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USE OF SOIL AMENDMENTS FOR IMPROVING RICE YIELDS UNDER SUBSURFACE DRAINAGE IN SALINE SODIC SOIL IRRIGATED WITH BRACKISH WATER

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Impact of soil amendments and brackish water on yield of three varieties of rice provided with bamboo subsurface drainage in a saline sodic soil was investigated. The yield of grain decreased significantly with the increase of brackishness of irrigation water subjected to both subsurface drainage and non-drainage conditions irrespective of treatments and varieties. Application of cowdung and straw alone produced higher yield significantly under non-drainage condition while no significant difference in yield was observed subjected to bamboo subsurface drainage situation, BR3 and Iratom 24 behaved equally under non-drained condition, while subsurface drainage was provided, BR3 produced highest yield. Application of gypsum in the presence of organic matters (cowdung and straw) produced higher yield at low brackish water irrigation. The performance of all the varieties in lime treated soil was found to be comparatively lower than that of gypsum treated ones but better than that of addition of straw only.

Keywords: Brackish water; Rice; Saline sodic soil; Soil amendments.

Introduction

The coastal and offshore areas of Bangladesh comprises saline, saline sodic and acid saline soils. The areas are mostly monocropped during monsoon with wet land rice yielding poor output. Many investigators used organic matter from different sources and got encouraging yield of rice[1-3]. However, organic matter has a short term impact and could not be considered as a soil reclaimer for long. On the other hand, a number of investigators worked to counter balance the injurious impact of salinity by the addition of gypsum and lime[4-5]. Moreover, informations are also available on leaching of saline soil followed by addition of organic matter and gypsum to improve the yield[5] and they showed that leaching has profound influence on yield whether other treatments are included or not. However, the experiments were mostly done in the green house. In the field subsurface drainage may be installed for keeping the water table well below the root zone[6]. Rice cultivars differ widely in their susceptibility to salt injury[7] and thus use of salt resistant variety could be one of the approach for potential utilization of saline soil. In coastal areas, quality water is meagre but medium (EC 2.5 dSm^{-1}) and high (EC 5.0 dSm^{-1}) brackish irrigation water is abundant in shallow or deep tube wells. Therefore, an experiment was designed to evaluate the effect of organic matter, gypsum and lime on yield of three cultivars of rice grown in a saline sodic soil irrigated with different grades of brackish water under subsurface drainage and non drainage conditions.

Materials and Methods

The experiment was conducted in saline sodic soil (Ece 4.6 dSm^{-1}; pH 8.5; ESP 17.5) at Benerpota of Satkhira district. The land was divided into blocks, two non drainage and the other two for subsurface drainage. Then each block was divided into three subblocks for irrigation with three grades of brackish water. Each subblock was further subdivided into three plots for two sources of organic matters and zero organic matter. Each plot was again divided into three split plots for gypsum, lime and without gypsum and lime. These split plots were further subdivided into three strips for three varieties of rice. The size of each strip plot was 4 m^2. The treatments used were as follows:

Brackish irrigation water (EC iw) : Low (0.7 dSm^{-1}); medium (2.5 dSm^{-1}) and high (5.0 dSm^{-1}),

Organic matters (OM): OM_o = Organic matter (0 t ha^{-1}),

CD = Cowdung (10 t ha^{-1}) and Str = Straw (10 t ha^{-1})

Gypsum (G) and Lime (L): G_oL_o = Gypsum and lime (0 t ha^{-1})

$G_{0.5}$ = Gypsum (0.5 t ha^{-1}) And $L_{0.5}$ = Lime (0.5 t ha^{-1})

Rice cultivars : BR3, BR15 and Iratom 24.

A total of 81 treatments were arranged according to 3^4 factorial strip plot design with two replications. Each subblock was separated by 2 metre buffer zone and each plot was surrounded by a 1 m wide ridge. PK (80:60 kg ha^{-1}) and one third of N (90 kg ha^{-1}) was applied as basal dose and the rest two third of N was top dressed in two equal splits, one at 30 days after transplantation (DAT) and the rest at 60 DAT. The organic matters were added 7 days prior to transplantation and kept at field moisture condition. Gypsum and lime were applied on the surface soil at the time of final land preparation. Thirty five days old healthy seedlings were transplanted as three seedlings in each hill spaced at 20 cm x 20 cm. The experimental blocks were irrigated with water of EC 1.2 dSm^{-1} during land preparation and also a 10 days more after transplantation (survival stage) followed by submergence of 2-5 cm standing water.

Table 1. Influence of brackish water, organic matter, gypsum and lime on grain yield of rice (t ha^{-1}) in bamboo subsurface drained and non drained soils.

A. Effect of brackish irrigation water.

Brackish irrigation water (ECiw DSm^{-1})		Non drained	Subsurface drained
Low (0.7)		4.21	4.71
Medium (2.5)		3.17	3.61
High (5.0)		2.19	2.66
	L.S.D (0.05)	0.08	0.44

B. Effect of organic matters.

Organic matter (0t ha^{-1})		3.00	3.40
Cowdung (10 t ha^{-1})		3.78	3.85
Straw (10 t ha^{-1})		3.20	3.70
	L.S.D (0.05)	0.20	0.23

C. Effect of gypsum and lime.

Gypsum and lime (0 t ha^{-1})		3.15	3.66
Gypsum (0.5 t ha^{-1})		3.30	3.67
Lime (0.5 t ha^{-1})		3.12	3.65
	L.S.D (0.05)	0.11	NS

D. Effect of rice cultivars.

BR3		3.19	3.76
BR15		3.10	3.62
Iratom 24		3.20	3.60
	L.S.D. (0.05)	0.08	0.14

Table 2. Influence of organic matters, gypsum and lime on grain yield (t ha^{-1}) of rice in non-drained soil irrigated with brackish waters.

Brackish irrigation Water (ECiw dSm^{-1})		Low (0.7)			Medium (2.5)			High (5.0)		
(t ha^{-1})	Varieties	G_0L_0	$G_{0.5}$	$L_{0.5}$	G_0L_0	$G_{0.5}$	$L_{0.5}$	G_0L_0	$G_{0.5}$	$L_{0.5}$
	BR3	3.80	4.31	4.17	3.08	3.03	3.17	1.97	1.90	2.10
OM_0	BR15	4.03	4.09	3.86	2.79	3.39	2.90	2.10	1.92	1.76
	Iratom24	3.47	4.51	3.91	2.96	3.05	2.66	2.12	2.10	2.14
	BR3	4.70	4.52	3.67	3.59	3.76	2.98	2.32	2.34	2.31
CD_{10}	BR15	4.50	4.23	4.45	3.08	3.25	3.36	2.27	2.43	2.27
	Iratom24	4.52	4.56	4.38	3.78	3.69	3.23	2.28	2.38	2.29
	BR3	3.89	4.48	4.01	3.03	3.51	2.53	2.31	2.31	2.29
Str_{10}	Br15	4.14	4.20	4.08	3.18	3.46	2.76	2.16	2.28	2.08
	Iratom24	4.45	4.65	4.51	3.00	3.08	3.39	2.15	2.19	2.24

L.S.D. (0.05) = 0.21

Table 3. Influence of organic matters, gypsum and lime on grain yield (t ha^{-1}) of rice in subsurface drained soil irrigated with brackish waters.

Brackish irrigation Water (ECiw dSm^{-1})		Low (0.7)			Medium (2.5)			High (5.0)		
(t ha^{-1})	Varieties	G_0L_0	$G_{0.5}$	$L_{0.5}$	G_0L_0	$G_{0.5}$	$L_{0.5}$	G_0L_0	$G_{0.5}$	$L_{0.5}$
	BR3	4.50	4.92	4.36	3.52	3.54	3.13	2.60	2.63	2.12
OM_0	BR15	4.17	4.16	4.20	2.94	3.54	3.45	2.66	2.64	2.77
	Iratom24	4.34	4.88	4.62	3.05	3.07	3.32	2.41	2.45	2.15
	BR3	5.31	5.60	5.02	3.69	4.03	3.89	2.86	2.88	2.77
CD_{10}	BR15	4.60	4.78	4.53	4.13	4.12	3.91	2.90	2.81	2.92
	Iratom24	4.60	4.90	5.35	4.34	3.26	3.77	2.86	2.97	2.88
	BR3	4.84	5.08	4.71	3.67	3.85	3.87	2.85	2.87	2.74
Str_{10}	Br15	4.45	4.48	4.64	3.78	3.85	3.62	2.73	2.14	2.73
	Iratom24	4.67	4.78	4.64	3.71	3.59	3.79	2.87	2.92	2.58

L.S.D. (0.05) = 0.1

Installation of subsurface drainage : For installation of subsurface drainage, trenches were made manually to a depth of 0.75 m and with a spacing of 2 m. Uniform bamboos were selected. The average internal diameter of the bamboo was 65 mm. The bamboos were splited into two equal halves longitudinally. Internal nodes were carefully removed and half was bored (0.5 mm dia.) at an interval of 15 cm in a single line and the halves put together again and tied by nylon rope. A nylon net was used to cover the bamboo logs for protection against entrance of foreign materials into the log.

Prepared bamboo logs were then placed on the ready trenches in such a way so that perforated halves remain on the top side with a slope of 0.1% and rice straw was spread around the logs. Cutout soils were replaced in the same order as was dugout. For consolidation of the fill soils, surface irrigation was given manually with water of EC 1.2 dSm^{-1}. The drainage logs were connected to outlet placed at 1m depth from the surface.

Result and Discussion

Results showed that the grain yield of rice declined significantly with the increase of brackishness of irrigation water both under subsurface drainage and non-drainage situations irrespective of treatments and varieties (Table 1A). Under non-drained condition, the yield decreased about 25% and 48% at medium and high brackish water respectively while 23% and 43% retardation was recorded under same situation provided with bamboo subsurface drainage as compared with low brackish water irrigated plots.

The yield of rice was generally higher in subsurface drained soil in comparison with non-drained soil resulting 12,14 and 21% higher yield at low medium and high brackish water respectively (Table 1A, 2-3). The adaptation of bamboo subsurface drainage has proven more effective when irrigation water was more brackish (ECiw 0.7 to 5.0 dSm^{-1}). The results are in good accord with the findings of Aich *et al.*[8] where preleaching simulated the subsurface drainage condition. Investigators working in this field[9-11] are in opinion that good subsurface drainage has been found to be prerequisite in overcoming and reclaiming saline soils. The application of cowdung and straw alone produced significantly higher yield of rice (Table 1B). The yield increased roughly by about 26 and 7% under non-drainage and 13 and 9% under subsurface drainage conditions due to addition of cowdung and straw respectively.

Application of gypsum alone produced higher yield of rice significantly under non-drainage condition (Tables 1C and 3). However, when subsurface drainage was provided, no significant difference in yield was observed. Contrary to this, Saravanan *et al.*[12] found higher yield of rice in saline sodic soil due to addition of organic matter and gypsum whether provided with leaching or not. Due to unavailability of salt resistant varieties, three non salt resistant cultivars of rice used did not vary widely among themselves (Table 1D). Under non-drained condition, BR3 and Iratom 24 behaved equally whereas when subsurface drainage was provided, BR3 produced highest yield.

In non drainage (ND) provision but having low brackish water irrigation (ECiw 0.7 dSm^{-1}) was found to be better than others (Table 2). Nevertheless, application of gypsum in the presence of straw produced higher yield of the varieties and maximum yield (4.65 $t\ ha^{-1}$) was recorded by Iratom 24 having irrigation with low brackish water. When lime was added in the presence of straw the some variety produced the highest yield (4.51 $t\ ha^{-1}$). The performance of all the varieties in lime treated soil was found to be comparatively lower than that of gypsum treated ones but better than that of addition of straw only.

In medium brackish water application of gypsum and lime was of no use. Instead of increase, the yield rather decreased. However, impact of gypsum/lime in the presence of cowdung was apparent and all the varieties gave more or less increased yield (Table 2). In the presence of cowdung alone, BR3 and Iratom 24 produced almost equal yield (3.59 and 3.78 $t\ ha^{-1}$) but BR15 produced significantly lower yield (3.08 $t\ ha^{-1}$) than the others. However, when cowdung was applied with gypsum the yield of BR3 and BR15 increased (3.75 and 3.25 $t\ ha^{-1}$) only.

In high brackish water irrigated plots, all the varieties behaved almost equally when cowdung was applied alone or in combination with gypsum or lime. The soil provided with subsurface drainage did not help to increase rice production irrespective of varieties and treatments at low brackish water irrigation in comparison with plots without drainage facility. However, in the saline water irrigated soils, the increase in yeild is quite notable and distinctly better than those of non drained plots (Table 3).

Application of gypsum/lime influenced the yield of the three varieties sporadically but virtually gypsum/lime has been found not very much effective. However, gypsum appears to be better than lime. Generally yield of rice decreased when lime alone was applied irrespective of varieties and quality of irrigation waters. The soil under study is alkaline in nature (ph>8) and the addition of lime in conjunction with Na^+ (saline water) might have increased the pH which in turn impeded the sulpher content of it which might have reduced the pH of the soil thus making congenial situation to some extent. It is apparent that the subsurface drainage has facilitated the increase in yield in all cases, that is cowdung or cowdung with Ca containing materials did not help in any way. Straw alone and in combination with lime/gypsum is rather parallel to cowdung in conjunction with lime/gypsum when low brackish water was used. Medium and high brackish water irrigation also behaved in similar way.

Subsurface drainage alone and in various combinations of gypsum and cowdung gave signifcantly higher yield of rice of all the varieties. The effectiveness of the treatments increased with the brackishness of irrigation water (EC 0.7 to 5.0 dSm-1) irrespective of the varieties. It is worth mentioning that in saline sodic soil subsurface drainage is one of the reasons to increase crop yield. The effectiveness of subsurface drainage would increase if supplemented with the ameliorating agents.

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