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EFFECT OF SULPHUR AND ZINC ON GROWTH, YIELD AND NUTRIENT UPTAKE OF BORO RICE (CV. BRRI DHAN 29)

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ABSTRACT

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The experiment was conducted at Bangladesh Agricultural University, Mymensingh farm during 2004 Boro season to evaluate the effect of S and Zn on rice (cv. BRRI dhan29). There were seven treatments viz. S_0Zn_0, $S_{10}Zn_0$, $S_{20}Zn_0$, $S_0Zn_{1.5}$, S_0Zn_3, $S_{10}Zn_{1.5}$ and $S_{20}Zn_3$. The subscripts of S and Zn represent the dose in kg ha^{-1}. The highest grain (5.76 t ha^{-1}) and straw (7.32 t ha^{-1}) yields were recorded in the $S_{20}Zn_3$ treatment (100% recommended dose). The S_0Zn_0 (control) had the lowest grain yield with 4.35 t ha^{-1} as well as the lowest straw yield with 5.47 t ha^{-1}. The application of both S and Zn fertilizers significantly increased S and Zn contents as well as their uptake over control.

Key word: Sulphur and Zinc, Growth, BRRI dhan29

INTRODUCTION

Agriculture in Bangladesh is dominated by intensive rice cultivation covering about 80% of arable land and the most dominant cropping pattern is Boro-T.Aman rice. Out of total rice production in this country about 48%, 45% and 7% come from boro, aman and aus crop, respectively (BBS, 2000).

Nutrient stresses in Bangladesh soils are increasing day by day. Before 1980's, deficiency of NPK was a major problem in Bangladesh soils, and thereafter along with NPK, deficiency of S and Zn are frequently reported (Islam *et al*., 1986; Islam & Hossain, 1993; Hoque & Jahiruddin, 1994). Sulphur deficiency has been recognized in many areas of Bangladesh which roughly covers 44% of the total cropped area (Hossain, 1990). The use of almost S free fertilizers such as urea and TSP may be an important reason for widespread occurrence of S deficiency problem. Hoque and Jahiruddin (1994) suggested this element would be applied in every rice crop.

Depletion of soil fertility is a major constraint for sustainable crop production in Bangladesh. As our soils are deficit in NPK with S and Zn, necessary study should be done to grow rice successfully and profitably. On the other hand, continuous application of large amounts of micronutrients can be toxic to the plants. If plant nutrients are not supplied in an adequate amount with an appropriate proportion, high yielding crop varieties under intensive cropping may fail to express their full potential. Considering above points, the present study was undertaken with an objective of evaluating the single and combined effects of S and Zn on boro rice (cv. BRRI dhan29).

MATERIALS AND METHODS

The experiment was conducted at the farm of Bangladesh Agricultural University, Mymensingh, (Old Brahmaputra Floodplain, and AEZ 9) during 2004. The crop under study was Boro rice. The experiment was laid out in a randomized complete block design (RCBD) with four replications. The unit plot size was 5m × 3m. There were seven treatments with various combinations of S and Zn doses with an equal rate for N, P and K. The treatments combination were $T_{1:}$ S_0Zn_0 (control), $T_{2:}$ $S_{10}Zn_0$, T_3: $S_{20}Zn_{0,}$ T_4: $S_0Zn_{1.5}$, T_5: $S_0Zn_{3,}$ T_6: $S_{10}Zn_{1.5,}$ T_7: $S_{20}Zn_{3.}$

Fertilizers such as urea, TSP, MP, gypsum and ZnO were used as sources for N, P, K, S and Zn, respectively. One-third dose of urea and the full dose of all other fertilizers were applied as basal to the individual plots during final land preparation. The second split of urea was applied 35 days after transplanting i.e. at maximum tillering stage and the third split 60 days after transplanting i.e. at panicle initiation stage (BRRI, 1990).

The sprouted seeds of Boro rice were sown in the seedbed on 7 December 2003 Seedlings were transplanted in the experimental plots on 25 January 2003. The spacing of transplanting was 20 cm × 20 cm, and three seedlings were transplanted in each hill.

The normal cultural practices including weeding and insecticide spray were done as and when required. After transplanting, 5-6 cm water was maintained in each plot throughout the growth period.

Data were recorded on plant height (cm),no. of effective tillers/hill, panicle length(cm), grains/panicle ,1000 grain wt.(g), grain yield (t/ha), straw yield(t/ha) and biological yield(t/ha).

Soil samples from the experimental field before the start of the experiment were collected from ten different random spots from a depth of 0-15 cm. The soil samples were mixed thoroughly to make a composite sample and the unwanted materials such as stubbles, stones, weeds, etc. were removed from soil. The soil samples were air-dried, ground, and sieved through a 2 mm (10 meshes) sieve. The composite sample was stored in a clean container for physical and chemical analysis.

The initial soil sample was analyzed for soil texture, pH, organic matter, total N, available S and Zn contents. The textural class was determined following Marshall's triangular coordinate using USDA system. Soil pH was measured with the help of a glass electrode pH meter, the soil-water ratio being 1: 2.5. Organic carbon content of soil was determined following wet oxidation method (Page *et al.*, 1982). Total N content in soil was determined by Kjeldahl method. Available S content was determined by extracting soil sample with $CaCl_2$ (0.15%) solution as described by Page *et al.* (1982). Available S content was determined by extracting soil sample with $CaCl_2$ (0.15%) solution as described by Page *et al.* (1982). The results are presented in Table 1.

Table 1. Physical and chemical characteristics of initial soil of experimental field

Characteristics	Experimental field	
	Content	Interpretation
pH (soil: water = 1: 2.5)	6.9	Slightly acidic
Organic matter (%)	1.92	Medium
Total N (%)	0.09	Low
Available S (µg g^{-1})	10.0	Low
Available Zn (µg g^{-1})	0.70	Low
Textural class	Silt loam	

Plant analysis was conducted. Nitrogen, sulphur and zinc elements were determined. The analysis of variance for various crop characters and also for nutrient concentration and uptake were done following the principle of F-statistics. Mean comparisons of the treatments were adjudged by the Duncan's Multiple Range Test (Gomez and Gomez, 1984).

RESULTS AND DISCUSSION

Effects of S and Zn on growth and yield parameters of rice

Plant height

The height of Boro rice plant was significantly affected due to application S and Zn (Table 2). Apparently, the tallest plant was observed in $S_{20}Zn_3$, the recommended dose of S and Zn (BARC, 1997), which was superior to all other treatments. The shortest plant was recoded in S_0Zn_0 (control). Plant height due to different treatments varied from 84.95 to 96.58 cm. Significant effect of S and Zn on plant height of rice has also been observed by many others in the past (Tejasarwana, 1991; Salam and Subramanian, 1993; Uddin *et al.*, 1997).

Effective tillers hill^{-1}

The effective tillers were appreciably increased due to addition of S and Zn particularly when used at the recommended rate (Table 2). The number of tillers hill^{-1} due to different treatments varied from 7.6 to 12.1. The maximum tiller (12.1) was recorded in $S_{20}Zn_3$ which was superior to all other treatments and the lowest in control receiving neither S nor Zn. Islam *et al.* (1996) also reported a significant increase in tillering of BR11 rice at BAU farm and at farmer's field in Melandha by applying 20kg S ha^{-1}. Tejasarwana (1991) also observed increased tiller number due to the application of Zn.

Panicle length

Panicle length responded significantly to S and Zn application (Table 2). The treatment containing 100% of the recommended dose of S and Zn produced the highest result (25.26 cm) and the control did the lowest (22.73 cm). Panicle length was approximately similar among treatments except the control. The present study is in partial agreement with the results reported by Balakrishnar and Natarajaratnam (1986).

Thousand grain weight

The weight of 1000 grains did not vary significantly with various treatments. The 1000-grain weight followed the order $T_4>T_2>T_7>T_5>T_3>T_6>T_1$ (Table 2). The grain weight varied from 23.56 to 24.89 g over the treatments. Hossain *et al.* (1997) reported that micronutrient deficiency might limit the grain yield of rice by reducing tillering and grain formation, but not affecting the weight of individual grain.

Table 2. Effect of S and Zn on grain and yield components of Boro rice (cv. BRRI dhan29)

Treatment	Plant height (cm)	No. of effective tillers/hill	Panicle length (cm)	Grains panicle^{-1}	1000 grain wt (g)
T_1: S_0Zn_0	84.95 d	7.60 c	22.73 d	126.3 c	23.56
T_5: $S_{10}Zn_0$	89.74 bcd	10.13 b	24.05 abcd	144.1 ab	24.54
T_2: $S_{20}Zn_0$	93.33 ab	11.11 ab	25.09 ab	148.2ab	24.93
T_6: $S_0Zn_{1.5}$	85.70 d	10.53 ab	23.26 cd	138.7 b	24.27
T_3: S_0Zn_3	86.56 cd	9.66 b	23.67 bcd	141.0 b	24.49
T_7: $S_{10}Zn_{1.5}$	91.21 bc	9.86 b	24.72 abc	145.7 ab	24.59
T_4: $S_{20}Zn_3$	96.59 a	12.10 a	25.26 a	152.8 a	24.89
SE (±)	1.628	0.573	0.451	2.811	NS
CV (%)	5.14	9.78	3.24	4.42	6.22

Subscripts of S and Zn represent the dose in kg ha^{-1}, Figures having common letter in a column are not significantly different by DMRT at 5% level, SE = Standard error of means; CV = Co-efficient of variation

Effects of S and Zn on grain and straw yields of rice

Grain yield

The grain yield was significantly affected due to application of S and Zn (Table 3). The grain yield varied from 4.35 to 5.76 t ha^{-1}. The highest grain yield was obtained in $S_{20}Zn_3$. The $S_{10}Zn_{1.5}$ which is the 50% of recommended dose produced the intermediate grain yield (4.95 t/ha). Grain yield was higher in $S_{20}Zn_3$ compared to other treatments due to higher production of effective tillers hill^{-1} and increased number of grains panicle^{-1}. A number of researchers reported that S and Zn contribution gave significantly higher yield than control (Hoque *et al.* 1994; Akter *et al.* 1994; Mandol *et al.* 1998). Islam *et al.* (1997) observed that application of 20kg S ha^{-1} increased grain yield of BR11 rice by 34% and the application of 5kg Zn ha^{-1} increased the yield by 15%.

Straw yield

Like grain yield there was a significant and positive effect of S and Zn on straw yield of Boro rice (Table 3). The straw yield varied between 5.47 and 7.32 t ha^{-1} with the highest yield obtained in $S_{20}Zn_3$, the second highest in $S_{20}Zn_0$ and the lowest in S_0Zn_0. Islam *et al.* (1997) reported a significant increase in the straw yield of BR11 rice due to application of S and Zn. It was also seen in the Table 3 that the biological yield of Boro rice varied from 9.82 t ha^{-1} in T_1 (control) to 13.08 t ha^{-1} in $S_{20}Zn_3$.

Table 3. Effect of S and Zn on grain and straw yields of Boro rice (cv. BRRI dhan29)

Treatment	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Biological yield (t ha-1)
T_1: S_0Zn_0	4.35 c	5.47 d	9.82
T_5: $S_{10}Zn_0$	4.73 bc	6.45 abc	11.18
T_2: $S_{20}Zn_0$	5.57 a	7.25 a	12.82
T_6: $S_0Zn_{1.5}$	4.50 bc	5.62 cd	10.12
T_3: S_0Zn_3	4.57 bc	6.14 bcd	10.71
T_7: $S_{10}Zn_{1.5}$	4.95 b	6.53 ab	11.48
T_4: $S_{20}Zn_3$	5.76 a	7.32 a	13.08
SE (±)	0.136	0.274	-
CV (%)	4.79	7.41	-

Subscripts of S and Zn represent the dose in kg ha^{-1}, Figures having common letter in a column are not significantly different by DMRT at 5% level. SE = Standard error of means CV = Co-efficient of variation

Effect of S and Zn on N, S and Zn content in rice

Nitrogen (N)

Nitrogen (N) content in both grain and straw varied due to application of S and Zn supplied from fertilizer (Table 4), however this variation was not significant. The grain N content varied from 1.27 to 1.34% over the treatments (Table 4). The highest N content (1.34%) in grain was found in the $S_{20}Zn_3$. All the treatments showed better effect on N content of rice grain over control. N content in straw ranged from 0.625 to 0.768%, the highest value being in $S_{20}Zn_3$ and the lowest in control. Hoque (1999) reported that application of S and Zn showed a decreasing effect on the N concentration of rice grain while an increasing effect was recorded in case of rice straw.

Sulphur (S)

Application of S and Zn fertilizers significantly increased the S content in both grain and straw (Table 4). The grain S content ranged from 0.086 to 0.107%. The S content of grain was found maximum in $S_{20}Zn_0$ and also in $S_{20}Zn_3$. The second highest value (0.105%) of S content was found in $S_{10}Zn_{1.5}$ which was 50% of the recommended dose. In case of straw the S content varied from 0.087 to 0.107%. The highest value (0.107%) was obtained in $S_{20}Zn_3$ over the control. All the treatments responded better over control. The findings are in conformity with the results reported by Khan *et al.* (1992) and Mandata *et al.* (1994) who noted that concentration of S in rice plant increased with increase rate of S application.

Zinc (Zn)

It appeared that the Zn content in grain varied from 17.35 to 32.51 ppm (Table 4). The highest value was obtained in the $S_{20}Zn_3$ and the lowest value was found in control (S_0Zn_0). All the treatments responded better over control. In case of straw, the Zn content varied from 37.46 to 61.57 ppm. The highest Zn content was observed in $S_{20}Zn_3$. It also showed that all the treatments responded better over control. . Hossain *et al.* (1989) found that Zn concentration in both grain and straw increased considerably due to application of Zn to soil.

Table 4. Effect of S and Zn on N, S and Zn concentrations in grain and straw of Boro rice (cv. BRRI dhan29)

Treatment	N concentration (%)		S concentration (%)		Zn concentration (ppm)	
	Grain	Straw	Grain	Straw	Grain	Straw
T_1: S_0Zn_0	1.27	0.625 d	0.086d	0.071 e	17. 35 d	37.46 d
T_5: $S_{10}Zn_0$	1.30	0.690 bc	0.104 b	0.081 c	26.31 c	49.87 c
T_2: $S_{20}Zn_0$	1.32	0.715 ab	0.107 a	0.084 b	28.69 b	51.17 bc
T_6: $S_0Zn_{1.5}$	1.28	0.653 cd	0.102 c	0.073 e	29.08 b	52.36 b
T_3: S_0Zn_3	1.29	0.678 bcd	0.104 b	0.077 d	32.33 a	61.04 a
T_7: $S_{10}Zn_{1.5}$	1.31	0.700 bc	0.105 b	0.082 bc	29.17 b	60.42 a
T_4: $S_{20}Zn_3$	1.34	0.768 a	0.107 a	0.087 a	32.51 a	61.57 a
SE (±)	NS	0.0057	0.0019	0.0016	0.548	0.696
CV (%)	2.81	1.43	3.28	3.43	3.40	2.26

Subscripts of S and Zn represent the dose in kg ha^{-1}, Figures having common letter in a column are not significantly different by DMRT at 5% level. SE = Standard error of means CV = Co-efficient of variation

Effect of S and Zn on nutrient uptake by rice

Nitrogen uptake

There was a significant effect of the treatments on N uptake by Boro rice (Table 5). The highest N uptake by both grain and straw was observed in the $S_{20}Zn_3$ receiving 100% recommended dose and the lowest N uptake was noted in the control receiving no S or Zn. The total N uptake by the crop (grain + straw) ranged from 91.23 to 133.62 kg ha^{-1} and ranked as $T_4>T_2>T_7>T_5>T_3>T_6>T_1$ over the treatments.

Sulphur uptake

The uptake of S by both grain and straw due to different treatments was significantly influenced. It appeared from Table 5 that $S_{20}Zn_3$ recorded the highest S uptake by grain and straw and S_0Zn_0 (control) did the lowest. The total S uptake ranged between 7.73 and 12.33 kg ha^{-1}. Islam *et al.* (1997) and Poongothai *et al.* (1999) reported that application of S significantly increased S uptake by rice.

Zinc Uptake

There was a significant variation in Zn uptake by both grain and straw due to different rate of S and Zn application. The Zn uptake by rice straw was considerably higher compared to rice grain. Concerning Zn uptake by the crop, the maximum uptake was due to the application of full dose of recommended S and Zn and the minimum was due to no use of S and Zn (Table 5). Such result was equally true for grain and straw. The total Zn uptake was found to vary from 287.77 to 618.09 g ha-1 due to S and Zn treatments. Salam and Subramanian (1988) reported that Zn application increased Zn uptake by plant.

Table 5. Effect of S and Zn on N, S and Zn uptake by Boro rice (cv. BRRI dhan29)

Treatment	N uptake (Kg ha^{-1})			S uptake (Kg ha^{-1})			Zn uptake (g ha^{-1})		
	Grain	Straw	Total	Grain	Straw	Total	Grain	Straw	Total
T_1: S_0Zn_0	55.47 d	35.76 e	91.23	3.73 e	4.00 e	7.73	75.47e	212.30 e	287.77
T_5: $S_{10}Zn_0$	61.68 bc	45.19c	106.87	4.92 c	4.99 d	9.91	124.50d	316.60c	441.13
T_2: $S_{20}Zn_0$	73.89 a	52.02b	125.91	5.98 a	6.08 b	12.06	167.20b	419.42b	586.61
T_6: $S_0Zn_{1.5}$	57.45 d	36.77e	94.22	4.12 d	4.60 d	8.72	128.80d	277.72d	421.65
T_3: S_0Zn_3	58.19 cd	40.24d	98.43	4.60cd	4.75 c	9.35	147.90c	296.18cd	444.05
T_7: $S_{10}Zn_{1.5}$	62.67 b	42.41cd	105.08	5.16 b	5.35 c	10.51	143.90c	342.35 b	471.15
T_4: $S_{20}Zn_3$	77.41 a	56.21a	133.62	6.15 a	6.18 a	12.33	187.40a	430.71 a	618.09
SE (±)	1.291	0.969	-	0.073	0.119	-	4.034	7.153	-
CV (%)	3.50	3.81	-	2.49	4.10	-	5.01	3.78	-

Subscripts of S and Zn represent the dose in kg ha^{-1}, Figures having common letter in a column are not significantly different by DMRT at 5% level. SE = Standard error of means CV = Co-efficient of variation

CONCLUSION

It may be concluded that application of 20 kg S ha^{-1} might be necessary for obtaining satisfactory yield of rice in Old Brahamputra Floodplain soil and application of 3 kg Zn ha^{-1} might give an added benefit.

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