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Effect of Secondary and Micronutrients on the Yield and Nutrient Uptake by BRRI Dhan 32 in the Old Himalayan Piedmont Plain and Tista Meander Floodplain Soil

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Abstract: Two identical field experiments were conducted in the farmer's field at Dinajpur and Rangpur with a view to investigate the requirement of secondary (Ca, Mg and S) and micronutrients (Zn, Cu, B and Mo) for the cultivation of BRRI Dhan-32. There were 12 treatments, Grain and straw yields were significantly reduced by the omission of secondary (Ca, Mg and S) and micronutrients (Zn, Cu, B and Mo) from the complete treatment in both the locations. The treatment comprising secondary and micronutrients gave the highest yield of 4913 and 4732 kg ha^{-1} at Dinajpur and Rangpur locations, respectively while the absolute control produce the minimum yield ((2743 and 2627 kg ha^{-1}). Amongst secondary nutrients, omission of S (T_5) from the complete treatment showed lower yield compared to Ca and Mg missing treatments. Boron and Zn missing plots showed lower yield compared to those of Cu and Mo missing plots. Application of secondary and micronutrients revealed a beneficial effect on yield contributing characters, which in turns resulted in higher grain yield of BRRI Dhan 32.

Key words: Secondary and micronutrient, yield, BRRI Dhan 32

Introduction

Rice is the principal cereal crop of Bangladesh and constitutes about 97 % of the total cereal production (Bari, 1997). The per hectare average yield of the crop is 1.98 tons which is far below the world standard (BBS, 1999). Among the factors that affect crop production, fertilizer is the single most important one that plays a crucial role in yield increase, provided other factors are not too limiting. Today inorganic fertilizers hold to key the success of the crop production systems of Bangladesh agriculture, being responsible for about 50 % of the total production (FRG, 1997). However, the contribution of fertilizers to crop yields may vary depending on many other factors like crop variety, seasons, soil characteristics and management practices.

In the past, the farmers of Bangladesh commonly use only three primary nutrients viz., N, P and K. The importance of secondary (Ca, Mg and S) and micronutrients (Zn, Cu, B and Mo) are almost ignored. Since most of the soils of Bangladesh are low in organic matter content (less than 2%) intensive cultivation of rice on these soils, together with high analysis NPK fertilizers is depleting the soil more rapidly, especially sulphur. Sulphur deficiency has been recognized about 44% oft otal cropped area in Bangladesh. Since S is considered as the fourth major nutrient for plant growth, but in the past it has not been paid much attention to correcting the deficiencies.

Deficiencies of micronutrients with an emphasis to Zn in particular, have been reported in wetland rice soils of Bangladesh (Rahman *et al.*, 1978). It was reported that about 2.0 M hectare of agricultural land is Zn deficient under different agro-ecological zones (AEZ) of Bangladesh. Boron deficiency is reported on some soils and crops (Jahiruddin, 1993, Jahiruddin *et al.*, 1995 ; Mondal *et al.*, 1992; Islam *et al.*, 1997). Boron deficiency may induce grain sterility in rice (Ambak and Tadano, 1991). Approximately 1 M ha of cultivable land in Bangladesh is suspected to have B deficiency problem (Ahmed and Hossain, 1997). Besides Zn and B, deficiencies of other micronutrients may also occur in Bangladesh due to high cropping intensity. Significance response of Mo application has been reported in the Brahmaputra Floodplain soils of Bangladesh (Ahmed, 1982). Soils high in metal oxides (sesquioxides) have low Mo availabilities (Miller and Donahue, 1997).

Higher crop yield naturally have higher requirement of nutrients due to more pressure on the land for available forms of nutrients. Thus balance fertilization along with management practices play a key role in sustaining higher yields of crops under different cropping patterns and also can preserve soil health on a long term basis. Hence, a pragmatic step should be taken for balance application of fertilizer with the limiting nutrient elements whenever necessary.

The present investigations were undertaken in the farmer s field of Rangpur and Dinajpur to assess the effect of secondary (Ca, Mg and S) and micronutrients (Zn, Cu, B and Mo) application on the yield and nutrient uptake by BRRI Dhan 32 rice (*Oryza sativa*) for increase sustainable yield.

Materials and Methods

Two identical field experiments were conducted in the farmer's field at Dinajpur (Old Himalayan Piedmont Plain) and Rangpur (Tista Meander Floodplain) soil with a view to investigate the requirement of secondary (Ca, Mg and S) and micronutrients (Zn, Cu, B and Mo) for the cultivation of BRRI Dhan-32 during the T. Aman season of 1999 following the principle of missing element trial. The experimental soil belongs to Zamun series under Old Himalayan Piedmont Plain in Dinajpur and Gangachara series under Tista Meander Floodplain soil in Rangpur. The important physico-chemical characteristics of the experimental soils are presented in Table 1. The experiment was laid out in a Randomized Complete Block Design having 12 treatments with three replications per treatment. The treatments were as N P K S Ca Mg, Zn, Cu, Mo, B (complete), Complete- S Ca Mg Zn Cu Mo B, Complete- S, Ca, Mg, Complete-Zn Cu Mo B, Complete-S, Complete-Ca, Complete-Mg, Complete-Zn, Complete-Cu, Complete-Mo, Complete-B and all missing (absolute control). The rate of N, P, K, S, Ca, Mg, Zn, Cu, Mo and B were 75, 15, 45, 15, 28, 15, 5, 2.5, 1.5 and 2 kg ha^{-1} as urea, diammonium phosphate, muriate of potash, sulphur powder, CaO, MgO, zinc oxide, $CuSO_4 5H_2O$, ammonium molybdate and boric acid, respectively. The entire fertilizers except nitrogen (urea) were applied at the time of final land preparation. Nitrogen was applied in three equal splits, the first split with other fertilizers, the second split at tillering stage and the third split prior to panicle initiation

Table 1: Some important characteristics of initial soils

Parameter	Value	
	Dinajpur location (Old Himalayan piedmont plain soil)	Rangpur location (Tista meander floodplain soil)
Texture	Sandy loam	Sandy loam
Organic C (%)	0.80	1.10
Total N (%)	0.05	0.07
Bray P (mg ka^{-1})	24.40	36.90
Exchangeable K (meqv. %)	0.16	0.05
Exchangeable Ca (meqv.%)	2.50	3.10
Exchangeable Mg (meqv.%)	0.99	1.37
Available S (mg ka^{-1})	6.50	6.68
Available Zn (mg ka^{-1})	0.47	0.45
Available Cu (mg ka^{-1})	0.64	1.70
Available B (mg ka^{-1})	0.21	0.22

stage of crop growth. Thirty days old seedlings of BRRI Dhan-32 were transplanted in the experimental plots and were harvested at maturity. Intercultural operation such as weeding, irrigation etc. was done. Ten plants were randomly collected from each plot before harvesting to record the data on yield contributing parameters. Grain and straw yields were recorded plot wise. The plant samples were oven dried at 65° C for 48 h and ground. Plant samples were chemically analyzed to determine S, Ca, Mg, Zn, Cu and B contents following standard analytical methods (Page *et al.*, 1989; Hunter, 1984).

Results and Discussion

The results obtained from the experiment conducted in Dinajpur and Rangpur location responded significantly to the added secondary and micronutrient fertilizers (Table 2 and 4). The highest grain yield of 4913 and 4732 kg ha^{-1} in Dinajpur and Rangpur locations, respectively produced from the complete treatment T_1 (S+Ca+Mg+Zn+Cu+B+Mo). The lowest grain yield was observed in absolute control treatment (T_{12}) in both the locations. The treatment comprising all seven of the secondary and micronutrients (S+Ca+Mg+Zn+Cu+B+Mo) produced 46 and 40% yield increment in Dinajpur and Rangpur, respectively, over treatment T_2 where only NPK were applied. It appeared from the Table 2 and 4 that secondary nutrient (T_3) and micronutrient (T_4) missing treatment from the complete treatment produced significantly decreased yield compared to complete treatment (T_1) in both locations (Fig.1).

Amongst secondary nutrients (S, Ca and Mg), omission of S treatment (T_5) from the complete treatment (T_1) showed lower grain yield of rice compared to Ca and Mg missing treatments. In case of individual effect of micronutrient, Zn and B missing treatments (T_8 and T_{11}) recorded lower grain yield compare to Mo and Cu missing treatments (T_9 and T_{10}) in both locations. The pronounced effect of S and B on grain yield of rice as observed in the present study agrees well with the findings of Abedin *et al.* (1994), Hoque and Khan (1981), Islam *et al.*, (1997), Jahiruddin *et al.* (1992) and Karim (2001).The available S, B and Zn content of the initial soil of both Dinajpur and Rangpur location is low to very low for rice cultivation (FRG, 1997).Therefore, the response of rice to S, B and Zn is quite expected. The omission of S, Mg, Zn and B from the complete nutrients caused yield reduction in Dinajpur by 11.7, 8.67, 10.6 and 12%, respectively and in Rangpur it was 12.45, 4, 5.11 and 8.7 %, respectively (Fig. 1).

Like grain yield, straw yield was also significantly affected by missing of different nutrient elements (Table 2 and 4). The yield of straw varied from 3952 to 6332 kg ha^{-1} in Dinajpur and 3940 to 7098 kg ha^{-1} in Rangpur location depending on the treatment used. The highest yield of 6332 and 7098 kg ha^{-1} in Dinajpur and Rangpur locations, respectively was recorded when all the nutrients were applied, while lowest straw yield of rice was observed in control treatment (T_{12}) in both locations (Table 2 and 4).

Plant height responded markedly to the fertilizer treatments in both Dinajpur and Rangpur locations. The plant height varied from 97.2 cm in T_{12} treatment to 125.0 cm in T_1 (complete) treatment in Dinajpur and 82.7 cm in T_{12} treatment to 100.4 cm in T_1 (complete) treatment in Rangpur location. The omission of secondary and micronutrient (T_2) from the complete treatment (T_1) resulted 7.0 cm shorter plant compared to that obtained in complete treatment (T_1) in Dinajpur and 9.5 cm in Rangpur location. The omission of S, Zn and B from the complete treatment produced significantly shorter plant height compared to that found when all nutrients were added (T_1). Varshney (1988) also reported similar findings for rice.

Panicle length also responded significantly to the fertilizer treatment in both the locations (Table 2 and 4). The panicle length ranged from 22.5 to 25.7 cm in Dinajpur and 20.9 to 23.6 cm in Rangpur location depending on treatments. The longest panicle length was observed in complete treatment (T_1) and the shortest was in control (T_{12}) or T_2 treatment where no secondary and micronutrients were added. The

Table 2: Yield and yield components of BRRI Dhan 32 as influenced by secondary and micronutrient application in Dinajpur location

Treatments	Grain yield (kg ha^{-1})	Straw yield (kg ha^{-1})	Plant height (cm)	Panicle length (cm)	Tillers/hill (no)	Grains/ panicle (no)	1000 seed wt. (g)
T_1=Complete	4913a	6332a	125.0a	25.7a	10.4	133.7a	23.0
T_2=NPK	3373g	5142f	118.0d	23.0de	9.4	105.0de	21.79
T_3=Com.SCaMg	4003f	5153f	120.8bcd	23.9a-e	9.6	110.3cd	22.27
T_4=Com. ZnCuBMo	4130ef	5442e	121.5a-d	23.3cde	10.0	110.0cd	22.86
T_5=Com.-S	4337d	5195f	118.6cd	24.6a-d	10.1	112.9bc	21.59
T_6=Com.-Ca	4713b	5417e	123.0ab	24.9abc	9.7	115.3bc	21.93
T_7=Com.-Mg	4487bc	5750bc	123.0ab	24.6a-d	9.5	113.8bc	21.60
T_8=Com.-Zn	4390d	5642cd	118.1d	25.2ab	10.1	115.3bc	22.07
T_9=Com.-Cu	4743ab	5825b	119.8bcd	23.5b-d	10.4	111.7bcd	22.13
T_{10}=Com.-Mo	4673bc	5708bc	122.2abc	24.1a-e	10.0	119.0b	22.17
T_{11}=Com.-B	4317de	5517de	118.7d	25.5a	9.8	109.3cd	22.07
T_{12}=Control	2743h	3952g	97.2e	22.5e	8.4	98.7e	21.53

The figures having common letter in a column are not significantly different by DMRT at 5% level.

Table 3: Nutrient uptake by rice grain (BRRI Dhan-32) as influenced by secondary and micronutrient application at Dinajpur

Treatments	S (kg ha^{-1})	Ca (kg ha^{-1})	Mg (kg ha^{-1})	Zn (kg ha^{-1})	Cu (kg ha^{-1})	B (kg ha^{-1})
T_1=Complete	3.22a	2.62a	6.87a	107.51a	27.018a	63.84a
T_2=NPK	1.72f	1.33c	6.04e	64.52f	11.44e	32.01e
T_3=Com.SCaMg	2.59cd	2.14b	6.47d	86.01c	15.33d	54.01b
T_4=Com. ZnCuBMo	2.26de	1.65c-e	5.09cd	78.86d	15.01d	45.25c
T_5=Com.-S	2.17e	2.16ab	6.36ab	94.05b	21.96c	52.59b
T_6=Com.-Ca	3.14ab	1.50de	6.28b	99.02b	23.47bc	54.28b
T_7=Com.-Mg	2.69c	2.04bc	5.50c	99.90b	26.07a	52.62b
T_8=Com.-Zn	2.65cd	1.91b-d	5.22cd	71.55e	23.37bc	52.86b
T_9=Com.-Cu	2.70c	2.21ab	6.80ab	96.75b	15.81d	60.77a
T_{10}=Com.-Mo	2.83bc	2.02bc	6.54ab	97.21b	25.23ab	52.69b
T_{11}=Com.-B	2.58c-e	1.86b-d	5.61c	85.59b	22.44c	41.31d
T_{12}=Control	1.41f	1.20e	3.11f	43.23g	9.15f	30.81e

The figures having common letter in a column are not significantly different by DMRT at 5% level

Table 4: Yield and yield components of BRRI Dhan 32 as influenced by secondary and micronutrient application in Rangpur location

Treatments	Grain yield (kg ha^{-1})	Straw yield (kg ha^{-1})	Plant height (cm)	Panicle length (cm)	Tillers/hill (no)	Grains/ panicle (no)	1000 seed wt. (g)
T_1=Complete	4732a	7098a	100.4a	23.6a	11.9a	121.0a	23.67
T_2=NPK	3375f	5060f	90.9g	21.2c	10.7bc	104.1d	22.58
T_3=Com.SCaMg	3820e	6220d	92.8f	22.6ab	10.0ab	107.7b-d	22.49
T_4=Com. ZnCuBMo	4170cd	6660bc	97.2e	22.7ab	10.4b	108.4b-d	22.14
T_5=Com.-S	4143d	5730c	91.8fg	23.4ab	10.9ab	109.5b-d	22.76
T_6=Com.-Ca	4660ab	5990ab	98.9bc	23.0ab	11.5ab	107.5b-d	22.08
T_7=Com.-Mg	4527b	6790a-c	99.4b	23.4ab	10.7bc	115.0ab	22.99
T_8=Com.-Zn	4490b	7080ab	98.8b-d	23.2ab	10.8b	106.9b-d	23.37
T_9=Com.-Cu	4720ab	6975ab	97.8de	22.7ab	11.0ab	112.6a-c	23.23
T_{10}=Com.-Mo	4703ab	7055ab	98.4cd	22.7ab	11.3ab	110.9a-d	22.75
T_{11}=Com.-B	4320c	6480cd	98.4cd	22.4b	11.0ab	105.9cd	23.50
T_{12}=Control	2627g	3940g	82.7	20.9c	9.8c	88.87e	21.93

The figures having common letter in a column are not significantly different by DMRT at 5% level.

Table 5: Nutrient uptake by rice grain (BRRI Dhan-32) as influenced by secondary and micronutrient application at Rangpur

Treatments	S (kg ha^{-1})	Ca (kg ha^{-1})	Mg (kg ha^{-1})	Zn (kg ha^{-1})	Cu (kg ha^{-1})	B (kg ha^{-1})
T_1=Complete	3.94a	3.62a	6.30a	137.51a	50.44a	77.84a
T_2=NPK	2.59e	1.91c	4.15f	87.64f	14.12f	38.79e
T_3=Com.SCaMg	2.67e	2.04c	4.33f	131.30ab	28.47d	60.73c
T_4=Com. ZnCuBMo	3.19d	2.78b	4.84e	100.63e	19.88e	57.08d
T_5=Com.-S	2.62e	2.62b	5.39cd	119.01d	28.89d	66.62b
T_6=Com.-Ca	3.88ab	2.02c	5.66bc	135.90a	36.07c	61.44c
T_7=Com.-Mg	3.62abc	3.01b	5.13de	133.86a	39.08bc	66.14b
T_8=Com.-Zn	3.91ab	3.00b	5.86b	126.86bc	41.80b	60.24c
T_9=Com.-Cu	3.41cd	3.09ab	6.04ab	136.42a	20.16e	68.75b
T_{10}=Com.-Mo	3.76ab	2.98b	5.64bc	135.16a	38.67bc	58.84c
T_{11}=Com.-B	3.60bc	2.83b	4.89e	122.95cd	35.61c	46.61d
T_{12}=Control	1.83f	1.75c	2.71g	74.74g	8.44g	37.15e

The figures having common letter in a column are not significantly different by DMRT at 5%

Table 6a: Correlation matrix (n=10) among the yield components of BRRI Dhan 32 at Dinajpur location

Characters	Grain yield	Straw yield	Panicle length	Tillers/hill	Grains/panicle	100 grains wt.
Grain yield	1					
Straw yield	0.774**	1.000				
Panicle length	0.717**	0.664*	1.000			
Tillers/hill	0.851**	0.771**	0.564NS	1.000		
Grains/panicle	0.701*	0.762**	0.705*	0.652*	1.000	
1000 grain wt.	0.148NS	0.252NS	-0.047NS	0.311NS	0.502NS	1

*, $P<0.05$, ** $P<0.01$, ***, $P<0.001$

NS = not significant

Table 6b: Correlation matrix (n = 10) among the yield components of BRRI Dhan 32 at Dinajpur location

Characters	Grain yield	Straw yield	Panicle length	Tillers/hill	Grains/panicle	100 grains wt.
Grain yield	1					
Straw yield	0.631*	1.000				
Panicle length	0.848**	0.441NS	1.000			
Tillers/hill	0.852**	0.431NS	0.760**	1.000		
Grains/panicle	0.822**	0.286NS	0.814**	0.832**	1.00	
1000 grain wt.	0.576*	0.098NS	0.514NS	0.641*	0.595*	1

*, P<0.05, ** P<0.01, ***, P<0.001
NS = not significant

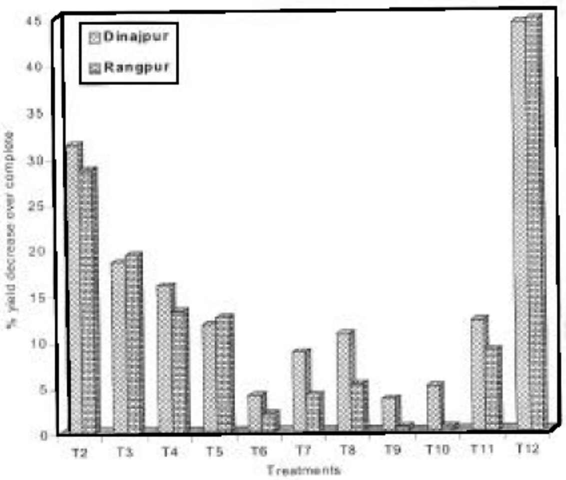

Fig. 1: Percent yield (grain) decrease of BRRI Dhan 32 over complete treatment at Dinajpur and Rangpur

tillers/hill of 8.0 was in control (T_{12}) treatment in Dinajpur. In Rangpur location significantly highest number of tillers /hill of 11.9 was noted in complete treatment (T_1) and the lowest number of fertile tillers/hill of 9.8 was in control (T_{12}) treatment. Treatment T_2 where no secondary and micronutrients were added observed lower number of tillers /hill compared to complete treatment (T_1).

fertilizer treatment significantly increase the production of fertile tillers /hill of rice plant in Rangpur, however in Dinajpur the fertile tillers /hill of rice was insignificant (Table 2 and 4). The highest number of fertile tillers /hill of 10.5 was observed in complete treatment (T_1) and lowest number of fertile Like other yield components, the different nutrients significantly affect the number of filled grains /panicle of BRRI Dhan 32 in both the locations (Table 2 and 4). The number of filled grains /panicle varied from 98.7 in T_{12} treatment to 133.7 in complete treatment (T_1) in Dinajpur and 88.9 in T_{12} treatment to 121 in complete treatment (T_1) in Rangpur location. The omission of secondary nutrient (T_3) and micronutrient (T_4) from complete treatment (T_1) produced significantly lower grains/panicle in both Dinajpur and Rangpur locations.

The added nutrients did not significantly increase 1000 grains weight of BRRI Dhan 32 (Table 2 and 4). The highest 1000 grains weight of 23.02 and 23.7 g were found in T_1 treatment and lowest weight of 21.53 and 21.93 g in T_{12} (control) at Dinajpur and Rangpur location, respectively. The result indicates that the secondary and micronutrient were not limiting for the translocation of carbohydrate from the photosynthetic organs (leaf and stem) to the grains.

The uptake of S, Ca, Mg, Zn, Cu and B by rice grain was significantly influenced by different treatments. The lowest uptake of S, Ca, Mg, Zn, Cu, and B were recorded in control treatment (T_{12}) and the highest uptake in complete treatment (T_1) in both locations. The uptake of S, Ca, Mg, Zn, Cu, and B by rice grain ranged from 1.41-3.22 kg ha^{-1}, 1.20-2.62 kg ha^{-1}, 3.11-6.87 kg ha^{-1}, 43.23-107.51 g ha^{-1}, 9.15-27.01 g ha^{-1}, and 30.81-63.84 g ha^{-1}, respectively at Dinajpur (Table 3) and 1.83-3.94 kg ha^{-1}, 1.75-3.62 kg ha^{-1}, 2.71-6.30 kg ha^{-1}, 74.74-137.51 g ha^{-1}, 8.44-50.44 g ha^{-1}, and 37.15-77.84 g ha^{-1}, respectively in Rangpur location (Table 5).

Correlation statistics was done (Table 6a and 6b) to examine the interrelationship among the yield and yield components. The values of correlation coefficient indicated that grain yield was dependent on grains/panicle (r = 0.70*; $P \leq 0.05$, 0.82**; $P \leq 0.01$), panicle length (r = 0.72**; $P \leq 0.01$, 0.85**; $P \leq 0.01$) and tillers/hill (r = 0.85**; $P \leq 0.01$, 0.85**; $P \leq 0.01$). Grain yield was also significantly correlated with straw yield (r = 0.77**; $P \leq 0.01$, 0.63* ; $P \leq 0.05$). Overall results, thus, suggested that application of secondary and micronutrients especially S, Mg, Zn and B along with NPK is necessary for obtaining satisfactory yield of BRRI Dhan 32 in sandy loam soil.

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