Salinity stress during booting and heading stages affects yield in rice

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Abstract: The experiment was carried out in pot culture during July to December 2012 to investigate the effect of salinity at two growth stages on yield and yield components in three rice mutants. The treatment composed of three elite rice mutants *viz.,* RM250-1012, RM300-30 and RM250-150, and 8 dS m^{-1} salinity imposed at two growth stages of booting and heading. Results indicated that morphological parameters such as plant height, number of leaves and tillers $hill^{-1}$ and panicle length, physiological characters such as biological yield and harvest index, yield attributes such as number of number of grains $panicle^{-1}$ and 1000-grain weight were decreased in saline treated plants than control plants. However, the decrease in above parameters due to salinity was greater when salinity imposed at booting stage as compared to salinity imposed at heading stage. Among the genotypes, the yield loss due to salinity was less in RM300-30 than that in the others, which further revealed that RM300-30 had a greater tolerance to salinity than RM250-1012 and RM250-150.

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1. Introduction

Rice (*Oryza sativa* L.) is the principal staple food of the people in South and South-East Asia (Mondal et al., 2013a; Adam and Mondal, 2014). Among the various factor limiting rice yielding, salinity is one of the oldest and most serious environmental problems in the world (Mondal et al., 2013b). However, salinity problem received very little attention in the past, but due to increased demand for growing more food to feed the booming population of the world, it has became imperative to explore the potentials of these lands. The effective reclamation of the saline soils is difficult and complex due to frequent inundation and tidal flooding. It could be, therefore, being wise to grow the salt tolerant cultivars of rice in the coastal area or for localities where salinity is increasing due to effect of increase seas level. The 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 for this saline area. Thus this vast land remains fallow and unproductive year around. Therefore, development of salt tolerant rice cultivars is highly demanding to enhance production of rice in South and South-East Asia.

Rice is moderately salt sensitive crop species (Summart et al., 2010). It has been reported that rice at critical level (4 dS/m) might give normal straw yield (Islam et al., 2004). It exhibits considerable intra-specific variability in resistance to NaCl salinity (Maiti et al., 2008; Mondal et al., 2013b). Soil salinity affects growth of rice plant at all stages of its life cycle. But degree of deleterious effects may vary on the growth stages to the plant (Pearson, 1957). The stages of seedling and flowering are critical for the salinity of irrigation water. The stages of seedling and flowering are critical for the salinity of irrigation water (Rad et al., 2012). Saline water applied during booting and panicle initiation stages implicated greater adverse effect than that of later growth stages (Asch et al., 2000). As the salinity stress can occur throughout all the rice cycle, it's necessary to understand the plants behaviour when exposed to salt stress at different stages of its development, as well as the effects on grain production. The objective of this study was to evaluate the grain yield of rice and its components as affected by salinity at two stages of booting and heading.

2. Materials and Methods

The pot culture experiment was carried out at the glass house of Universiti Putra Malaysia, during the period from 20 July to 15 December 2012. Geographically the experimental area is located at $102^{0}12'$ N latitude and $101^{0}42'$ E longitudes at the elevation of 31 m above the sea level. The pH value, cation exchange capacity (CEC) and electrical conductivity (EC) of the soil were 5.58, 16.30 meq/100 g soil and 0.36 dSm^{-1}, respectively. Three promising salt tolerant rice mutants namely RM250-1012, RM300-30 and RM250-150 were used as planting material.

Inner wall of each perforated plastic pot is covered by a piece of cloth so that soil cannot easily washout. Soils were collected from rice growing field, Tanjung Karang, Selanor, Malaysia. The collected soil was well pulverized and dried in the sun. Plant propagules and inert materials were removed from this soil. The dry soil was thoroughly mixed with well rotten cow dung. This prepared medium was used in filling the pots after well mixing with given amounts of urea, triple superphosphate, muriate of potash and gypsum at the rate of 1.35, 1.55, 0.0.82 and 0.75 g pot^{-1} corresponding to 125, 150, 80 and 50 kg ha^{-1}, respectively. Plastic pots of 15 cm diameter and 20 cm height were used for the experiment. The pots of the experiment were filled with 3.0 kg of soils. The pots were placed in 150-Liters tray type water reservoir for nutrient solution. The water depth of the reservoir was 18 cm and it was always maintained by addition of water at weekly basis. For smaller size of the pots, a Hoagland's solution was used weekly in water reservoir for normal plant growth and development.

The experiment was designed in a Split Plot arrangement with four replications in which growth stage treatments were the main factor and genotypes the sub-factor. Each pot contained one hill and denoted a replication. Seeds were sown on 20 July, 2012 and plants were thinned to one plant per pot at 25 days after sowing and then the pots were placed water reservoir tray. The treatments of the experiment were: Three rice mutants *viz.,* RM250-1012, RM300-30 and RM250-150, and salinity imposed at two growth stages of booting to maturity and heading to maturity. Only 8 dSm^{-1} salinity levels imposed in the treatment. The required quantities of commercial salts were applied to water reservoir at booting to maturity and heading to maturity stages to impose salinity. To maintain specific salinity level, a high salinity (30 dS m^{-1}) solution was poured slowly to water reservoir until getting a desired salinity. The salinity levels of the water reservoir was monitored weekly by EC meter (Model: Z865, SCHOTT Instruments, Germany) and saline solution was added (when necessary) to maintained required salinity level in the reservoir. Weeding was done as and when necessary. Water was supplied to water reservoir as and when needed to maintain a specific water height to ensure sufficient moisture for the normal growth of the crops.

At harvest, morphological parameters, dry mass weight in different plant parts, yield attributes and grain yield was recorded. Harvest index was calculated by dividing economic yield to biological yield of plant multiplied with 100 and expressed in percentage. The collected data were analyzed statistically following the analysis of variance (ANOVA) technique and the mean differences were adjudged by Duncan's Multiple Range Test (DMRT) using the statistical computer package program, MSTAT-C.

3. Results and Discussion

3.1 Morphological characters: The effect of salinity imposed at two growth stages on plant height, number of leaves and effective tillers hill^{-1}, biological yield (BY) hill^{-1} and panicle length was significant (Table 1). Results showed that salinity imposed both at booting and heading stages negatively affected morphological characters of rice mutants. Reduction in plant height, leaf and tiller number, BY and panicle length due to salinity imposed at booting stage was greater than the heading stage. Results further revealed that salinity imposed at heading to maturity stages had no significant negative effect on morphological characters over control except number of leaves hill^{-1} and BY. The number of leaves hill^{-1} and BY decreased significantly over control when salinity imposed at heading stage. Tillering and booting phases are two physiologically important growth stages contributing to good plant population stand as well as yield (Alamgir and Ali, 1998). Salinity reduces the growth of plant through osmotic effects, reduces the ability of plants to take up water and this causes reduction in growth. If excessive amount of salt enter the plant, the concentration of salt will eventually rise to a toxic level in older transpiring leaves causing premature senescence and reduced the photosynthetic leaf area of a plant to a level that cannot sustain growth (Mums, 2002). In the present experiment, salinity imposed at booting hampered growth and development of rice plant. On the other hand, salinity imposed at heading; meanwhile the plant nearly completed its vegetative growth and development. So salinity imposed at heading stage is less affected the morphological characters than salinity imposed at booting stage.

The interaction effect of genotype and growth stages on morphological characters was significant except panicle length (Table 2). Results showed that all morphological characters decreased over control in all the mutant lines but the decrement was not similar in all the mutants. The decrease in plant height, number of leaves and effective tillers hill^{-1}, BY hill^{-1} and panicle length due to salinity at both stages was the less in RM300-30 than the other two mutants, RM250-1012 and RM250-150. These results indicate that mutant RM300-30 was comparative more tolerant to salinity for vegetative characters than the other two mutants, RM250-1012 and RM250-150.

3.2 Yield components and yield: The effect of salinity imposed at different growth stages on yield contributing characters such as number of filled and unfilled grains panicle^{-1}, 1000-grain weight, grain yield and harvest index (HI) was significant (Table 1). Results showed that salinity imposed both at booting and heading stages affect negatively on yield contributing characters thereby yield and HI. Results further revealed that reduction in yield components was more pronounce when salinity imposed at booting stage than salinity imposed at heading stage. The yield components affected more in booting stage than heading stage because of salinity imposed at this stage seriously hampered growth and development of rice plant than salinity imposed at heading stage (Table 1). Though salinity imposed at heading to maturity stages had no significant negative effect on morphological characters over control but it had tremendous negative effect on yield components and yield. It is possible because of during flowering and grain filling period, salt stress also causes a reduction of photosynthesis, which occurs due to decreased availability of CO_2 inside the leaf, by closing the stomata. This entails a series of cumulative effects, once water and osmotic potentials of leaves, stomatal conductance, transpiration rate, relative water content in the leaves, and synthesis of biochemical constituents are affected. These effects, combined, result in a shorter accumulation of photoassimilates in the leaves and affect the grain yield components (Sultana et al., 1999).

Table 1. Salinity effect under different growth stages on morphological characters and yield attributes in rice mutants

Growth stages of salinity imposed	Plant height (cm)	Leaves hill^{-1} (no.)	Effective tillers hill^{-1} (no.)	Biological yield (g hill^{-1})	Panicle length (cm)	Filled grains panicle^{-1} (no.)	Unfilled grains panicle^{-1} (no.)	1000-grain weight (g)	Grain weight hill^{-1} (g)	Harvest index (%)
Control	87.7 a	91.7 a	16.8 a	94.2 a	24.9 a	125.9 a	21.6 c	23.38 a	44.85 a	47.30 a
Booting stage	73.5 b	69.1 c	14.0 b	75.3 c	22.6 b	101.1 c	46.4 a	20.66 c	29.53 c	38.95 c
Heading stage	85.2 a	87.0 b	16.5 a	87.6 b	24.8 a	113.1 b	33.6 b	21.88 b	37.04 b	41.80 b
F-test	**	**	**	**	**	**	**	**	**	**
CV (%)	3.59	4.17	7.99	4.87	4.95	5.55	9.13	4.80	6.73	6.15

In a column, figures having the same letter (s) do not differ significantly as per DMRT; ** = Significant at 1% level of probability

Table 2. Interaction effect of variety and growth stages of salinity imposed on morphological characters and yield attributes in rice mutants

Interaction		Plant height (cm)	Leaves hill^{-1} (no.)	Effective tillers hill^{-1} (no.)	Biological yield (g hill^{-1})	Panicle length (cm)	Filled grains panicle^{-1} (no.)	Unfilled grains panicle^{-1} (no.)	1000-grain weight (g)	Grain weight hill^{-1} (g)	Harvest index (%)
Mutant	Growth stage										
M_1	Cont.	87.1ab	78.0d	14.7c	85.2cd	24.3	122.0ab	26.7e	22.86ab	36.82d	43.20b
	BT	71.5 d	60.5f	12.2d	71.6f	21.7	97.6e	58.0a	19.70d	21.08f	29.44d
	HD	84.6bc	75.4de	14.0cd	79.5de	24.4	109.8d	40.1c	20.40cd	28.22e	35.50c
M_2	Cont.	85.3ab	88.0c	16.3bc	92.3b	25.0	126.0ab	18.6f	23.17ab	42.83bc	46.40b
	BT	72.7d	70.4e	14.5c	80.3d	22.8	108.4d	30.5d	21.58bc	35.94d	44.75b
	HD	82.6 c	84.4c	16.4b	88.8bc	24.9	117.7bc	25.9e	22.35ab	38.92cd	43.33b
M_3	Cont.	90.6 a	109.2a	19.5a	105.0a	25.3	129.8a	19.4f	24.10a	54.90a	52.29a
	BT	76.4 d	76.44d	15.2bc	74.0ef	23.4	97.3e	50.7b	20.70cd	31.56e	42.65b
	HD	88.3ab	101.0b	19.1a	94.4b	25.2	111.8cd	34.8c	22.88ab	43.97b	46.58b
F-test		*	**	*	**	NS	*	**	*	**	**
CV (%)		3.59	4.17	7.99	4.87	4.95	5.55	9.13	4.80	6.73	6.15

In a column, figures having the same letter (s) do not differ significantly as per DMRT at $P \leq 0.05$; *, ** = Significant at 5% and 1% level of probability, respectively; NS = Not significant; M_1= Mutant RM250-1012; M_2= Mutant RM300-30; M_3= Mutant RM250-150; Cont.= Control; BT= Booting stage; HD= Heading stage

Interaction between genotypes and growth stages due to salinity had significant effect on all yield attributes and grain yield (Table 2). Results revealed that yield attributes negatively affected by salinity at any growth stages in all the mutant lines. Results further revealed that yield attributes and yield affected more when salinity imposed from booting to maturity stages than salinity imposed from heading to maturity stages in all the mutants. However, decrease in yield components and yield due to salinity was not similar at both the growth stages among the mutants. The decrease of number of filled grains panicle^{-1}, 1000-grain weight, yield hill^{-1} and HI due to salinity was less in the mutant, RM300-30 than the other two mutants, RM250-1012 and RM250-150. Similarly, HI was less affected under salinity in RM300-30 than the others. On the other hand, the decrease of the above studied parameters due to salinity was the highest in RM250-

1012. These results indicate that mutant RM300-30 was comparatively more tolerant to salinity at any growth stages than the other two mutants, RM250-1012 and RM250-150. These results are consistent with many workers (Alamgir & Ali, 1998; Islam et al., 2004; Mondaal et al., 2013b) who reported that salinity tolerant genotypes had less negative effect on morpho-physiological characters and yield attributes than the susceptible ones.

4. Conclusion

Between the two growth stages, booting to maturity stages is more susceptible than heading to maturity stages in rice life cycle. The three studied rice mutants were variably affected in morpho-physiological attributes and yield contributing characters by salinity at different growth stages; and among the mutants, RM300-30 was found comparatively more tolerant under saline condition than the other mutants with less TDM and yield reduction. Therefore, this mutant (RM300-30) may have adopted in moderate saline condition after few more field trials.

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References

1. Adam AB, Mondal MMA. Response of rice mutants to water stress imposed at reproductive stages. Journal of Food Agriculture and Environment 2014; 12: 454-457.
2. Mondal MMA, Puteh AB, Ismail MR, Rafii MY. Optimizing plant spacing for modern rice varieties. International Journal of Agriculture and Biology 2013a; 15: 175-178.
3. Mondal MMA, Puteh, AB, Malek MA, Rafii MY. Salinity induced morpho-physiological characters and yield attributes in rice genotypes. Journal of Food Agriculture and Environment 2013b; 11: 610-614.
4. Summart J, Thanonkeo P, Panichajakul S, Prathepha P, McManus MT. Effect of salt stress on growth, inorganic ion and proline accumulation in Thai aromatic rice. African Journal of Biotechnology 2010; 9:145-152.
5. Islam MS, Molla AH, Quayum MA. Effect of different levels of salinity on grain filling in rice. Bulletin of Institute of Tropical Agriculture Kyushu University 2004; 24:19-22.
6. Maiti RK, Vidyasagar P, Banerjee PP. Characterization of salinity tolerance in rice genotypes at the germination and seedling stages. Indian Journal of Agricultural Research 2008; 57:114-117.
7. Pearson GA. Factors influencing salinity of submerged soils and growth of Caloro rice. Soil Science 1959; 87:198-206.
8. Rad HE, Aref F, Rezae M. Response of rice to different salinity levels during different growth stages. Research Journal of Applied Science, Engineering and Technology 2012; 4: 3040-3047.
9. Asch F, Dingkuhn M, Dorffling K. Salinity increases CO_2 assimilation but reduces growth in field-grown irrigated rice. Land and Soil 2000; 218: 1–10.
10. Alamgir ANM, Ali MY. Growth of rice genotypes under salinity stress. Chittagong University Journal of Science 1998; 22: 47-53.
11. Munns R. Comparative physiology of salt and water stress. Plant Cell Environment 2002; 25: 239-250.
12. Sultana N, Ikeda T, Itoh R. Effect of NaCl salinity on photosynthesis and dry matter accumulation in developing rice grains. Environmental and Experimental Botany 1999; 42: 211-220.

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