YIELD RESPONSE OF BORO AND T. AMAN RICE TO NPKS FERTILIZERS IN HIGH GANGES RIVER FLOODPLAIN SOIL

S. M. ZAMAN[1], M. R. AMIN[2], D. A. CHOUDHURY[3], R. U. CHOUDHURY[4] and M. I. HOSSAIN[5]

[1]On-Farm Research Division, Bangladesh Agricultural Research Institute (BARI), Khulna, [2]Farm Division, [3]On-Farm Research Division, [4]Plant Genetic Resources Center, [5]Statistics Section, BARI, Gazipur-1701, Bangladesh.

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ABSTRACT

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The experiment was conducted at farmer's field of Kalaroa under Satkhira district, during three consecutive years of Boro and T. Aman season of 2001 to 2003 to determine the response and to find out the optimum rate of nutrients (NPKS) for Boro (Brri dhan-28) and T. aman (Brri dhan-30) rice to NPKS on the yield under AEZ 11. Four different levels of NPKS were assigned in RCB design with 4 dispersed replications. Average of three years study reveals that a considerable response of Boro and T. aman rice to NPKS was observed. However, the response to N and P was more distinct in comparison to K and S. Similarly, the response was more evident in Boro rice compared with T. aman rice. Yield of Boro rice increased upto the application of 140, 35, 20 and 20 kg/ha of NPK and S, respectively. But in T. aman yield was increased upto the application of 95, 20, 20 and 15 kg/ha of NPK and S, respectively. From the regression analysis it was found that the relationship was almost quadratic in nature. The optimum rate of NPKS for Boro rice was 130-25-20-15 kg/ha, respectively whereas for T. aman rice it was 90-15-15-10 kg/ha of NPKS, respectively.

Key words: Boro, T. aman, NPKS fertilizer and high Ganges river floodplain

INTRODUCTION

The major cropping pattern in Bangladesh agriculture mostly consist of rice based cereal crops (Haque 1998). More than 60% of the total cropped area covered by Boro-T.aman rice cropping pattern in Bangladesh (FRG 1997). This is the dominant cropping pattern in medium high land area of Khulna region under high Ganges River floodplain (AEZ 11). The area and production of HYV Boro rice in Khulna region was 111134 ha and 342470 tones; meanwhile HYV T. aman rice was 184673 ha and 465840 tones, respectively (BBS 2004). Soil fertility and productivity changes over time and this change is towards negative direction because of intensive cropping with modern varieties, improper and imbalance use of fertilizer and manure (BARC 2005). Again crops grown in different cropping patterns and environment responded differently to fertilizer nutrients. Mineral fertilizer inputs are the crucial factors to the overall nutrient balance in intensive cropping systems (Islam *et al.* 1998). Fertilizer recommendation for crops in a cropping pattern of a particular AEZ needs change after a certain period of time. Application of imbalance fertilizer to individual crop commonly found among the farmers of Khulna region is detrimental to soil. Some of the nutrients like P, K, S and Zn have residual effect and it should be considered for a judicious and economic fertilizer management. The application of fertilizer in proper amounts must be done to boost up agricultural production to an economically desirable level. Hence, the present study was carried out to determine an economically optimal dose of fertilizer nutrients for Boro-T.aman rice cropping pattern at Satkhira under AEZ11.

MATERIALS AND METHODS

The experiment was conducted at farmer's field of multilocation testing site (MLT), Kalaroa under Satkhira district during 2001, 2002 and 2003. The land type was medium high land with 8.1 pH. The experimental plot of onion was laid out in randomized complete block design with four dispersed replications. The variety was BRRI dhan-28 for Boro and BRRI dhan-30 for T. aman rice.The unit plot size was 5m x 3m. The initial soil organic matter was 1.88%. The total N was 0.092%. P, K and S level were 4.80, 0.22 and 13.21 microgram gm^{-1} soils, respectively (Appendix table 1). Four different levels of N, P, K and S for Boro and T.aman rice was tested based on the soil analysis are shown in Table 1. The experiment was initiated with Boro rice (Var. BRRI dhan-28). Forty days old seedlings were transplanted during 21-24 January with a spacing of 25cm X 15cm and harvested during the last week of April. Thirty days old seedlings of T.aman rice (var. BRRI dhan-30) were transplanted during 4-6 August with a spacing of 20cm X 15cm and were harvested during the last week of November. Fertilizer doses were calculated according to original soil status of the experimental plots using Fertilizer Recommendation Guide 1997. The entire quantity of P, K, S and Zn were applied as basal dose at the time of final land preparation and N was applied in three equal splits as top dress at 15 DAT, at maximum tillering stage and before panicle initiation stage. The source of NPK and S were Urea, TSP, MP and Gypsum, respectively. Weeding was done at 20 DAT and 40 DAT. Furadan and Diazinon 60 EC were applied to control insect pests. Data on yield and yield attributes were recorded and analyzed statistically. Regression analysis was done and the optimum and economic dose of fertilizer nutrients were calculated using the formula $Y = - b/2c$ and $Y= 1/2c (Pf/Py-b)$, respectively from the response curve (Gomez and Gomez 1984).

Table 1. Different nutrient doses for Boro-T. aman rice cropping pattern

Level	Nutrient (Kg/ha) for Boro				Level	Nutrient (Kg/ha) for T. aman			
	N	P	K	S		N	P	K	S
1	0	0	0	0	1	0	0	0	0
2	100	25	20	10	2	65	15	15	10
3	140	35	30	20	3	95	20	20	15
4	195	45	40	30	4	130	30	30	20

RESULTS AND DISCUSSION

Effect of NPKS on Boro rice

Effect of different levels of NPKS on the yield of Boro rice is shown in Table 2. Grain yield influenced significantly due to different rates of nutrients. However, the trend was not same over the years. During 2000-2001, yield increased significantly over control treatment but it was identical to 100, 140 and 195 kg N/ha. But significantly the highest grain yield was obtained with 140 kg N/ha and yield was decreased less or beyond that level during 2001-02 and 2002-03. Average of three years data showed that grain yield increased considerably with the increase of nitrogen up to 140 kg ha^{-1} and tended to decline after that. About 84% yield increased with 140 kg N/ha over control and it was 42 and 48% for 100 and 195 kg N/ha, respectively. Tanaka (1986) reported that excess nitrogen gave higher dry weight around heading simultaneously becomes low, causing a yield decline due to reduced ripening percentage. Fertilization with P at the rate of 25, 35 and 45 kg/ha did not differ significantly (Table 2).

Table 2. Yield of Boro rice as affected by different levels of nutrients

Nutrient levels (kg/ha)	Grain yield (t/ha)			Mean (t/ha)	% Yield increase over control
	2000-2001	2001-2002	2002-2003		
N level					
0	3.51b	3.00c	2.79c	3.10	-
100	5.41a	4.51b	3.29b	4.40	42
140	5.90a	5.75a	5.45a	5.70	84
195	5.50a	4.80b	3.50b	4.60	48
CV%	11.48	12.05	10.90		
P level					
0	4.70b	4.70b	4.13b	4.51	-
25	5.50a	5.51a	4.98a	5.33	18
35	5.90a	5.75a	5.45a	5.70	26
45	5.61a	5.40a	4.89ab	5.30	18
CV%	10.81	11.90	11.25		
K level					
0	5.58b	5.11b	3.82b	4.92	-
20	6.11a	5.92a	5.52a	5.85	19
30	5.90a	5.75a	5.45a	5.70	16
40	5.60ab	5.30ab	4.79ab	5.23	6
CV%	11.0	10.85	12.05		
S level					
0	5.16a	4.92b	4.23b	4.77	-
10	5.63a	5.51a	5.15a	5.43	14
20	5.90a	5.75a	5.45a	5.70	19
30	5.75a	5.52a	4.48ab	5.25	10
CV%	10.90	12.20	11.92		

Table 3. Yield of T. aman rice as affected by different levels of nutrients

Nutrient levels (kg/ha)	Grain yield (t/ha)			Mean (t/ha)	% Yield increase over control
	2000-2001	2001-2002	2002-2003		
N level					
0	3.90c	3.21b	2.34b	3.15	-
65	5.40b	4.70a	3.70a	4.60	46
95	6.21a	5.25a	4.17a	5.21	65
130	5.51a	4.91a	3.98a	4.80	52
CV%	11.58	11.30	12.05		
P level					
0	4.95b	4.67b	3.91a	4.51	-
15	5.63a	5.15a	4.55a	5.11	13
20	6.21a	5.25a	4.17a	5.21	16
30	5.50a	5.10a	4.19a	4.93	9
CV%	10.95	11.50	11.92		
K level					
0	5.85a	4.85a	3.40b	4.70	-
15	6.25a	5.18a	4.05a	5.16	10
20	6.21a	5.25a	4.17a	5.21	11
30	6.00a	5.00a	3.49ab	4.8	2
CV%	12.03	11.90	11.58		
S level					
0	5.60a	4.71a	3.55b	4.62	-
10	6.00a	5.00a	4.30a	5.10	10
15	6.21a	5.25a	4.17a	5.21	13
20	6.13a	5.07a	3.65ab	4.95	7
CV%	11.85	11.59	11.25		

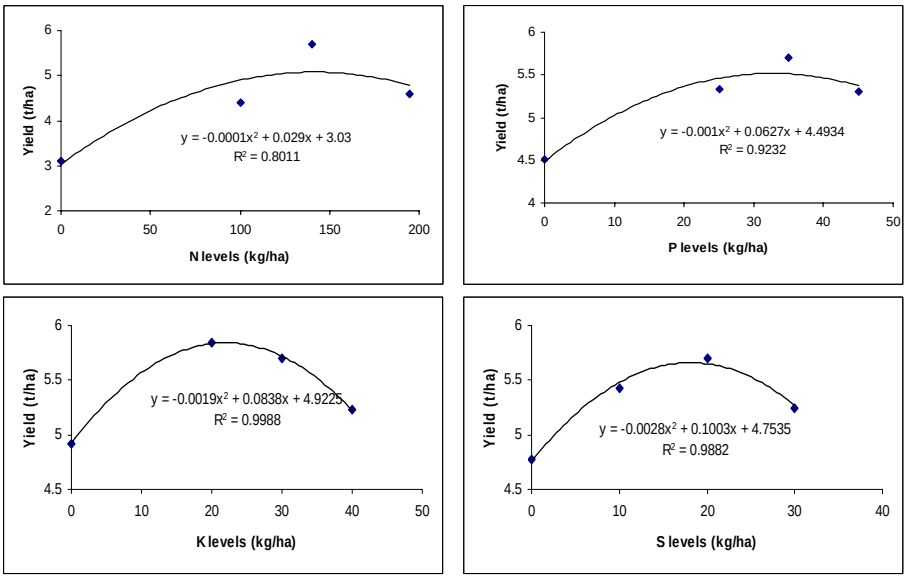

Fig. 1. Response of Boro rice to N, P, K, and S at Kalaroa, Satkhira

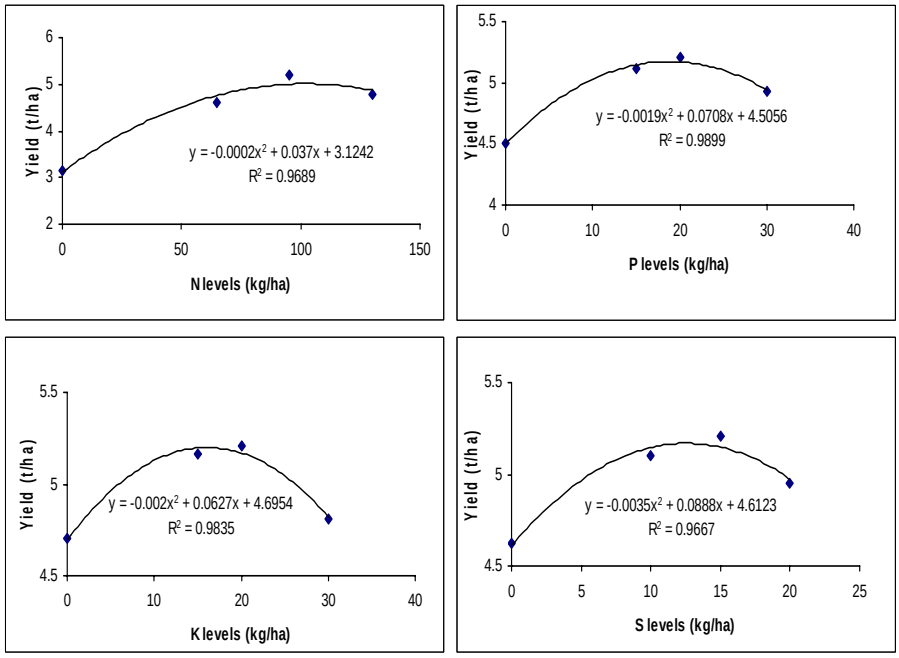

Fig. 2. Response of T. aman rice to N, P, K, and S at Kalaroa, Satkhira

Almost similar trend was observed over the years. Average of three years data showed that yield increased by 26% over control upto application of 35 kg P/ha. However, about 18% yield increased with 25 and 45 kg P/ha over control. It might be due to very low status of phosphorus in the soil and Boro rice responded positively in yield increment at a higher dose of P. Abedin *et al.* (1998) reported that the general recommended dose of P fertilizer for rice in Bangladesh is 25 kg/ha and the frequency of P fertilizer application might vary from no application for several seasons to application in every year. Response of Boro rice to potassium was observed to some extent. However, yield was identical with 20, 30 and 40 kg K/ha. More or less similar trend was found over the years. The highest yield increment (19%) over control was obtained with 20kg K/ha and the rate of increment was decreased with the further increase of K. Initial status of K in the experimental field was medium, therefore, response to added K was not very distinct. Singh *et al*. (1985) did not found significant response due to potassium alone and combination with phosphorus due to high available status of potassium in the experimental soil. A considerable response to added S was observed. Grain yield increased significantly upto application of 10 kg S/ha and after that level yield did not increased significantly. During 2000-01, no significant yield difference was observed even with control treatment. On an average 19% yield increased with

20kg S/ha over control and it was 14% for 10kg S/ha. Islam and Bhuiyan (1993) reported that to achieve yield target of rice fertilization with S along with N, P and K fertilization is extremely important especially in S–deficient soils.

Effect of NPKS on T. aman rice

Effect of different levels of NPKS on the yield of T.aman rice is shown in Table 3. The highest yield was obtained with 95 kg/ha, which was also identical with 65 and 130kg N/ha during 2001-02 and 2002-03. But in 2000-01, it was identical with 130 kg N/ha. Average of three years data showed that the highest yield (5.2 t/ha) was obtained from 95 kg N/ha. About 65 % yield increased with 95 kg N/ha over control and it was 46 and 52% for 65 and 130kg N/ha, respectively. Grain yield of T.aman rice did not differ significantly among 15, 20 and 30 kg P/ha. However, the yield was higher with 20 kg P/ha. Almost similar trend was observed over the years. Average of three years data showed that higher yield was obtained with 20 and 30 kg P/ha and about 16% and 13% yields increased with 20 and 30 kg P/ha, respectively over control. Beyond 20kg P/ha yield did not increased appreciably. Response of T. aman rice to K was not observed at all. Yield did not differ significantly among the different levels of K, even with control. But during 2002-03, significantly higher yield was recorded with 15 and 20 kg K/ha. Average of three years data showed that higher yield was recorded from 15 and 20 kg K/ha and yield increased about 10 and 11%, respectively over control. Response of T. aman rice to S was not prominent. Yield did not differ significantly among the different levels of S, even with control. But during 2002-03, significantly higher yield was recorded with 10 and 15 kg S/ha. Average of three years data showed that higher yield was recorded from 10 and 15 kg S/ha and yield increased about 10 and 13 %, respectively over control. Beyond that level yield was decreased.

Table 4. Response function of Boro to N, P, K and S for rice yields (average of 3 years).

Nutrient	Regression equation	R2	Optimum rates of nutrient (kg/ha)	Maximum yield (t/ha) at optimum level of nutrient
N	Y=3.03+0.029x-0.0001x2	0.80	131	5.14
P	Y=4.4934+0.0627x-0.001x2	0.92	27	5.47
K	Y=4.9225+0.0838x-0.0019x2	0.99	19	5.85
S	Y=4.7535+0.1003x-0.0028x2	0.98	16	5.65

Table 5. Response function of T. aman to N, P, K and S for rice yields (average of 3 years).

Nutrient	Regression equation	R2	Optimum rates of nutrient (kg/ha)	Maximum yield (t/ha) at optimum level of nutrient
N	Y=3.1242+0.037x-0.0002x2	0.96	90	4.83
P	Y=4.5056+0.0708x-0.001x2	0.98	16	5.17
K	Y=4.6954+0.0627x-0.002x2	0.98	14	5.19
S	Y=4.6123+0.0888x-0.0035x2	0.96	11	5.18

Regression analysis

Regression analysis of Boro and T.aman rice yield on an average of 3 years was done to fit the quadratic functions for estimating the optimum levels of each nutrient over the different levels of NPKS/ha (Fig. 1 and Fig. 2). Dobermann *et al.* (2000) stated that the optimal rate of fertilizer application to a crop is that rate which produces the maximum economic returns at the minimum cost, and this can be derived from a nutrient response curve. The large and significant R^2 value in case of K and S of regression for Boro and in case of NPKS of regression for T. aman indicates that the quadratic response fitted the data. Response curve shows that yield increased with the increasing of nutrients at certain level and thereafter yield was decreased. Fig. 1 shows that yield of Boro rice increased with increasing level of fertilizer nutrients to a certain limit and then decreased with further increase of nutrients level. But the increment of yield was prominent in case of N and the highest yield (5.70 t/ha) was obtained from 140 kg/ha. P has distinct effect on the yield. The highest grain yield (5.70 t/ha) was obtained from 35 kg P/ha. Application of 20 kg/ha of K produced the highest yield (5.85 t/ha) and further application of K yield began to decrease. The reason might be medium P status in soil (Appendix table-1). From the regression equations for Boro (Table 4), the agronomically optimum levels of NPKS/ha were estimated as 145-31-22-18 and the economically optimum fertilizer doses were 131-27-19-16 kg/ha for maximum yield of 5.14, 5.47, 5.85 and5.65 t/ha, respectively. Fig. 2 shows that yield of T. aman rice increased with increasing level of fertilizer nutrients to a certain level and then decreased with further increase of nutrients level. But the yield increment was prominent in case of N and the highest yield (5.21 t/ha) was obtained from 95 kg/ha. Similar trend was observed with P. From the regression equation for T. aman rice (Table 5), the agronomically optimum levels of NPKS/ha were estimated as 92-35-16-13 kg/ha and the economically optimum fertilizer doses were 90-16-14-

11 kg NPKS/ha for maximum yield of 4.83, 5.17, 5.19 and 5.18 t/ha respectively. The economically optimal doses were less than the optimal agronomic dose that was economically viable at Kalaroa, Satkhira during the experimentation years.

The cumulative result indicated that fertilizer dose that maximized yield of Boro rice was 145-31-22-18 kg NPKS/ha and 92-35-16-13 kg NPKS/ha for T. aman rice while 131-27-19-16 kg NPKS/ha was profitable for Boro and 90-16-15-12 kg NPKS/ha for T. aman in respect of yield and economics. The present recommended dose is relatively lower but judicious that ensures higher yield than that of farmer's traditional practices; and it will be helpful to improve soil health for sustainable higher yield. So, 131-27-19-16 kg NPKS/ha for Boro and 90-16-15-11 kg NPKS/ha for T.aman rice could be proposed for recommendation in high Ganges river floodplain area under AEZ 11a.

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REFERENCES

Abedin, M. J. and Saleque, M. A. 1998. Effects of phosphorus fertilizer management on phosphorus sorption characteristics of lowland rice soil. Thai J. Agric. Sci. 31(1): 122-129.

BARC. 2005**.** Bangladesh Agricultural Research Council. Farmgate, Dhaka. p. 260.

BBS (Bangladesh Bureau of Statistics) 2004. Yearbook of Agricultural Statistics. Ministry of planning. Govt. of the people's republic of Bangladesh.

Dobermann, A. and Fairhurst, T. 2000. Economics of fertilizer use. Rice-Nutrient disorders and nutrient management. Potash and Phosphate Institute, Canada and International Rice Research Institute, Philippines. p.38.

FRG (*Fertilizer Recommendation Guide)*. 1997. Bangladesh Agricutural Research Council. Farmgate, Dhaka. p.196.

Gomez, K. A. and Gomez, A. A.1984. Statistical Procedure for Agricultural Research. 2nd edn., International Rice Research Institute, Los Banos, Philippines. John Willy and Sons. New York. p.324.

Haque, M. S. 1998. Integrated nutrient management with inorganic and biofertilizers in legume based cropping patterns. *Proc. of the national workshop on integrated nutrient management for crop production and soil fertility*. 24-25 March, 1998. BARC, Gazipur. pp.99-109.

Islam, M. F. and Haque, M. F. 1998. Balanced fertilization with inorganic fertilizers in some dominant cropping patterns. *Proc. of the national workshop on integrated nutrient management for crop production and soil fertility*. 24-25 March, 1998. BARC. Gazipur. pp.1-22.

Islam, M. M. and Bhuiyan, N. I. 1993. Comparison of gypsum and thiovit as sources of sulphur for wetland rice. Bangladesh rice J. 4(1&2): 73-75.

Singh, R., Dubey, S. N. and Srivastava, S. K. 1985. Direct, residual and cumulative response of rice to phosphorus, potassium and farm yard manure. Indian J. Agron. 30(2): 145-149.

Tanaka, A. 1986. Historical changes in plant types of rice varieties in Hokkaido. J. Sci. Soil manure, Japan. 39:526-534. *Cited from nitrogen and rice.* IRRI, Philippines. p.10.

Appendix table 1. Initial soil nutrient status of the experimental site at Kalaroa, Satkhira

Nutrient	Soil test value	Soil test interpretation
PH	8.1	Slightly alkaline
Organic matter (%)	1.88	Medium
EC (mmhos/cm)	0.66	Non saline
Total N%	0.092	Low
Available P (ppm)	4.80	Very low
K (meq./100g soil)	0.22	Medium
S (ppm)	13.21	Low
Zn (ppm)	0.51	Low

Appendix table 2. The price of inputs and the price of outputs at Kalaroa, Satkhira

Price of fertilizers	Price of rice and straw
Urea = 6.00 Tk/kg	Rice straw = 0.50 Tk./kg
TSP = 14.00 Tk/kg	Rice grain =7.00 Tk./kg
MP = 10.00 Tk/kg	
Gypsum = 4.00 Tk/kg	
Cowdung = 0.40 Tk/kg	