	6	96.50 b	110.00 b-d	109.33 cd	31.00 c	27.67 b	20.00 ef	134.00 e	91.33 e	51.33 c	3214.68 c	3214.58 a	2123.12 ab
	8	92.50 b	104.00 cd	103.33 de	21.01 e	22.67 c	19.00 f	99.00 g	68.00 f	40.33 d	2652.11 d	3191.72 a	1719.04 d
LSD (0.05)		6.887	7.206	6.307	3.47	3.584	1.731	11.56	5.757	3.053	219.7	299.8	152.7

Table followed common letter (s) within the column do not differ significantly at 5% level of DMRT

Number of tillers hill^{-1} : The interaction effect of salinity levels and advanced lines in relation to tillers hill^{-1} was found significant ($P \leq 0.05$) (Table 1) at 80, 95 DAT and maturity. The maximum number of tillers hill^{-1} was found in PNDB-100 at control condition and the minimum number of tillers hill^{-1} was found in PNR-166 at 8 dSm^{-1} level of soil salinity. Statistically similar number of tillers hill^{-1} was found in PR-26305-M-2 and PNR-166 at 6 dSm^{-1} and PNDB-100 at control, 6 dSm^{-1} and 8 dSm^{-1} salinity levels. Balasubramania and Rao (1977) reported adverse effect of salinity on tillering.

Number of leaves hill $^{-1}$: The interaction effect of salinity levels and the advanced lines in relation to the number of leaves hill^{-1} was statistically significant ($P \leq 0.05$) (Table 1) at different DAT. at 80 DAT, the highest number of leaves hill^{-1} (191.50) was found in PNDB-100 ¬ control and the lowest (99.00) in PNR-166 ¬ 8dSm^{-1}. The moderate number of leaves hill^{-1}. The moderate number of leaves hill^{-1} (160.00) was obtained from PR-26305-M-2 ¬ control followed by PR-26305-M-2 ¬ 6 dSm^{-1} and PR-26305-M-2 ¬ 8 dSm^{-1}. Statistically similar number of leaves was found in PNDB-100 at control and 6 dSm^{-1} salinity level. At 95 DAT, statistically similar number of leaves was found in PR-26305-M-2 at control and 6 dSm^{-1} salinity levels. At maturity statistically similar number of leaves was found in PNDB-100 and PR-26305-M-2 at 6 dSm^{-1} and PNDB-100 at control and 6 dSm^{-1} salinity levels. PNDB-100 and PNR -166 are statistically similar at 8 dSm^{-1} salinity level. From the results, it is clear that the number of leaves hill^{-1} decreased with increasing salinity level. Khan *et al.* (1997) conducted an experiment with rice and found that the number of leaves hill^{-1} seriously decreased by salinity.

Leaf area hill^{-1} (cm^2): The interaction effect of salinity levels and the advanced lines in relation to leaf area was obtained significant ($P \leq 0.05$) at 80, 95 DAT and maturity (Table 1). At 80 DAT, the highest leaf area (4110.19 cm^2) was found in PNDB-100 at condition and the lowest (2652.11 cm^2) in PNR-166 at 8 dSm^{-1} level of soil salinity. Similar results were also found at 95 DAT and maturity. At 80 DAT, statistically similar leaf area (LA) was found in PNDB -100 and PR-26305-M-2 at 6 dSm^{-1} and PR-26305-M-2 at control, 6 dSm^{-1} and 8 dSm^{-1} salinity levels. At 95 DAT, statistically similar leaf area (LA) was found in PNDB-100 and PNR-166 at different salinity levels. The magnitude of reduction in leaf area was found the highest at the highest level of salinity in all the advanced lines. AT different DAT, the results reveal that the advanced line PNDB - 100 was more effective to leaf area development at the highest salinity level.

Root dry weight hill^{-1} (g): The interaction effect of salinity levels and the advanced lines in relation to root dry weight hill^{-1} was found statistically significant ($P \leq 0.05$) at different DAT (Table 2). At 80 DAT, the highest root dry weight hill^{-1} (28.40 g) from PR-26305-M-2 at 8 dSm^{-1} level of soil salinity and the lowest (15.75 g) from PNR-166 at control condition. Statistically similar root dry weight hill^{-1} was found in PNDB-100 and PNR-166 at 6 dSm^{-1} and PNDB-100 at control and 6 dSm^{-1} salinity levels, At maturity DAT, statistically similar root dry weight hill^{-1} was found in PNDB - 100 and PR-26305-M-2 at 8 dSm^{-1} and PNR-166 at 6 dSm^{-1} and 8 dSm^{-1} salinity levels. In all the advanced lines, the root dry weight hill^{-1} significantly increased with increasing salinity level. The results indicate that the advanced lines were stable in root production under salinity stress.

Table 2. Interaction between different salinity levels and the T. aman rice genotypes on root, stem and leaf dry matter production and TDM

Genotypes x Salinity levels (dS/m)		Root dry wt. per hill (g)			Stem dry wt. per hill (g)			Leaf dry wt. per hill (g)			TDM per hill (g)		
		80 DAT	95 DAT	At maturity	80 DAT	95 DAT	At maturity	80 DAT	95 DAT	At maturity	80 DAT	95 DAT	At maturity
PNDB-100	0.27	25.50 b	9.50 a	9.27 e	39.90 ab	44.23 cd	48.60 b	17.90 a	14.40 a	8.50 b	83.30 a	91.93 a	94.07 b
	6	25.80 b	10.90 e	11.10 d	38.25 a-c	40.90 de	35.67 de	17.00 ab	14.33 a	7.77 c	82.55 a	80.97 c	78.23 cd
	8	28.30 a	13.03 c	12.90 bc	35.00 c	39.83 e	33.43 e	15.05 c	13.13 ab	6.87 d	82.35 a	77.77 c	74.73 d
PR-26305-M-2	0.27	17.80 b	7.17 g	9.27 e	41.60 a	51.53 a	44.57 c	17.80 a	14.03 a	9.50 a	81.55 a	83.03 bc	89.80 b
	6	21.15 c	9.57 f	12.23 cd	36.15 b-d	38.67 e	38.50 d	17.60 a	12.33 b	8.73 b	80.35 a	65.33 d	80.66 c
	8	28.40 a	13.10 c	13.83 ab	32.00 d	32.73 f	37.13 de	17.20 ab	11.10 c	7.67 c	80.75 a	60.60 d	80.00 c
PNR-166	0.27	15.75 e	12.13 d	12.67 bc	36.35 b-d	52.83 a	57.87 a	15.50 bc	14.00 a	9.33 a	81.90 a	87.77 ab	108.37 a
	6	27.00 ab	14.83 b	13.93 ab	34.95 cd	50.43 ab	47.67 bc	14.00 c	13.90 a	9.27 a	81.35 a	82.97 bc	93.10 b
	8	28.10 a	16.67 a	14.40 a	22.76 e	47.17 bc	45.90 bc	9.60 d	10.67 c	7.80 c	53.40 b	81.43 c	89.10 b
LSD (0.05)		1.998	0.762	1.316	4.073	3.977	3.603	1.755	1.224	0.498	9.942	5.77	5.03

Table followed common letter (s) within the column do not differ significantly at 5% level of DMRT

Table 3. Interaction between salinity levels and the T. aman rice genotypes on yield and yield contributing parameters

Genotypes x Salinity levels (dS/m)		Lenth of panicle (cm)	Filled grains per panicle (No.)	Unfilled grains per panicle (No.)	100-grain wt. (g)	Grain yield per hill (g)	Harvest index (%)
PNDB-100	0.27	23.33 b	67.33 b	28.66 cd	19.53 d-f	36.85 b	47.09 a
	6	21.00 cd	57.33 c	30.00 cd	19.13 ef	23.10 d	26.03 c
	8	20.00 d	46.00 d	32.00 bc	18.90 f	19.33 d	23.78 c
PR-26305-M-2	0.27	26.00 a	56.33 c	27.33 d	25.53 a-d	29.22 c	36.21 b
	6	22.33 bc	57.33 c	32.33 bc	20.26 b-e	23.65 d	26.27 c
	8	19.67 d	45.67 d	40.67 a	19.93 c-f	16.33 e	21.15 d
PNR-166	0.27	24.00 b	82.33 a	26.67 d	21.50 a	39.23 a	36.81 b
	6	21.33 cd	62.00 bc	28.00 d	21.16 ab	25.33 d	27.15 c
	8	20.00 d	49.67 d	34.00 b	20.90 a-c	16.22 e	18.26 e
LSD (0.05)		1.807	6.106	3.603	1.099	2.308	1.998

Table followed common letter (s) within the column do not differ significantly at 5% level of DMRT

Stem dry weight hill^{-1} (g): The interaction effect of salinity levels and advanced lines in relation to stem dry weight hill^{-1} was found significant ($P \leq 0.05$) (Table 2) at different DAT. At 80 DAT, the highest stem dry weight hill^{-1} (41.60 g) was found in PR-26305-M-2 at control condition and the lowest (22.76g) was found in PNR-166 at 8 dSm^{-1} level of soil salinity. Statistically similar stem dry weight hill^{-1} was found in PR-26305-M-2 and PNR-166 at 6 dSm^{-1} and PNDB-100 at all salinity. At 95 DAT, the highest stem dry matter hill^{-1} was found in PNR-166 at control and the lowest was found in PR-26305-M-2 at 8 dSm^{-1} level of soil salinity. Statistically similar stem dry weight hill^{-1} was found in PNDB-100 and PR-26305-M-2 at 6 dSm^{-1} and PNR-166 at all salinity levels. At maturity, statistically similar stem dry weight hill^{-1} was found in PNDB-100 and PR-26305-M-2 at 8 dSm^{-1} and PNR-166 at 6 dSm^{-1} and 8 dSm^{-1} salinity levels. The result showed that stem dry weight hill^{-1} decreased gradually with increasing salinity level at different DAT.

Leaf dry weight hill^{-1} (g): The interaction effect of salinity levels and advanced lines in relation to leaf dry weight hill^{-1} was significant ($P \leq 0.05$) (Table 2) at different DAT. At 80 DAT, The highest leaf dry weight hill^{-1} (17.90 g) was obtained from PNDB-100 at control followed by PR-26305-M-2 Ý control, PR-26305-M-2 ¬ 6dSm^{-1} and PR-26305-M-2 ¬ 8 dSm^{-1} level of soil salinity and the lowest (9.60g) was found in PNR-166 at 8 dSm^{-1} level of soil salinity. Statistically similar leaf dry weight hill^{-1} was found in PNDB-100and PR-26305-M-2 at 6 dSm^{-1} and PR-26305-M-2 at all salinity levels. At 95 DAT, the highest leaf dry weight hill^{-1} (14.40g) was obtained from PNDB - 100 at control followed by PR-26305-M-2 ¬ control and PNR-166 ¬ control and the lowest (10.67g) was found in PNR-166 at 8 dSm^{-1} level of soil salinity. Statistically similar leaf dry weight hill^{-1} was found in PNDB-100 and PNR-166 at 6 dSm^{-1} and PNR-166 at control, 6 dSm^{-1} and 8 dSm^{-1} salinity levels. At maturity, the highest leaf dry weight hill^{-1} (9.50g) was obtained from PR-26305-M-2 at control followed by PNR-166 ¬ control and PNR-166 ¬ 4 dSm^{-1} , and the lowest (6.87g) was found in PNDB-100 at 8 dSm^{-1} level of soil salinity. Statistically similar leaf dry weight hill^{-1} was found in PNR-166 at control and 6 dSm^{-1} salinity level.

Total dry matter hill^{-1} (TDM) (g): The interaction effect of salinity levels and advanced lines in relation to TDM hill^{-1} was found significant (P $\leq$ 0.05) (Table 2) at different DAT. At 80 DAT, the statistically similar TDM hill^{-1} was found in PNDB-100, PR-26305-M-2 and PNR-166 at different levels of soil salinity. At maturity, the highest TDM hill^{-1} (108.37g) was found in PNR- 166 at control condition and the lowest (74.73g) was found in PNDB-100 at 8 dSm^{-1} level of soil salinity. Statistically similar total dry matter (TDM) hill^{-1} was found in PNDB-100 and PR-26305-M-2 at dSm^{-1} and PNR-166 at 6 dsm^{-1} and8 dsm^{-1} salinity levels. The result showed that total dry matter hill^{-1} decreased gradually with increasing salinity level at different DAT

Yield and yield contributing characters

Panicle length (cm): The interaction effect of salinity and the advanced lines in relation to panicle length was found non-significant (P$\leq$ 0.05) (Table 3). The highest panicle length (26.00 cm) was observed in PR-26305-M-2 at control condition and the lowest (19.67 cm) was found in same advanced line at 8 dSm^{-1} level of soil salinity. Statistically similar panicle length was found in PNDB-100, PR-26305-M-2 and PNR-166 at 8 dSm^{-1} salinity level. The panicle length in PNDB-100 and PNR-166 were statistically similar at 6 dSm^{-1} salinity level. The result indicates that cell division and cell enlargement occurred properly under control condition but these were inhibited by the increase of salinity level.

Filled grains panicle^{-1} (No): The interaction effect of salinity and the advanced lines in relation to filled grains panicle^{-1} was found significant (P$\leq$ 0.05) (Table 3) .The highest number of field grains panicle^{-1} (82.33) was produced in PNR-166 at control condition and the lowest (45.67) in PR-26305-M-2 at 8 dSm^{-1} level of soil salinity. Statistically similar filled grains panicle^{-1} was found in PNDB-100 and PNR-166 at 8 dSm^{-1} and PR-26305-M-2 at control and 6 dSm^{-1} salinity levels.

Unfilled grains panicle^{-1} (No): The interaction effect of salinity and the advanced lines in relation to the number of unfilled grains panicle^{-1} was statistically significant (P$\leq$ 0.05) (Table 3). However, the highest number of unfilled grains panicle^{-1} (40.67) was observed in PR-26305-M-2 at 8 dSm^{-1} level of soil salinity and the lowest (26.67) in PNR-166 at control condition.

1000-grain weight (g): The interaction effect of salinity levels and advanced lines in relation to 1000-grain weight was found non significant (P$\leq$ 0.05) (Table 3)

Grain yield hill^{-1} (g): The interaction effect of salinity levels and the advanced ones in relation to grain yield hill^{-1} was significant (P$\leq$ 0.05) (Table 3). The highest grain yield hill^{-1} (39.23g) was obtained from PNR-166 at control condition and the lowest (16.22) in same advanced line at 8 dSm^{-1} level of soil salinity. It is indicated that PNR-166 abruptly decreased grain yield hill^{-1} at 8 dSm^{-1} level of soil salinity compared to PR-26305-M-2 and PNDB-100.

Harvest index (HI%): The interaction effect of salinity levels and advanced lines in relation to harvest index was found significant (P $\leq$ 0.05) (Table 3) .Statistically similar harvest index was found in PR- 26305-M-2 and PNR-166 at 6 dSm^{-1} and PNDB -100 at 6 dSm^{-1} and 8 dSm^{-1} salinity levels. This result indicates that harvest index reduced with the increasing salinity levels. So the advanced line PNR- 166 was found as less tolerant compared to PR-26305-M-2 and PNDB- 100.

Over all results indicate that advanced line PNR-166 was the best of all, advanced line PNDB-100 was intermediate and PR-26305-M-2 was theless tolerant to salinity stress.

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