Journal of Advanced Scientific Research

Available online through http://www.sciensage.info/jasr

ISSN
0976-9595
Research Article

RECLAMATION OF SALINE SOIL USING GYPSUM, RICE HULL AND SAW DUST IN RELATION TO RICE PRODUCTION

Fatema Kaniz*, Md. Harunor Rashid Khan

Department of Soil, Water and Environment, University of Dhaka, Bangladesh

**Corresponding author: lopa_du3@yahoo.com*

ABSTRACT

Experiments were conducted to evaluate the potentiality and effectiveness of gypsum, rice hull and saw dust to reclaim and/or improve saline soils collected from coastal areas of Bangladesh. Growth and yield parameters of rice, such as, plant height, 1000-grain weight, grain and straw yield, number of tillers, protein content of grain and harvest index were found to be significantly ($p \leq 0.05$) induced by the application of gypsum, rice hull and saw dust. The maximum growth and yield performance of rice were determined by the highest dose (10 t ha^{-1}) of saw dust followed by the highest dose (10 t ha^{-1}) of rice hull. The highest dose of gypsum (400 kg ha^{-1}) was found to be increased the vegetative growth (plant height, tiller production) of rice. The highest value (0.48) of Harvest Index was obtained by the application of rice hull at 10 t ha^{-1}. The highest content of N in rice plants at maturity were found 1.38% with the application of saw dust at the rate of 10 t ha^{-1}, 0.19% for P, 1.41% for K and 0.75% for S with gypsum application at the rate of 400 kg ha^{-1} . Application of gypsum, rice hull and saw dust at highest dosages increased the uptake of N, P, K and S in rice plant.

Keywords: Saline soil, gypsum, rice hull, saw dust

1. INTRODUCTION

Bangladesh is a land of agriculture. Once it had enormous potential for achieving food security, but the saying is now a bygone truth. In Bangladesh coastal areas constitute about 2.5 million hectares which amount to about 25 percent of the total cropland of the country. Of this, nearly 0.84 million hectares are affected by varying intensities of salinity, resulting in very poor land utilization [1]. Salinity is one among the major abiotic stresses limiting profitable crop production worldwide [2-3]. Over 800 million hectares (Mha) land is salt affected either by containing excessive soluble salts (397 Mha) or exchangeable sodium (434 Mha) worldwide [4-5]. Elevated osmotic stress, ions toxicity (due to over accumulation of Na^+ in particular), imbalance nutrition and salinity-induced oxidative damage are the principal causes to hamper plants growth under salinity [6-7]. However, salt resistant genotypes regulate the ion and water movements and also uphold better antioxidant defense system [8]. In field conditions saline soil can be recognized by the spotty growth of crops and often by the presence of white salt crust on the surface. 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 country it has become imperative to explore the potentials of these lands [1]. Studies in the past have compared the effectiveness of various amendments at improving the physical and chemical properties of saline sodic and sodic soils [9-10]. The relative effectiveness of gypsum and sulfuric acid has received the most attention because they are widely used as reclamation amendments. Most recently, crops or crops residues and synthetic polymers have been included in efficiency studies [10-13]. Gypsum is mainly blamed for its slow reaction but much popular due to its low cost and availability. The significance of organic matter has been proven through its effect on improving the physical conditions of soils for crop growth besides its role as fertilizers. Keeping all these views in consideration, the experiment was undertaken with the following objectives:

(a) Reclamation of saline soils by using different doses of gypsum, rice hull and saw dust.
(b) To evaluate the effects of gypsum, rice hull and saw dust on the growth, yield and mineral nutrition of rice grown in saline soil.

2. MATERIAL AND METHODS

The study was conducted using a salt-tolerant rice variety, BR-47 in the net house of the University of Dhaka during April to July, 2011. The soil used in the experiment was collected from Amtoli thana in Barguna district which was located between 20.1508^0 N latitude and 90.1264^0 E longitude. The soil was silty clay loam affected by various degrees of salinity, ECe 3.36 dsm^{-1}[14], pH 5.35 [15], Turbidity 940 mg kg^{-1} [16], Organic Carbon 1.53% [17] , total N 0.082%, available ammonium N 14.55 mg kg^{-1}, available nitrate N 33.95 mg kg^{-1} [15], water soluble phosphorus in not detectable range [18], available K 23 mg kg^{-1} [19], available sulfur 435 mg kg^{-1}, available Cl 17980 mg kg^{-1} [20], available Fe 78.5 mg kg^{-1}; available Mn 23.25 mg kg^{-1}; available Zn 4.27 mg kg^{-1} [21], carbonate 0.1 C mol kg^{-1} [20] , water soluble ions viz. Na 75 mg kg^{-1}, K 19 mg kg^{-1}, Ca 30.5 mg kg^{-1}, Mg 28 mg kg^{-1} [17], exchangeable cations viz. Ca 346 mg kg^{-1}, Mg 300 mg kg^{-1}, Na 851 mg kg^{-1}, K 201 mg kg^{-1} [17], SAR 8.01 and ESP 24.65% [20]. Six kilograms of air dried, ground and 5 mm sieved composite soil was filled in each earthen pots (size: 8L). Four seedlings/hill and three hills in each pot in a triangular grid were transplanted. The experiments were conducted following 3 doses of gypsum, 3 doses of rice hull 3 doses of saw dust in a non factorial completely randomized block design with two sampling time and two replications. So in total 1x9x2x2=36 pots were used for the experiments. Treatment combinations are given in Table-1.

Table 1: Treatment combinations of gypsum, saw dust and rice hull.

Treatment combinations	Gypsum (kg ha^{-1})	Rice hull (t ha^{-1})	Saw dust (t ha^{-1})
$G_0R_0S_0$ (T_1)	00	00	00
$G_{200}R_0S_0$ (T_2)	200	00	00
$G_{400}R_0S_0$ (T_3)	400	00	00
G_o R_5 S_o (T_4)	00	5	00
G_o R_{10} S_o (T_5)	00	10	00
G_o R_0 S_5 (T_6)	00	00	5
G_o R_0S_{10} (T_7)	00	00	10

Basal dose of N, P_2O_5 and K_2O were applied at the rate of 50 kg ha^{-1}, 40 $kgha^{-1}$ and 50 kg ha^{-1} from Urea, TSP and MP fertilizers, respectively and were mixed with the soil of each pot. The whole TSP, MP and half of the Urea were applied during pot preparation by thorough mixing of the fertilizers with soil. Then the soil in each pot was puddled by hand using almost same amount of tap water per pot and then kept submerged for 3 days. After submergence, fertilizers were mixed thoroughly with soil and again submerged for 2 days. Plant height and number of tillers were recorded at 20 DT (Early Tillering Stage, ETS: 10-25 DT), 40 DT (Maximum Tillering Stage, MTS: 26-55 DT), and 100 DT (Maturity Stage, Mat.: 85-110 DT).The plants were harvested at 1 cm above the soil surface and the plant height, number of tillers, grain and straw yield, nutrient content of plant, and yield components viz. grain to straw ratio, 1000 grain weight of rice, protein content and harvest index were recorded. Total N, P, S & K contents in rice plant [15] were determined. Nutrient uptake was determined from total nutrient content and plant dry matter weight. Statistical analyses such as Analysis of Variance (ANOVA), Duncan's Multiple Range Test (DMRT) and Least Significant Difference (LSD) of the experimental results were done for interpretation.

3. RESULTS AND DISCUSSIONS

3.1. Growth and yield of rice

Analysis of the relevant data demonstrated that the individual variables such as gypsum, rice hull and saw dust exerted significant effects on the growth and yield performance of rice. Plant height increased significantly with time. Again, the rate of increase of plant heights was found greater at tillering stage as compared to that of maturity stage indicating that the growth was normal. The tallest plant height (116 cm) was recorded during maturity stage of rice in the G_o R_{10} S_o (T_5) treatment that is with the application of rice hull at the highest dosage (Table-2).

Numbers of tillers at different stages of growth of rice as influenced by gypsum, rice hull and saw dust are shown in Table-2. Number of tillers increased with time and with the higher rate of treatments. The highest number of tillers at the maturity stage was found with the application of rice hull and saw dust at a rate of 10 t ha^{-1} that is 30 and 32, respectively. Number of tillers was found to be decreased a little at the maturity stages of growth, which is a usual phenomenon especially for problem soils. The number of tillers per pot was largest (33) in the T_7 (G_o R_0S_{10}) treatment during maximum tillering stage. The analysis of the results shows that the application of gypsum, rice hull and saw dust at the highest dosages resulted the maximum plant height and number of tillers per pot due to favorable physico-chemical conditions created by them. Gypsum can be considered beneficial for this problem soil in terms of fodder production as good vegetative growth obtained with gypsum application at highest dosage that is at the rate of 400 kg ha^{-1}. Grain Yield, Straw Yield, Grain-Straw Ratio, 1000 Grain Weight of Rice and protein content of rice grain increased significantly ($p \leq 0.05$) with the treatments, except for the application of gypsum at a rate of 200 kg/ha (T_2: G_{200} R_0 So). This increment was more striking for saw dust application where %IOC was 78 for grain yield and % IOC was 48 for 1000 grain weight. But the second highest % IOC (62 for grain yield and 45 for 1000 grain weight) was recorded for the highest dose of rice hull, which suggests that further trials are needed for the determination of suitable dosage of rice hull and saw dust. The trends of influences of the treatments were almost similar for the other yield parameters of rice (Table-3).

Again Grain-Straw Ratios (G/S) were highest for gypsum application at the rate of 400 kg ha^{-1} and saw dust application at the rate of 10 t ha^{-1}. Addition of gypsum at 400 kg ha^{-1} increased the protein content of rice most due to addition of sulfur which is a building block element of protein. 1000 grain weight of rice was the highest (30.51) for saw dust application at the rate of 10 t ha-1 because saw dust improved the physical condition of soil and also reduced the salinity. Again harvest index was highest for application of rice hull at the rate of 10 t ha^{-1}. They increased yield because they produced some sticky like substances to create favorable physico-chemical condition, reduced bulk density, increased water movement to wash out salinity and released various plant nutrients after their decomposition. In most cases saw dust was better than rice hull at maximum tillering stage may be due to higher decomposition rate of saw dust compared to that of rice hull.

Table 2: Plant heights and Number of tillers at different stages of growth as influenced by gypsum, saw dust and rice hull

Treatment combinations	Plant Height (cm)			Tiller/Pot			Harvest Index
	ETS	MTS	Mat.	ETS	MTS	Mat.	
$G_0R_0S_0$ (T_1)	55 d	67 d	84 e	15 d	20 e	19 e	0.4505 b
$G_{200}R_0S_0$ (T_2)	58 c	69 d	100 d	17 dc	24 d	23 d	0.4503 b
$G_{400}R_0S_0$ (T_3)	61.5 b	87 a	110 b	20 c	26 c	26 c	0.4649 ab
$G_o R_5 S_o$ (T_4)	59 c	76 c	104 c	22 b	25 cd	25 c	0.4676 a
$G_o R_{10} S_o$ (T_5)	67 a	88 a	116 a	28 a	31 b	30 b	0.4878 a
$G_o R_0 S_5$ (T_6)	58 c	76 c	98 d	21 b	26 c	25 c	0.4685 a
$G_o R_0S_{10}$ (T_7)	62 b	82 b	108 bc	29 a	33 a	32 a	0.4642 ab
LSD (5%)	3.05	6	6	2.05	2	2	0.037

Table 3: Grain, Straw Yield, Grain- Straw ratio, 1000 Grain Weight and Protein Content of Rice as influenced by gypsum, saw dust and rice hull

Treatment combinations	Grain Yield (g/pot)	Straw Yield (g/pot)	Grain-Straw Ratio (G/S)	% IOC* of grain yield	Protein Content of Rice Grain	1000 Grain Weight	% IOC of 1000 Grain
$G_0R_0S_0$ (T_1)	16.40 e	20 f	1.2195 b	-	9.61 d	20.55 c	-
$G_{200}R_0S_0$ (T_2)	17.20 e	21 f	1.2209 b	5	12.2 c	27.12 cb	31
$G_{400}R_0S_0$ (T_3)	19.30 d	22.21 e	1.5531 a	18	13.1 b	28.27 b	38
$G_o R_5 S_o$ (T_4)	21.53 c	24.51 d	1.1384 c	31	11.9 c	28.90 b	41
$G_o R_{10} S_o$ (T_5)	26.58 b	27.91 c	1.0500 d	62	12.7 b	29.72 a	45
$G_o R_0 S_5$ (T_6)	26.10 b	29.61 b	1.1344 c	59	13.5 ab	29.12 ab	42
$G_o R_0S_{10}$ (T_7)	29.11 a	33.60 a	1.229 b	78	14.1 a	30.51 a	48
LSD (5%)	2.05	1.20	0.084	-	0.4	0.8	-

% IOC =percent increased over control

3.2. Mineral nutrition of rice

Data on the nutrient content (nitrogen, potassium, sulfur and phosphorus) and nutrient uptake per pot of plants at different growth stage of rice influenced by gypsum, saw dust and rice hull are given in Table-4, 5 & Figure-1, 2, 3 & 4.

Table 4: Nitrogen content (%) and Potassium content (%) in rice plant tissue at different stages of growth as influenced by gypsum, saw dust and rice hull

Treatment combinations	N (%)			K (%)		
	ETS	MTS	Mat.	ETS	MTS	Mat.
$G_0R_0S_0$ (T_1)	1.24 d	1.14 d	0.96 d	0.5 e	0.6 e	0.65 d
$G_{200}R_0S_0$ (T_2)	1.34 c	1.21 cd	1.09 c	0.65 b	0.95 cb	1.12 b
$G_{400}R_0S_0$ (T_3)	1.38 cb	1.26 c	1.12 c	0.85 a	1.11 a	1.41 a
$G_o R_5 S_o$ (T_4)	1.44 b	1.30 bc	1.18 bc	0.52 d	0.83 d	0.99 c
$G_o R_{10} S_o$ (T_5)	1.48 ba	1.33 b	1.18 bc	0.58 c	0.92 c	1.03 c
$G_o R_0 S_5$ (T_6)	1.51 a	1.41 ab	1.24 b	0.53 d	0.89 cd	1.09 b
$G_o R_0S_{10}$ (T_7)	1.55 a	1.46 a	1.38 a	0.63 bc	0.99 b	1.11 b
LSD (5%)	0.075	0.07	0.12	0.02	0.065	0.056

Table 5: Sulfur content (%) and Phosphorus content (%) in rice plant tissue at different stages of growth as influenced by gypsum, saw dust and rice hull

Treatment combinations	S (%)			P (%)		
	ETS	MTS	Mat.	ETS	MTS	Mat.
$G_0R_0S_0$ (T_1)	1.15 f	0.40 f	0.20 f	0.17 e	0.096 d	0.084 e
$G_{200}R_0S_0$ (T_2)	2.25 b	0.81 b	0.65 b	0.25 b	0.16 b	0.12 c
$G_{400}R_0S_0$ (T_3)	2.50 a	0.90 a	0.75 a	0.30 a	0.19 a	0.14 b
$G_o R_5 S_o$ (T_4)	1.50 e	0.51 e	0.30 e	0.20 d	0.15 c	0.11 d
$G_o R_{10} S_o$ (T_5)	1.80 c	0.56 d	0.35 d	0.22 cd	0.15 c	0.11 d
$G_o R_0 S_5$ (T_6)	1.70 d	0.59 c	0.34 d	0.21 d	0.16 b	0.12 c
$G_o R_0S_{10}$ (T_7)	1.85 c	0.85 ba	0.45 c	0.23 c	0.16 b	0.19 a
LSD (5%)	0.1	0.025	0.03	0.015	0.009	0.01

The present investigation revealed that the nitrogen, potassium, sulfur and phosphorus content in rice plant tissue gradually decreased with time as supply of these nutrients from soil became lower. Nitrogen content in plant straw was higher with the treatment application of rice hull and saw dust (T_4, T_5, T_6 and T_7) as they add organic matter in turn, nitrogen to the soil. The value of potassium was found to be much higher with gypsum (T_2 and T_3) due to lowering of sodium content of soil as the ionic radii of calcium is greater than sodium but less than potassium and may be due to selective uptake of potassium by plant for stomata growth or to maintain turgidity. Saw dust also increased potassium content of rice but at the latter stages of growth, after the completion of their decomposition. Sulfur content in plant straw was higher with the treatment application of gypsum (T_2 and T_3) as they added sulfur to the soil. Phosphorus content in plant straw was higher with the treatment application of gypsum (T_2 and T_3) as application of gypsum creates optimum pH condition for the availability of phosphorus. Nitrogen uptake was highest with the application of saw dust and rice hull as they are an important source of nitrogen. Potassium, sulfur and phosphorus uptake was higher with gypsum and saw dust application at highest dosages due to favorable condition created by them for nutrient availability of plant.

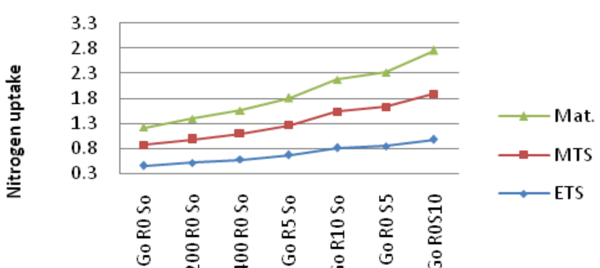

Fig 1: N uptake per pot (capacity 6kg soil) in rice plant tissue at different stages of growth influenced by gypsum, rice hull and saw dust

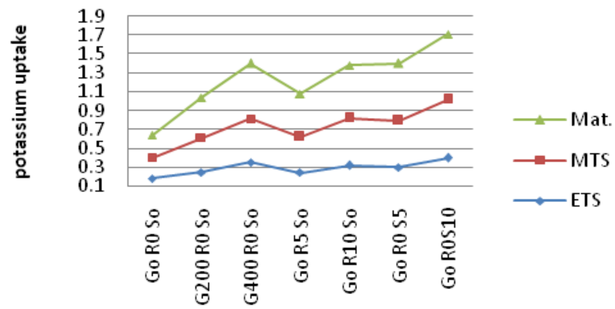

Fig 2: Potassium uptake per pot (capacity 6kg soil) in rice plant tissues at different stages of growth influenced by gypsum, rice hull and saw dust

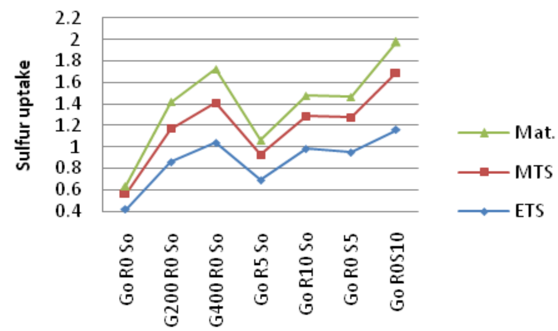

Fig 3: Sulfur uptake per pot (capacity 6kg soil) in rice plant tissues at different stages of growth influenced by gypsum, rice hull and saw dust

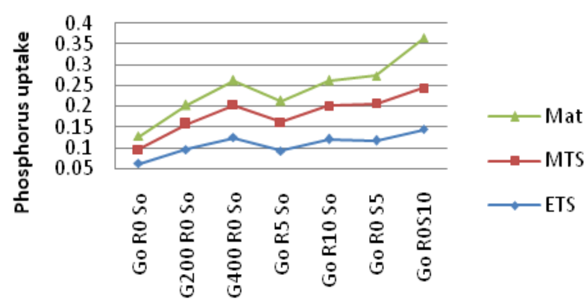

Fig 4: Phosphorus uptake per pot (capacity 6kg soil) in rice plant tissue at different stages of growth influenced by gypsum, rice hull and saw dust

4. CONCLUSION

The results obtained from the present research studies are encouraging and suggestive. Accordingly, the findings of the studies are: Application of rice hull and saw dust was found to be effective in improving the adverse effect of salinity on yield performance of rice. Again the application of gypsum, rice hull and saw dust were found to improve nitrogen, phosphorus, potassium and sulfur nutrition of rice. The findings suggest that the substantial research is still essential to work out the elevated doses of gypsum, rice hull and saw dust to minimize the adverse effects of salinity in a cost-effective way. Again, sustainable use of gypsum, rice hull and saw dust as the ameliorating agents for the production of rice under saline environments and their residual effects should be checked. The ability of the amending materials for salt removal and adaptability by farmers i.e., socio-economic considerations should also be kept in mind before recommendation.

5. REFERENCES

1. Karim Z, SG Hussain, M Ahmed. Salinity Problems and Crop Intensification in the Coastal Regions of Bangladesh. Soils Publication no.33, BARC, 1990. pp.63.
2. Kumar V, Shriram V, KaviKishor PB, Jawaliand N, MG Shitole. *Plant Biotech. Rep*, 2010; **4**:37-48.
3. Tavakkoli E, Fateh F, Coventry S, Rengasamy P, McDonald GK. *J. Exp. Bot,* 2011; **62:**2189-2203.
4. Food and Agricultural Organization (FAO). Global network on integrated soil management for sustainable use of salt-affected soils. FAO Land and Plant Nutrition Management Service, Rome, Italy, 2005.
5. Munns R. *New Phytol.* 2005; **167**:645-663.
6. Pitman MG, Lauchli A. Global impact of salinity and agricultural ecosystems. In: Salinity: Environment-Plants Molecules. Lauchli, A. and V. Luttge (eds.). Kluwer, Dordrecht, The Netherlands, 2002. pp: 3–20.
7. Munns R, James RA, Läuchli A. *J. Exp. Bot*, 2006; **57**:1025-1043.
8. Rout NP, Shaw BP. *Plant Sci,* 2001; **160**:415-423.
9. Amezketa EA, Aragues R, Gazol R. *Agron. J*, 2005; **97:**983-989.
10. Hanay A, Buyuksonmez F, Kizilolu FM, Canbolat MY. *Compost Sci. and Utilization*, 2004; **12(2)**:175-179.
11. Mace JE, Amrhein C, Oster GD. *Arid Soil Research and Rehabilitation*, 1999; **13**:171-188.
12. Khan MJ, Comparison of various sulfur containing amendments on the growth of tomato grown in sodic soil and DTPA extractable micronutrients. MS Thesis. Univ. Arizona,Tucson, USA, 1992.
13. Zahow FM, Amrhein C. *Soil Sci. Soc. Am. J*, 1992; **56**:1257-1260.
14. Chapman HD. Cation Exchange Capacity. *In*: Method of Soil Analysis, Part 2, (Black CA Ed.), American Society of Agronomy. Inst. Pub., Madison, WI, USA, 1965. pp.891-900.
15. Jackson MI .Soil Chemical Analysis. Prentice Hall of India Pvt. Ltd., New Delhi, 1973.
16. Peavy SH, Rowe DR, George T. Environmental Engineering. McGraw-Hill Book Co., Singapore, 1985.
17. Black CA. Methods of Soil Analysis. Part II. American Society of Agron Inc. Madison, Wisconsin, USA, 1965.
18. Olsen SR, CV Cale and FS Watanabe and LA Dean. Estimation of Available Phosphorus in Soils by Extraction with Sodium Bicarbonate. USDA Circ. 939, Washington, USA, 1954.
19. Pratt PF. Methods of Soil Analysis (Black CA Ed.) Am. Soc. Agron. Madison, Wisconsin, USA, 1965.pp.1022.
20. Richards LA (Ed.). Diagnosis and Improvement of Saline and Alkali Soils, USDA Handbook No. 60, U.S. Govt. Print. Office, Washington, D.C, 1954. pp.84,98 and 156.
21. Hesse PR. A Text Book of Soil Chemical Analysis, John Murray Publ., London, 1971.