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Improvement of yield of salt tolerant rice genotypes/varieties through gypsum application

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ABSTRACT

Salinity intrusion causes problems in the coastal areas of Bangladesh. Climate change creates hazards like cyclone, sea level rise, and storm surge have been increasing the salinity problem in many folds. The coastal region covers about 20% of the country, from where cultivable land more than 30%. Agricultural land uses in these areas are very poor, because of high content of salinity in Rabi season. Already, 830,000 million hectares of land already identified as affected by soil salinity. A field experiment was carried out at saline prone area, Suparishata, Sodor, Satkhira under natural salinity condition during Rabi season 2017-2018. The experiment was carried out with two varieties namely, V_1=Binadhan-10, V_2=BRRIdhan67 and four levels of gypsum with control G_0: 0 kg ha^{-1}, G_1: 75 kg ha^{-1}, G_2: 150 kg ha^{-1} and G_3: 225 kg ha^{-1}. The experiment was laid out in a split plot design with three replications. The unit plot size was 3m x 4m. The recommended fertilizer doses applied for the experiment were 80 kg N ha^{-1}, 15 kg P ha^{-1}, 50 kg K ha^{-1}. Nitrogen, phosphorus, potassium, sulphur and zinc were supplied from urea, TSP, MoP, gypsum and zinc sulphate monohydrate respectively while urea was applied in three equal splits. Application of silicon had significant effect on plant height, number of effective tiller m^{-2}, length of panicle, total number of spikelets panicle^{-1}, thousand grain weight, number of filled spikelets panicle^{-1}, grain yield straw yield. It seems that the crop responded to the application of gypsum from 75-225 kg ha^{-1}. Overall results suggest that an application of gypsum 225 kg ha^{-1} along with N, P, K, Zn and Boron might be necessary to ensure satisfactory yield of rice in saline prone area under natural salinity condition.

Key Words: *Salinity, Saline soil, Gypsum, BINAdhan and BRRIdhan*

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I. Introduction

Salinity is one of the major causes hindering agricultural productivity in the world. Globally nearly 7% of the world is afflicted by soil salinity (Gupta and Abrol, 1990) Salinity caused by anthropogenic factors (secondary stalinization) is often related to large-scale development of irrigated agriculture without adequate drainage and clearing of natural deep rooted vegetation. Problems associated with the presence of excess salts in the soil have for long constrained agricultural productivity, largely due to inappropriate agricultural management practices. The salinity problems are rapidly expanding as reclamation is expensive and time consuming. In SAARC region, 7% of the total agriculture land (218 million ha.) is affected by salinity in Bangladesh (Gurung et al., 2013). Importantly productivity increases must be achieved in ways which do not cause impairment of resource base i.e. productivity increases are achieved in a sustainable way. Sea level rise and salinity intrusion are likely to be intensified in future affecting crop production seriously in the low-lying coastal area of Bangladesh. However, the coastal area has been increasing day by day due to rising of temperature and consequently sea level. Now-a-days, more than 80 % of the total area of the Khulna, Bagerhat and Satkhira districts are affected by different magnitudes of soil salinity of which about 35 percent is in the grip of strong salinity (Mainuddin et al., 2011). The salinity situation in the coastal area of Bangladesh is going to worsen in the future. Increasing level of salinity in the country is posing serious threatening catastrophe for crop production. Salinity is a year round problem in the coastal agriculture, it varies over the year with the peak salinity occurring during December to April, and the least during July to September. Therefore, boro rice and other rabi crops are mostly affected in the coastal area due to salinity stress. Bangladesh Rice Research Institute (BRRI) and Bangladesh Institute of Nuclear Agriculture (BINA) have developed salinity tolerant rice cultivars BRRI dhan47, BRRI dhan61, BRRI dhan67, Binadhan-8 and Binadhan-10, respectively, for cultivation during boro season. In addition to the development of salt tolerant cultivars, better understanding of nutritional disorders in the context of plant nutrient uptake and physiological as well as biochemical mechanisms of slat tolerance in rice plants may suggest some strategies for plant breeders and growers for developing salinity tolerant varieties and management practices for cultivation in saline areas. There are some agronomic management practices through which salinity level of a soil can be lowered and/or the stress effects on crops can be mitigated. Application of gypsum and organic amendments, row arrangement of the crops and irrigation methods, seed priming, mulching. Introduction of salinity tolerant rice varieties in combination with agronomic management practices for the amelioration of salinity stress effect is the key for improving crop productivity in the salinity affected coastal area of Bangladesh.

II. Materials and Methods

The field experiment was conducted at saline prone area, Suparishata, Sodor, Sathkira under natural salinity condition (Figure 01**)** during 2017-2018. The experiment was carried out with two varieties namely, V_1=Binadhan10, V_2=BRRIdhan67 and four levels of gypsum with control G_0: 0 kg ha^{-1}, G_1: 75 kg ha^{-1}, G_2: 150 kg ha^{-1} and G_3: 225 kg ha^{-1}. The experiment was laid out in a split plot design with three replications. The unit plot size was 3m x 4m. The treatments were randomly distributed to the plots within a block. Seedlings were raised in well prepared wet seed bed at the sub-station Satkhira farms. No manuring and fertilization was done but water and pest management practices were followed in order to raise healthy seedlings. After uniform leveling, the experimental plots were laid out according to the requirement of the treatment. The plots of Boro rice were fertilized with N, P, K, Zn and Boron respectively according to the recommendation of BARC fertilizer recommendation guide (2012). The whole amount at triple super phosphate, muriatic of potash silicon, gypsum and zinc sulphate were applied to the soil at the time of final land preparation. Urea was applied in three equal splits. One split of urea was applied with other fertilizers as basal dose and the other two splits were applied 21 and 45 DAT. The seed bed was wet by application of water both in the morning and evening on the previous day before uprooting the seedling. Thirty days old seedlings were uprooted carefully from the seedling nursery for transplanting in the experimental plots. Only selected healthy seedlings were translated in the experimental plots in 1 February 2018 in 20 cm apart line maintaining a distance of 15 cm from hill to hill with three seedlings $hill^{-1}$ proper care was taken during the growing period of the crop.

Intercultural operating was done in order to ensure and to maintain the normal growth of the plant as and when needed. After one week of transplanting dead seedling were replaced carefully by transplanting fresh seedlings from the same source. The experiment plots were infested with some common weeds which were removed twice by hand weeding. After transplanting six irrigations were needed to maintain 5-6 cm standing water in each plot. Finally, the field was drained out 7 days before harvest. Observations were regularly made and the field looked nice with normal green plants. The crops were harvested on 27 April, 2018 with sickle at full maturity. The maturity of crops was determined when some 70% of the seeds became attain their character's color. Grain and straw yields plot were recorded after threshing by a pedal thresher winnowing and drying in the sun properly including the grains and straws of the sample plants. The weight of grains was adjusted to 12% moisture content. Grain and straw yield were them converted to t ha^{-1}. From the 10 randomly harvested hills, the following data were recorded, plant height, number of total tillers $hill^{-1}$, number of effective tillers $hill^{-1}$, number of non-effective tillers $hill^{-1}$, number of grain $panicle^{-1}$, number of unfilled spikelet's $panicle^{-1}$,1000 grain weight, Grain yield (t ha^{-1}), Straw yield (t ha^{-1}).The initial soil samples were collected from the plough depth level (0-15) cm. The samples were taken by means of an auger from different spots of the field and mixed thoroughly to make a composite sample. The composite sample was air dried ground and sieved through a 10-mesh (2 mm) sieve and stored in a plastic bag for physical and chemical analysis. The initial soil sample was analyzed for physical and chemical properties in the laboratory of the Department of Soil Science, Bangabandhu Sheikh MujiburRahman Agricultural University, Gazipur-1706.

Soil samples were analyzed for both physical and chemical characteristics. The soil samples were analyzed following the standard methods as follows. Soil pH was measured with the help of a glass electrode pH meter; the soil water ratio being maintained at (1:2.5). Organic carbon in soil sample was determined volumetrically by wet oxidation method of Walkley and Black (1934). The organic matter content was calculated by multiplying the percent of organic carbon by 1.72 (van Bemmelen factor). Cation exchange capacity of soil was determined by Na saturation method (Khorshidi et al., 2017). The soil samples were extracted with normal sodium acetate solution at pH 7.0 and all cations were leached out with sodium ions from the soils. The excess sodium ion was then washed out with alcohol. The absorbed sodium ions were extracted with normal ammonium acetate solution. The amount of Na^{+} in the extract was then determined by flame photometer and the results were expressed as $me100^{-1}$ g soil.

Total N content in soil was determined by micro-Kjeldahl method. Digestion was made with H_2O_2, conc. H_2SO_4 and catalyst mixture (K_2SO_4: $CuSO_4.5H_2O$: Se =100:10:1). Nitrogen in the digest was determined by distillation with 40% NaOH followed by titration of the distillate trapped in H_3BO_3 with 0.01N H_2SO_4 (Mishra et al., 1999). Bray-1 method (Olsen and Sommers, 1982) was followed to determine available P. A portion of 2.5 g of air dried soil sample was taken in a 125 ml conical flask then 20 ml of extracting solution (0.03N NH_4F in .025 N HCl was added. It was shaken 5 minutes and filtered through Whatman # 42 filter paper. A portion of 2 ml aliquot was taken into 25 ml test tube. Exactly 6 ml of distilled water and 2 ml of color reagent was added. The color reagent was prepared following Murphy and Relay (1962). Exchangeable K was extracted with NH_4OAc (pH 7) solution and the extractable K was determined by flame photometer (Black et al., 1965). Available Zn content of soil was determined by DTPA extraction method as described by Lindsay and Norvell (1978). The concentration of Zn in the extract was measured directly by atomic absorption spectrophotometer (AAS). Data recorded for different parameters were subjected to analysis of variance (ANOVA) and the treatment means were compared using the least significant different test.

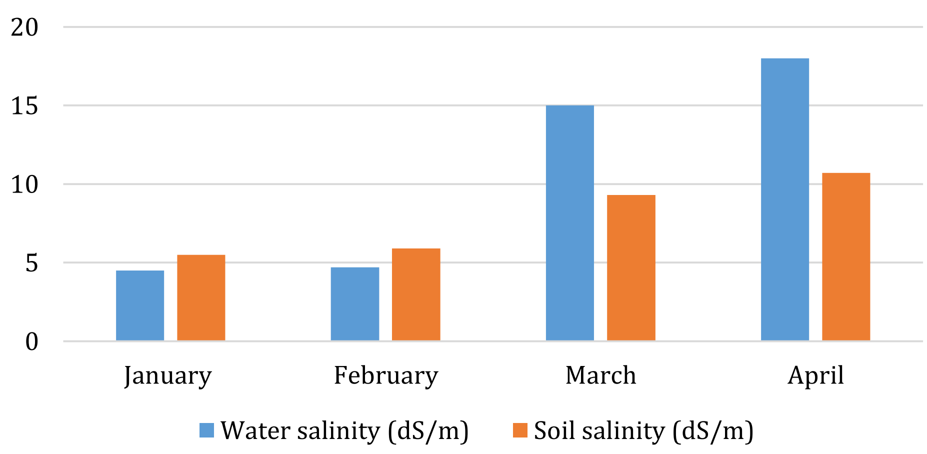

Figure 01. Water and Soil salinity status of experimental site

III. Results and Discussion

There are a statistically significant different in plant height, panicle number hill^{-1}, panicle length, spikelet percentage panicle^{-1}, total spikelets panicle^{-1}, thousand grain weight, grain yield, straw yield. Minimum plant height (95.2 cm) was noted for control treatment and maximum of that (104.4 cm) was obtained for 225 kg ha^{-1} gypsum application. The most plant height (104.5 cm) had observed at interaction of 225 kg ha^{-1} gypsum application in BRRIdhan 67 and the least plant height (94.5 cm) was obtained at interaction of control treatment in BRRIdhan 67. The most panicle number hill^{-1} (13.1 panicles) was shown with 225 kg ha^{-1} gypsum and the least panicle number hill^{-1} (10 panicles) was obtained in control treatment. The most panicle number hill^{-1} (13.5 panicles) was observed at interaction of 225 kg ha^{-1} gypsum application in BRRIdhan 67 least panicle number hill^{-1} was obtained at interaction of control treatment in Binadhan-10 (9.2 panicle). Maximum panicle length (26.1 cm) was observed with application of gypsum 225 kg ha^{-1} and minimum panicle length (23.1 cm) was obtained with control treatment. The most panicle length (26.6 cm) was observed at interaction of 225 kg ha^{-1} gypsum application in Binadhan10 and the least panicle length (22.5 cm) were obtained at interaction of control treatment in BRRIdhan67. The maximum filled spikelet percentage panicle^{-1} had obtained with application of 225 kg gypsum ha^{-1} (110.3 %), and the least filled spikelet percentage 90.03 %) was observed with application of 0 kg gypsum ha^{-1}. The highest filled spikelet percentage per panicle had shown under interaction of 225 kg gypsum ha^{-1} for var. BRRIdhan 67 and the least filled spikelet percentage (90.3%) had obtained at interaction 0 kg gypsum ha^{-1} treatment in Binadhan10.

The maximum unfilled spikelets per panicle (18.6) had obtained with application of 0 kg gypsum ha^{-1} and the least spikelet panicle^{-1} (118) was observed with 225 kg gypsum ha^{-1}. The highest unfilled spikelet per panicle (19) had shown under interaction with application of 0 kg gypsum ha^{-1} in BRRIdhan 67 and the least unfilled spikelet had obtained at interaction with 0 kg gypsum ha^{-1} in BRRIdhan 67. The results agreed to this authors and the application of gypsum and Zn alone or in combination was effective in enhancing the tiller production, spikelet number, and grain formation of rice irrespective of saline water concentrations which may be attributed to the synergistic effects of gypsum and Zn in a Rice under Gypsum and Zn in Saline Soil 427 saline environment (Mukhi, 1979).

The maximum 1000-grain weight (24.7 g) was found with the application of 225 kg gypsum ha^{-1} and least 1000 grain weight (22.8 g) with control treatments. The maximum 1000-grain weight (26 g) interaction with application of 225 kg gypsum ha^{-1} for var. Binadhan10 and least 1000 grain weight (21.5 g) had obtained at interaction with application of 0 kg gypsum ha^{-1} in BRRIdhan 67. The maximum grain yield 7.59 t ha^{-1} was recorded with application of 225 kg gypsum ha^{-1} and minimum grain yield 5.66 t ha^{-1} was recorded with control treatment. The minimum grain yield 7.59 t ha^{-1} was obtained at interaction of 225 kg gypsum ha^{-1} application in Binadhan-10 and the least grain yield 5.56 t ha^{-1} was obtained at interaction of control treatment in Binadhan-10. The maximum straw yield 8.21 t ha^{-1} was recorded with 225 kg gypsum ha^{-1} and minimum straw yield 6.58tha^{-1} was recorded with control treatment. The maximum straw yield 8.24 t ha^{-1} was obtained at interaction of 225 kg gypsum ha^{-1} application and var. Binadhan10 and the minimum straw yield 6.51 t ha^{-1} was obtained at interaction of 0 kg gypsum ha^{-1} and var. BRRI dhan 67 (Table 01). Gypsum application had a significant effect on the increase of the yield of rice in saline and alkali soils (Chapman and Cellier, 1986). Application of Zn alleviated the adverse effects of sodicity and salinity, and enhanced the crop yield (Shukla and Mukhi, 1980). Shah et al. (2005) found that a fairly good crop of rice with a small profit margin could be raised in the first year itself, by application of 20% of the gypsum requirements. Higher levels of gypsum proved economical only during subsequent years while application of gypsum beyond 80% of the requirement was of no avail. Soil pH declined with increase gypsum application. Chand et al. (2005) reported that application of gypsum with pressmud or with fulvic acid and zinc sulphate resulted in significantly higher rice yield in saline-sodic soil.

A significant higher efficiency in reclamation of clay saline soil was obtained in terms of reducing Na^+ and EC when gypsum was applied and water was added in comparison to non-treated soil with gypsum. The highest number of filled spikelets per panicle, grain and straw yields were obtained when rice plants were grown on soil treated with gypsum compared to soil with no gypsum. Application of gypsum which improved soil properties, rice growth and its productivity. This might be due to the valuable nutrient source of gypsum interns of Calcium, which mitigated the toxicity caused by salts in saline soils. Gypsum can also be considered as an effective application for clay saline soil in Satkhira regions of Bangladesh.

Table 01: Morphological characters and yield data influenced by gypsum fertilizer application during Boro 2017-18

Treatments	Plant height (cm)	Total tillers hill^{-1}(no)	Effective tillers hill^{-1}(no)	Panicle length (cm)	Filled grains panicle^{-1}(no.)	Unfilled grains panicle^{-1} (no.)	1000 seed wt. (g.)	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})
Variety									
Binadhan-10 (V_1)	100.4	13.1	11.9	25.8	118.7	17.13	25.3	6.34	7.65
BRRIdhan 67(V_2)	99	13.9	12.3	25.4	129.2	14.75	22.4	6.28	7.85
Level of sig.	NS	NS	NS	NS	**	NS	**	NS	NS
Gypsum rates									
0 kg ha^{-1}(G_0)	95.2d	12d	10.5d	24.2d	110.8d	24.3a	22.4d	5.61d	6.79d
75 kg ha^{-1} (G_1)	97.73c	12.8c	11.6c	25.1c	120.3c	19.3b	23.4c	6.1c	7.44c
150 kg ha^{-1} (G_2)	101.5b	14b	12.9b	26.2b	127.6b	13.1c	24.2b	6.54b	8.14b
225 kg ha^{-1} (G_3)	104.4a	15.1a	13.6a	26.9a	137.3a	6.9d	25.3a	6.99a	8.62a
$LSD_{0.05}$	1.26	0.4	0.4	0.5	4.2	2.5	0.49	0.22	0.32
Variety×Gypsum rates									
V_1G_0	95.9cd	11.67	10	24.6cd	106e	25.6a	23.9cd	5.63d	6.69e
V_1G_1	98.2bc	12.33	11.47	25.5bc	115.6d	21bc	24.9bc	6.18bc	7.25cd
V_1G_2	103.2a	13.67	12.87	26.2ab	121.7c	14.6de	25.7b	6.52b	8.06ab
V_1G_3	104.3a	15	13.63	26.8a	131.6b	7.2fg	26.9a	7.02a	8.61a
V_2G_0	94.5d	12.33	11	23.9d	115.7d	23ab	21.1f	5.59d	6.89de
V_2G_1	97.3bcd	13.33	11.83	24.6cd	125c	17.6cd	21.9ef	6.02c	7.64bc
V_2G_2	99.8b	14.47	12.93	26.2ab	133.4b	11.6ef	22.8de	6.56b	8.22a
V_2G_3	104.5a	15.33	13.7	27a	143a	6.6g	23.8d	6.95a	8.63a
$LSD_{0.05}$	1.8	NS	NS	1.2	5.8	3.5	0.7	0.31	0.45
CV(%)	7.17	12.82	5.04	5.06	2.55	12.35	6.07	2.74	3.59

IV. Conclusion

Gypsum application significantly increased Ca^{2+} and Mg^{2+} of the clay saline soil. The improvement of soil chemical properties in terms of removal Na^+ salt and reducing EC that caused a significant reduction in soil salinity obtained from gypsum 225 kg ha^{-1}. A significant improvement in growth and increase in yield of rice were obtained when gypsum was applied into clay saline soil and irrigation was done. Therefore, gypsum is considered as effective treatments to leach the soluble salts for reclamation of clay saline soil and better plant growth, and yield of rice genotypes.

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