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Effects of Sulphur, Zinc and Boron Supplied from Chemical Fertilizers and Poultry Manure to Wetland Rice (Cv. BRRI Dhan 30)

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Abstract: A field experiment was conducted to study the effects of S, Zn and B supplied from chemical fertilizers and poultry manure on yield and nutrient uptake by rice (cv. BRRI Dhan-30). There were ten treatments:- T_0, T_1, T_2, T_3, T_4, T_5, T_6, T_7, T_8 and T_9. The rate of different nutrients were 100 kg N ha^{-1} from urea, 30 kg P ha^{-1} from TSP, 60 kg K ha^{-1} from MP, 20 kg S ha^{-1} from gypsum, 2 kg Zn ha^{-1} from zinc oxide, 1 kg B ha^{-1} from borax and 4 t poultry manure ha^{-1}. The experiment was laid out in randomized complete block design with 3 replications. The different nutrients significantly increased plant height, effective tillers $hill^{-1}$, filled grains $panicle^{-1}$, 1000-grain weight, grain and straw yields of rice. The highest grain yield of 4850 kg ha^{-1} was obtained when S, Zn and B were applied together with NPK fertilizers (T_8) which was comparable to the yields obtained when S, Zn or B were applied singly or in combination of two with NPK fertilizers (T_2, T_3, T_4, T_5, T_6 and T_7) and also with the application of poultry manure with reduced NPK application (T_9). The concentrations and uptake of N, P, K and S by grain and straw were higher when poultry manure was used as a source of S, Zn and B with reduced amount of NPK(T_9). It appears that application of S, Zn and B along with NPK is essential in this soil to get maximum yield of BRRI Dhan-30. If poultry manure can be applied @ 4 t ha^{-1} the use of NPK can be reduced and S, Zn and B fertilizers may not be needed.

Key words: Sulphur, zinc, boron, rice, yield, nutrient uptake

Introduction

Nutrient stresses in Bangladesh soils are increasing day by day. Over the years, the Bangladesh Agriculture has experienced with an area of multiple nutrient deficiencies. Before 1980s deficiency of NPK was a major problem but thereafter along with NPK, deficiency of S, Zn and B came up (Jahiruddin *et al.*, 1992; Islam *et al.*, 1990, 1996, 1997, 1999; Islam and Hossain, 1993; Khanam *et al.*, 2001). Continuous use of chemical fertilizers accelerates the depletion of soil organic matter and impairs physical and chemical properties of soil in addition to micronutrient deficiencies. Poultry manure contains high amount of secondary and micronutrients in addition to N, P and K. When poultry manures are applied to the fields, it may supply sufficient amount of S, Zn and B to meet up the demand for the growth of rice plants. Chemical fertilizers are always expensive inputs for crop production, especially in a developing country like Bangladesh. The use of poultry manure and its proper management may reduce the need for chemical fertilizers allowing the small farmers to save part of the cost of crop production. Hence the present study was conducted to determine the effects of sulphur, zinc and boron supplied from chemical fertilizers and poultry manure on yield and nutrient uptake rice.

Materials and Methods

The experiment was conducted at the Soil Science Field Laboratory of Bangladesh Agricultural University, Mymensingh during the aman season from August to December 1999. The soil was silt loam in texture having pH 6.46, organic matter 1.45%, total nitrogen 0.09%, available sulphur 9.4 ppm, available zinc 1.7 ppm, available boron 0.25 ppm and CEC 16.4 me/100 g soil. The ten treatments were-T_0 ($N_0P_0K_0S_0Zn_0B_0$), T_1($N_{100}P_{30}K_{60}S_0Zn_0B_0$), T_2 ($N_{100}P_{30}K_{60}S_{20}Zn_0$ B_0), T_3 ($N_{100}P_{30}K_{60}S_0Zn_2B_0$), T_4 (N_{100} $P_{30}K_{60}S_0Zn_0B_1$), T_5 ($N_{100}P_{30}K_{60}S_{20}Zn_2B_0$), T_6 ($N_{100}P_{30}K_{60}S_{20}Zn_0B_1$), T_7 ($N_{100}P_{30}K_{60}S_0$ Zn_2B_1), T_8 ($N_{100}P_{30}K_{60}S_{20}Zn_2B_1$) and T_9 ($N_{57.3}P_{4.8}K_{36.5}$ + Poultry manure 4 t ha^{-1}). The different nutrients were 100 kg N from urea, 30 kg P from TSP, 60 kg K from MP, 20 kg S from gypsum, 2 kg Zn from zinc oxide, 1 kg B from borax and 4 t poultry manure ha^{-1} respectively. On oven dry basis, poultry manure had 1.78% N, 1.05% P, 0.98% K, 0.51% S, 160 ppm Zn and 48 ppm B. The rest 42.7 kg N, 25.2 kg P and 23.5 kg K ha^{-1} was expected to release after decomposition from 4 t poultry manure (fresh weight). The treatments were laid out in randomized complete block design. The full dose of poultry manure was applied to the plots one week before transplanting. Nitrogen from urea was applied in three equal splits to all the plots except control plots. The first split was applied during final preparation and remaining at 30 and 60 DAT of rice. The healthy seedlings of 35 days old were transplanted in the experimental plots on 21st August 1999. The seedlings were spaced 25 × 15 cm^2. Three seedlings were transplanted $hill^{-1}$. Intercultural operation such as weeding was done as and when necessary. The crop was harvested at maturity on 16th December 1999. Observations were made on yield and yield components. Along with yield components, data on chemical analysis of grain and straw were recorded by acid digestion method (Page *et al.*, 1989). Nutrient uptake by grain and straw was calculated from nutrient concentration (%) multiplied by respective yields.

Results and Discussion

Yield components: The application of manures and fertilizers showed a positive effect on the yield components of rice (Table 1). Plant height, effective tillers $hill^{-1}$, filled grains $panicle^{-1}$ and 1000-grain weight responded significantly due to different treatments. However, their effect was not significant on panicle length of rice. The tallest plant (107.07 cm) was found when poultry manure with reduced NPK (T_9) was applied and was statistically identical to those found when S, Zn or B was applied singly or in combination of two or three with NPK fertilizers. The shortest plant (90.3 cm) was found in control treatment (T_0) without any fertilizer or manure application. All the treatments produced significantly higher number of fertile tillers $plant^{-1}$ over control treatment (T_9). The highest number of effective tillers $plant^{-1}$ (12.5) was found when S, Zn and B were applied with NPK fertilizers and was statistically identical to those found with all other treatments except control treatment. The number of filled grains panicle was significantly increased by the addition of S, Zn or B from chemical fertilizers or poultry manure. The highest number of filled grains $panicle^{-1}$ (99.9) was found when S, Zn and B were supplied from chemical fertilizers along with NPK application. This result was statistically identical to those found when S, Zn or B were applied singly or in combination of two and also from poultry manure with reduced amount of NPK application. Thousand-grain weight of rice was significantly influenced by the addition of S, Zn or B supplied either from fertilizer or manure. The highest 1000-grain weight (24.4 g) was found when S, Zn and B were applied from chemical fertilizers with NPK (T_8) and was identically followed when poultry manure and reduced NPK (T_9) was added to soil. The application of S, Zn

Table 1: Effect of poultry manure and fertilizers on yield components of rice (BRRI Dhan 30)

Treatments	Plant height (cm)	Effective tillers hill^{-1}(no.)	Panicle length (cm)	Filled grains panicle^{-1}(no.)	1000-grain weight (g)
T_0	90.30c	8.40b	20.80	84.27c	21.30f
T_1	101.50b	11.00a	23.00	88.27bc	22.40e
T_2	103.40ab	11.90a	23.47	94.30ab	23.50cd
T_3	102.67ab	11.87a	23.60	94.60ab	23.50cd
T_4	102.70ab	11.60a	23.20	92.50ab	23.10d
T_5	106.37ab	12.30a	23.90	99.27a	23.87bc
T_6	105.30ab	12.00a	23.70	97.80a	23.70c
T_7	105.10ab	11.60a	23.93	96.30a	23.80c
T_8	107.00a	12.50a	24.20	99.90a	24.40a
T_9	107.07a	12.30a	24.23	99.40a	24.30ab
CV	2.63	7.40	NS	4.00	1.18

In a column the figure(s) having same letter(s) do not differ significantly at 5% level of probability; CV = Coefficient of variation, NS = Not significant

Table 2: Effects of poultry manure and chemical fertilizers on yield of rice (BRRI Dhan 30)

Treatments	Grain yield (kg ha^{-1})	Yield increase over control (kg ha^{-1})	Yield increase over control(%)	Straw yield (kg ha^{-1})	Yield increase overcontrol (kg ha^{-1})	Yield increase over control (%)
T_0	3038c	-	-	4717d	-	-
T_1	4258b	1220	40	5250cd	533	11
T_2	4633ab	1595	53	6633ab	1916	41
T_3	4558ab	1520	50	5983bc	1266	27
T_4	4542ab	1504	49	6233a-c	1516	32
T_5	4817a	1779	59	6483a-c	1766	37
T_6	4750a	1712	56	6483a-c	1766	37
T_7	4606ab	1568	52	6283a-c	1566	33
T_8	4850a	1812	60	7133ab	2416	51
T_9	4800a	1762	58	7350a	2633	56
CV	5.48	-	-	10.51	-	-

In a column the figure(s) having same letter(s) do not differ significantly at 5% level of probability; CV = Coefficient of variation, NS = Not significant

Table 3: Correlation matrix among the plant characters of rice (cv. BRRI Dhan 30)

Characters	Plant height	Effective tillers hill^{-1}	Panicle length	Field grams panicle^{-1}	1000-grain weight	Straw yield
Plant height						
Effective tillers plant^{-1}	0.69*					
Panicle length	0.58 ^{NS}	0.49 ^{NS}				
Grams panicle^{-1}	0.65*	0.57 ^{NS}	0.46 ^{NS}			
1000-grain weight	0.73*	0.80 **	0.52 ^{NS}	0.80**		
Straw yield	0.64*	0.63 ^{NS}	0.53 ^{NS}	0.68*	0.71*	
Grain yield	0.76*	0.83**	0.46 ^{NS}	0.68*	0.85**	0.66*

* = $P<0.05$; ** = $P<0.01$; NS = Not significant

Table 4: Effect of poultry manure and fertilizers on N. P, K, S and Zn uptake by rice (BRRI Dhan 30)

Treatments	Total N uptake (kg ha^{-1})	Total P uptake (kg ha^{-1})	Total K uptake (kg ha^{-1})	Total S uptake (kg ha^{-1})	Total Zn uptake (kg ha^{-1})
T_0	58.80f	14.32d	53.51f	5.62e	0.14g
T_1	77.55e	20.63c	69.41e	8.04d	0.18f
T_2	89.63b-d	26.01b	87.77b-d	11.22bc	0.23e
T_3	85.56de	20.52c	74.40de	10.00cd	0.28cd
T_4	87.28cd	23.57c	78.26c-e	10.00cd	0.22ef
T_5	93.68a-d	22.59c	79.89c-e	10.61bc	0.34ab
T_6	91.83a-d	22.91c	88.68bc	10.70bc	0.23e
T_7	88.57a-c	22.28c	78.14c-e	10.76bc	0.25de
T_8	97.97ab	28.03ab	95.88ab	12.96ab	0.37a
T_{10}	100.21a	30.28a	102.08a	14.80a	0.31bc
cv	5.91	6.5	9.19	11.89	6.90

In a column the figure(s) having same letter(s) do not differ significantly at 5% level of probability; cv = coefficient of variation.

or B applied singly or in combination of two significantly increased the 1000-grain weight compared to that when NPK was applied only. Application was S, Zn and B recorded the highest seed weight of rice which was statistically identical to that found when poultry manure was applied with reduced NPK fertilizers. These two treatments were significantly superior to other treatments in recording the 1000-seed weight of rice.

Yield: Grain yield of rice responded significantly due to the application of different nutrients (Table 2). The application of NPK (T_2) significantly increased the grain yield of rice compared to the control treatment (T_0). The application of S, Zn or B with NPK increased the grain yields of rice compared to that obtained with NPK application but such increase was not statistically significant. The application of S+Zn and S+B with NPK significantly increased the grain yields compared to that obtained with NPK application.

The highest grain yield of 4850 kg ha^{-1} was found in T_8 treatment and was statistically similar to those found in T_9, T_7, T_6, T_5, T_4, T_3 and T_2 treatments. It is evident that poultry manure supplied sufficient amount of S, Zn and B to rice plants reflecting in terms of grain yield. Grain yield was significantly correlated with plant height (r = 0.76*), effective tillers hill^{-1} (r = 0.83*), filled grains panicle −1 (r = 68*) and 1000-grain weight (r = 0.85*) (Table 3). The application of nutrients revealed a significant effect on straw yield of rice. The application of S, Zn and B alone or in combination with S could not significantly increase in straw yield compared that found in NPK application. The highest straw yield was found in T_9 was comparable to all other treatments except T_3, T_1 and T_0. Rajput and Warsi (1992) found that the application of organic manure and chemical fertilizers increased straw yield of rice. Islam *et al.* (1997) observed that application of S + Zn + B gave the highest grain yield of autumn rice with 41.8% yield increase over control. Zhang *et al.* (1996) showed that combined application of organic and inorganic fertilizers increased rice yield.

Nutrient uptake: The uptake of nitrogen, phosphorus, potassium, sulphur and zinc by rice was significantly influenced by different treatments (Table 4). Total N uptake ranged from 58.8 to 100.21 kg ha^{-1}. The highest N uptake was found when poultry manure was added with reduced amount of NPK application (T_9) and was statistically identical to those found in T_5, T_6, T_7 and T_8 treatments. The treatments T_2, T_3, T_4, T_5 and T_6 were statistically similar in respect of total N uptake. The lowest N uptake (58.8 kg ha^{-1}) was found in control treatment (T_0) receiving none of the nutrient elements added. Khanam *et al.* (2001) reported that poultry manure application in combination with urea fertilizer increased the total nitrogen uptake of rice. Total P uptake by rice differed significantly among the treatments. The highest total P uptake was found in T_9 treatment which was identically followed by T_8. The treatment T_2 was comparable to that of T_8 treatment in terms of total P uptake. All other treatments except T_0 were statistically alike in recording total P uptake. Total K uptake by rice ranged from 53.51 kg ha^{-1} in T_0 treatment to 102.08 kg ha^{-1} in T_9 treatment. The highest K uptake in T_9 treatment was comparable to that of T_8 treatment. The treatments T_8, T_6 and T_2 were statistically identical in total K uptake by the crop. The treatment T_2 was comparable to T_4, T_5, T_6 and T_7 treatments. The treatments T_7, T_1 and T_0 were also statistically identical. Total S uptake by rice ranged from 5.62 kg ha^{-1} in T_0 treatment to 14.80 kg ha^{-1} in T_9 treatment. The highest total S uptake observed in T_9 treatment was statistically similar to that found in T_8 treatment. The treatments T_8, T_7, T_6, T_5 and T_2 were statistically similar with respect to total S uptake. The treatments T_4, T_3 and T_1 treatments were also similar and higher than T_0 treatment. Islam *et al.* (1990) reported that S application increased total S uptake in rice. Total Zn uptake by rice varied from 0.14 kg ha^{-1} in T_0 treatment to 0.37 kg ha^{-1} in T_8 treatment. The highest total Zn uptake was observed in T_8 treatment which was statistically similar to that found in T_6 treatment. The treatments T_7, T_6, T_5, T_3 and T_2 were statistically similar but higher than T_0 treatment. Higher uptake of Zn by rice due to application of Zn was reported by Islam *et al.* (1997).

Results obtained from this study showed that for efficient transplant aman rice production, an application of S, Zn and B along with NPK is essential. If poultry manure is available and can be applied @ 4 t ha^{-1} the use of S, Zn and B fertilizers may not be needed.

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