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APPLICATION OF ASH FOR AMELIORATION OF SALINITY EFFECT IN RICE

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Abstract

Agricultural land use in coastal area covers 53% and the lands are mostly affected by salinity. Besides, the average yield of rice in these areas is very low due to salinity. Although, BRRI has developed salt registrant rice varieties, the average production can be improved through soil management. Thus, a pot experiment was conducted in the net house of Department of Agronomy, Bangladesh Agricultural University, Mymensingh, during March to August 2010 to investigate the ameliorative effect of ash application on yield and yield attributes of rice under various salinity levels. Rice var. BRRI dhan47 (a salt tolerant variety) was used in the experiment. The sodium chloride induced salinity levels were 20, 40, 60, 80 and 100 mM NaCl and the levels of ash applied were 1.5, 3, 4.5 and 6 t ha^{-1}. Results revealed that the different levels of salinity had significant adverse effect on plant height, tillers $hill^{-1}$, panicle $hill^{-1}$, grains $panicle^{-1}$, 1000-grain weight, grain yield, biological yield and harvest index. All the plants eventually died when they were exposed to salinity level of 40 mM NaCl or more and could not survive up to maturity. Application of ash enhanced the yield attributes and yield of rice under different salinity levels compared to those without ash. It was concluded that application of ash at the rate of 6 t ha^{-1} ameliorated the salinity stress effect on rice yield of BRRI dhan47.

Introduction

In Bangladesh, over 30% of the net cultivable area lies in the coastal area (Rasel *et al*, 2013). Out of 2.85 million hectare of coastal and off shore areas, about 0.833 million hectares are arable lands, which constitute about 52.8 % of the net cultivable area in 64 Upzilla of 13 districts (Rasel *et al*, 2013). This area is largely affected by varying degrees of soil salinity. Agricultural land uses in these areas are very poor and cropping intensity is very low. 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 Sandwip (Brammer, 1971).

Salinity level of 4 dsm^{-1} is considered as critical level for rice. However, rice exhibits considerable intra-specific variability in resistance to salinity (Flowers and Yeo, 1981; Maiti *et al.*, 2008).

Application of ash to the soil brought about linear increases in soil aeration, water holding capacity, soil total nitrogen, exchangeable bases and cat ion exchange capacity, but reduced soil bulk density and acidity. Ash supply Si to the soil which helps the plants to ameliorate the salinity stress (Ma, 2004; Liang *et al.*, 2003). Si is beneficial for growth of many plants under various a biotic (e.g. salt, drought and metal toxicity) and biotic (plant diseases and pests)

stresses (Ma, 2004; Liang *et al.*, 2003). A number of possible mechanisms are reported through which Si may increase salinity tolerance in plants (Liang *et al.*, 2003), including increased plant water status (Romero *et al.*, 2006), immobilization of toxic Na^+ ion (Liang *et al.*, 2003), reduced Na^+ uptake in plants and enhanced K^+ uptake (Tahir *et al.*, 2006; Liang *et al.*, 2005; Yeo *et al.*, 1999) and higher K^+: Na^+ selectivity (Hasegawa *et al.*, 2000). In particular, Si deposition in the endodermis is proposed to restrict Na+ transport along a "transpirational by pass" route from root to shoot in rice (Gong *et al.*, 2006). Therefore, the present study was under taken to investigate the ameliorative effect of ash on grain yield and yield attributes of rice var. BRRI Dhan47 under various salinity levels.

Materials and Methods

The experiment was conducted at the net house of the department of Agronomy, Bangladesh Agricultural University (BAU), Mymensingh during the period from March to August, 2010. The experimental site was located at 24° N latitude and 94^0 E longitude and 18 meter above sea level. The experimental site belongs to the Agro-ecological Zone of the Old Brahmaputra Floodplain (AEZ 9). The soil was collected within 6 cm from the top soil. The experimental soil was loamy in texture having a soil pH value of 6.43, moderate in organic matter content (Table 1). After collection, the soil was dried in sun and loosened. All the inert matter was removed. The pots were filled up by soil.

Bangladesh Rice Research Institute (BRRI) has developed var. BRRI dhan47 as a salt tolerant variety for boro season as the test crop. This variety can tolerate 12-14 dSm^{-1} salinity at seedling stage and 6 dSm^{-1} salinity for whole life The var. BRRI dhan47 matures within 150 days after transplanting. It attains a plant height of about 105 cm. The average yield of BRRI dhan47 is 6.1 tha^{-1} under normal condition and around 4 tha^{-1} in saline (BRRI, 2007). Five level of ash (viz. 0, 1.5, 3, 4.5 & 6 tha^{-1}) and six salinity level (viz. 0, 20, 40, 60, 80 & 100 mM NaCl) were used as treatment variables. The experimental was laid put in a factorial Randomized Complete Block Design with five replications. The total number of pots used in this study was 150 (6 x 5 x 5). Seeds of var. BRRI dhan47 were collected from BRRI Gazipur. Seeds were soaked into water in buckets for 24 hours and then taken out of water and incubated in gunny bags for sprouting. Sprouted seeds were sown on 21 March 2010 in the nursery bed.. Plastic pots were selected for the experiment to check the loss of saline water. The size of the pot was 13.5 cm diameter in top and 30 cm in height. Each of the pots was filled with 14 kg of the collected soil and fertilized with urea 25, TSP13, MoP 9 , gypsum 8 and zinc sulphate 1.5 g/ pot. The total amount of TSP, MoP, gypsum and zinc sulphate and one third urea was applied during the final pot preparation and rest of the urea was top dressed at 20 and 40 days after transplanting (DAT). Seedlings were uprooted from nursery bed on 27 April 2010 and transplanted immediately at 3 seedlings $hill^{-1}$. The insecticide Basudin 10 G @ 20 kg ha^{-1} were applied to control rice stem borer. The salinity was applied at tillering stage and ash was applied at final pot preparation mixing within 6cm of the potted top soil. The roof of the net house was covered with thin polythene sheet to protect the pots from rain water. Harvesting was done on 30 August 2010. Data on plant height, tillers $hill^{-1}$, grains $panicle^{-1}$, 1000-grain weight, grain yield (t ha^{-1}), straw yield (t ha^{-1}) and harvest index (%) were recorded properly.

Harvest index (HI) was calculated following the formula given below (Kozak *et al.*, 2007)

$$\text{Harvest index (HI)} = \frac{\text{Grain yield}}{\text{Biological yield}} \quad 100$$

The collected data were analyzed statistically following the analysis of variance (ANOVA) technique and the mean difference were adjudged by Duncan's Multiple Range Test (DMRT) using the statistical computer package program MSTAT-C (Gomez and Gomez, 1984).

Table 1. Initial nutrient status of the potted soil

Soil Parameters	Content
Soil pH	6.2
Organic carbon (%)	1.25
Organic matter (%)	1.67
Total nitrogen (%)	0.10
Available phosphorus (ppm)	26.00
Available potassium (me/100 g)	0.14
Available sulphur	13.90

Source: Soil science laboratory, Department of Soil Science, BAU, Mymensingh

Results and Discussion

Effect of salinity levels on yield and yield attributes of rice var. BRRI dhan47

Among the different salinity levels, seedlings of 0 mM NaCl and 20 mM NaCl were survive up to maturity but the seedlings of 40, 60, 80 & 100 mM NaCl were died (Table 2). The tallest plant (100 cm), higher number of tillers hill^{-1} (24) and panicle hill^{-1} (21) was recorded from control treatment
(0 mM NaCl) whereas the shortest plant (97 cm), lower number of tillers hill^{-1} (22) and panicles hill^{-1} (19) was recorded from 20 mM NaCl salinity level. Hasanuzzaman *et al.* (2009) reported that the plant height decreased with increasing salinity level. Zeng and Shannon (2000) stated that there were significant reductions in tiller number at higher salt levels.

The higher number of grains panicle^{-1} (94) and 1000-grain weight (25.67 g) was recorded in control treatment (0 mM NaCl) whereas the lower number of grains panicle^{-1}(93) and 1000-grains weight (24.67 g) was recorded when applied 20 mM NaCl salinity level. Islam (2004) reported that number of grains panicle^{-1} decreased with increased salinity levels. Also Mortazainezhad *et al.* (2006) was observed that 1000-grains weight was negatively influenced by different salinity levels in the rice cultivars.

Table 2. Effect of salinity on yield and yield attributes of rice var. BRRI dhan47

Salinity levels	Plant height (cm)	Tillers hill^{-1} (no.)	Panicle hill^{-1}	Grains panicle^{-1} (no.)	1000-grain weight (g)	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Harvest Index (%)
S_0	100a	24 a	21a	94a	25.67a	4.33a	7.22a	33.17a
S_1	97 b	22b	19b	93b	24.67b	4.02b	5.98b	33.15b
S_2	-	-	-	-	-	-	-	-
S_3	-	-	-	-	-	-	-	-
S_4	-	-	-	-	-	-	-	-
S_5	-	-	-	-	-	-	-	-
LSD ($_{0.05}$)	1.49	0.51	0.72	3.66	0.35	0.08	0.21	0.98
CV (%)	8.10	11.89	19.48	20.70	9.59	11.78	16.85	15.80

S_0= 0 mM NaCl, S_1= 20 mM NaCl, S_2= 40 mM NaCl, S_3= 60 mM NaCl, S_4= 80 mM NaCl and S_5= 100 mM NaCl.

The higher grain yield (4.33 t ha^{-1}), straw yield (7.22 t ha^{-1}) and harvest Index (33.17%) was recorded from control treatment (0 mM NaCl). On the other hand, the lower grain yield (4.02 t ha^{-1}), straw yield (5.98 t ha^{-1}) and harvest Index (33.15%) was recorded from the salinity level 20 mM NaCl. Sexcion *et al.* (2009) reported that grain yield decreased with increasing salinity levels. The seedlings of 40, 60, 80 & 100 mM NaCl were died after salt application.

Effect of ash on yield and yield attributes of var. BRRI dhan47

Different level of ash had significant effect on yield and yield attributes of BRRI dhan47 (Table 3). The maximum plant (101 cm) was recorded from 6 tha^{-1} ash which was identical to 4.5 t ha^{-1} ash whereas the shortest plant (95 cm) from the control treatment. Ogbodo *et al.* (2009) stated that plant height increase with the increasing ash level. The higher number of tillers $hill^{-1}$ (26) was recorded from the treatment 6 t ha^{-1} ash which was identical to 4.5 t ha^{-1} ash (24) whereas the lower number of tillers $hill^{-1}$ (20) from control.

Higher number of panicles $hill^{-1}$ (23), grains $panicle^{-1}$ (100) and 1000-grain weight (26.98 g) was recorded from the treatment 6 t ha^{-1} ash whereas the lower number of panicle $hill^{-1}$ (15), grains $panicle^{-1}$ (83) and 1000- grains weight (22.41 g) from the control.. The maximum grain yield (4.46 t ha^{-1}) was recorded from 6 t ha^{-1} ash, which was identical to the treatment 4.5 t ha^{-1} ash (4.45 t ha^{-1}) followed by 3 t ha^{-1} ash (4.20 t ha^{-1}). The lowest grain yield (3.70 t ha^{-1}) was recorded from the control treatment. Similarly, Subramoniam and Chandrasekaran (2005); Sudhakar *et al.* (2004) stated that the grain yield increased with the increasing level of ash. The highest straw yield (6.93 t ha^{-1}) and harvest index (35.40%) was recorded from the treatment 6 t ha^{-1} ash whereas the lowest straw yield (6.19 t ha^{-1}) and harvest index (31.17%) from control treatment (0 t ha^{-1} ash).

Table 3. Effect of ash on yield and yield attributes of rice var. BRRI dhan47

Levels of ash	Plant height (cm)	Tillers $hill^{-1}$ (no.)	Panicle $hill^{-1}$	Grains $panicle^{-1}$ (no.)	1000-grain weight (g)	Grain yield (tha^{-1})	Straw yield (tha^{-1})	Harvest index (%)
A_0	95 b	20d	15b	83b	22.41c	3.70c	6.15a	31.17b
A_1	97 ab	22cd	17b	93ab	24.41b	4.02bc	6.38a	31.8ab
A_2	98ab	23bc	21a	97ab	23.43ab	4.20ab	6.70a	32.04ab
A_3	101a	24ab	22a	99a	26.62a	4.45a	6.84a	35.34a
A_4	101a	26a	23a	100a	26.98a	4.46a	6.93a	35.40a
$LSD_{(0.05)}$	1.36	0.47	0.66	3.34	0.32	0.07	0.19	0.89
CV (%)	8.10	11.89	19.48	20.70	9.59	11.78	16.85	15.80

A_0 = Control, A_1 = 1.5 t ha^{-1}, A_2 = 3 t ha^{-1}, A_3=4.5 t ha^{-1}, A_1= 6 t ha^{-1}

Interaction of ash and salinity levels on yield and yield attributes of rice var. BRRI dhan47

The interaction effect of ash and salinity levels had significant effect on the yield and yield attributes of rice var. BRRI dhan47 (Table 4). The tallest plant (102 cm) was recorded from the treatment combination of 0 mM NaCl x 6 t ha^{-1} ash which was identical to 0 mM NaCl x 4.5 t ha^{-1} ash (102 cm) whereas, the shortest plant (92 cm) was recorded when no ash was applied with salinity level 20 mM NaCl. The number of tillers $hill^{-1}$ was higher (26) in the treatment combination of 0 mM NaCl x 6 t ha^{-1} ash which was identical to 0 m M NaCl x 4.5 t ha^{-1} ash (25) followed by 20 m M NaCl x 6 t ha^{-1} ash (25) whereas, lower (19) in the treatment combination of 20 mM NaCl x 0 t ha^{-1} ash. The number of panicles $hill^{-1}$ (23), grains $panicle^{-1}$

(101) and 1000-grain weight (21.36 g) was higher in 0 mM NaCl x 6 t ha^{-1} ash and lower number of panicles $hill^{-1}$ (15), grains $panicle^{-1}$ (76) and 1000-grain weight (17.20) was obtained from 20 mM NaCl x 0 t ha^{-1} ash.

The maximum grain yield (4.54 t ha^{-1}) was recorded from the treatment combination of 0 mM NaCl x 6 t ha^{-1} ash which was identical to 0 mM NaCl x 4.5 t ha^{-1} ash (4.52 t ha^{-1}) followed by 20 mM NaCl x 6 t ha^{-1} ash (4.39 t ha^{-1}).The lowest grain yield (3.49 t ha^{-1}) was obtained from the treatment combination 20 mM NaCl x 0 t ha^{-1} ash.

The harvest index was higher (37.32%) in the treatment combination 20 mM NaCl x 4.5 t ha^{-1} ash which was identical to 20 mM NaCl x 6 t ha^{-1} ash (37.10%) and lower (29.81%) in 20 mM NaCl x 0 t ha^{-1} ash.

Table 4. Interaction of ash and salinity levels on yield and yield attributes of rice vr. BRRI dhan47

Interactions	Plant height (cm)	Tillers $hill^{-1}$ (no.)	Panicle $hill^{-1}$	Grains $panicle^{-1}$ (no.)	1000-grain weight (g)	Grain yield (tha^{-1})	Straw yield (tha^{-1})	Harvest Index (%)
A_0S_0	98abc	21d	15d	91b	22.49e	3.94cd	32.51bcd	32.51bcd
A_0S_1	92d	19e	15d	76c	22.36e	3.49e	29.81e	29.81e
A_1S_0	98abc	22d	20bc	93ab	24.55d	4.27b	33.14bc	33.14bc
A_1S_1	95cd	21d	15d	94ab	24.29d	3.78d	30.46de	30.46de
A_2S_0	99ab	25bc	23a	99ab	26.00b	4.35ab	33.01bc	33.01bc
A_2S_1	97bc	22d	19c	95ab	24.77cd	4.04c	31.05cde	31.05cde
A_3S_0	102a	25ab	22a	101a	27.54a	4.52a	33.38bc	33.38bc
A_3S_1	101ab	24c	21ab	98ab	25.70bc	4.38ab	37.32a	37.32a
A_4S_0	102a	26a	23a	101a	27.76a	4.54a	33.70b	33.70b
A_4S_1	101ab	25abc	22a	98ab	26.23b	4.39ab	37.10a	37.10a
$LSD_{(0.05)}$	0.61	0.21	0.29	1.98	0.19	0.04	0.53	0.53
CV(%)	8.10	11.89	19.48	20.70	9.59	11.78	15.80	15.80

A_0 = Control, A_1 = 1.5 tha^{-1}, A_2 = 3 tha^{-1}, A_3=4.5tha^{-1}, A_1=6 tha^{-1}, S_0= 0 mM NaCl and S_1= 20 mM NaCl.

Conclusion

It can be concluded that, application of ash ameliorated the salinity stress effect on rice yield. It was also found that, the salt tolerance level of rice var. BRRI dhan47 was 20 mM NaCl when cultivated with 6 ton ha^{-1}ash .

References

Brammer, H. 1971. Agricultural development possibilities in Bangladesh. Soil Survey Project Technical Report No. 2. FAO, Rome.

Flowers, T. J. and A. R. Yeo. 1981. Ion relations of plants under drought and salinity. Aust. J. Plant Physiol. 13: 75-91.

Gomez, H. C. and A. A. Gomez. 1984. Statistical Procedures for Agric. Res., John Wiley and Sons. New York, p. 680. Gong H. J., D. P. Randall and T. J. Flowers. (2006). Silicon deposition

in the root reduces sodium uptake in rice (*Oryza sativa L.*) seedlings by reducing bypass flow. Plant Cell Environ. 29: 1970–1979.

Hasanuzzaman, M., M. Fujita, M. N. Islam, K. U. Ahamed and K. Nahar. 2009. Performance of four irrigated rice varieties under different levels of salinity stress. Int. J. Integrative Biol. 6(2): 85-90.

Hasegawa, P., R. A. Bressan, J. K. Zhu and H. J. Bohnert. 2000. Plant cellular and molecular responses to high salinity. Annu. Rev. Plant Mol. Biol. 51: 463-499.

Kozak, M., S. Samborski, M. S. Kang and J. Rozbicki. 2007. Applying statistics for nonsequential yield component analysis. Plant, Soil and Environment. 53(10): 456 463.

Liang, Y. C., W. Q. Zhang, J. Chen and R. Ding. 2005. Effect of silicon on H^+- ATPase and H^+-PPase activity, fatty acid composition and fluidity of tonoplast vesicles from roots of salt-stressed barley (*Hordeum vulgare L.*). J. Environ. Exp. Bot. 53: 29-37.

Liang, Y. C., Q. Chen, Q. Liu, W. Zhang and R. Ding. 2003. Effects of silicon on salinity tolerance of two barley cultivars. J. Plant Physiol. 160: 1157-1164.

Ma, J. F. 2004. Role of silicon in enhancing the resistance of plants to biotic and abiotic stresses. J. Soil Sci. Plant Nutrition. 50: 11-18.

Maiti, R., P. Vidyasagar and P. P. Banerjee. 2008. Characterization of salinity tolerance in rice (Oryza sativa L.) genotypes at the germination and seedling stages. Acta Agronomica Hungarica 56(2): 139-147

Mortazainezhad, F., R. Khavarinejad and M. Emami. 2006. Study of some parameters of yield and proline in rice plants under NaCl salinity stress. J. New. Agric. Sci. 2(4): 93-98.

Ogbodo, E. N. 2009. Changes in the Properties of an Acid Soil Amended with Burnt Rice Husk and the Effect on the Growth and Yield of Pepper at Abakaliki South Eastern Nigeria, Am. Eurasian J. Sustain. Agric. 3(3): 579-586.

Rasel, H. M., M. R. Hasan, B. Ahmed and M. S. U. Miah. 2013. Inves tigation of soil and water salinity, its effect on crop production and adaptation strategy. International J. of Water Res. and Env. Eng. 5(8): 475-481.

Subramoniam, S. R. and A. Chandrasekaran. 2005. Chemical properties of lateritic soil and yield of rice as influenced by addition of fly ash. International Rice Res. Notes. Int. Rice Res. Inst. Manila, Philippines. 30(1): 35-37.

Sudhakar, P. C., J. P. Singh and S. Kalyan. 2004. Effect of silicon sources and fertility levels on transplanted rice. International Rice Res. Notes. Int. Rice Res. Inst. (IRRI), Manila, Philippines. 29(2): 61-63.

Suzuki S., J. F. Ma, N. Yamamoto, T. Hattori, M. Sakamoto and T. Umezawa. 2012. Silicon deficiency promotes lignin accumulation in rice. Plant Biotechnol. 29: 391–394.

Tahir, M., A. Rahmatullah, T. Aziz, M. Ashraf, S. Kanwal and A. Muhammad. 2006. Beneficial effects of silicon in wheat under salinity stress-pot culture. Pak. J. Bot. 38: 1715-1722.

Yeo, A. R., S. A. Flowers, G. Rao, K. Welfare, N. Senanayake and T. J. Flowers. 1999. Silicon reduces sodium uptake in rice (Oryza sativa L.) in saline conditions and this is accounted for by reduction in transpirational bypass flow. Plant cell Environ. 22: 559-565.

Zeng. L. H. and M. C. Shannon. 2000. Salinity effects on seedling growth and yield components of rice. Crop Sci. Society America, Madison, USA. 40(4): 996-1003.