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DVELOPMENT OF FERTILIZER RECOMMENDATION FOR THE CROPPING PATTERN POTATO-BORO-T.AMAN IN IRRIGATED MEDIUM HIGHLAND CONDITION UNDER AEZ -9

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Abstract

The experiment was carried out in the Old Brahmaputra Floodplain soil at the farmer's field of Farming System Research and Development (FSRD) site, Kushumhati, Sherpur under Sherpur district in the medium high land under AEZ-9 for the three consecutive years 2003-06 to determine economic combined dose of organic and inorganic fertilizers for Potato-Boro-T.*aman* cropping pattern. Six treatment management packages including one farmer's practices, and one fertilizer control were tested. The other four treatments were soil test based (STB) fertilizer dose for moderate and high yield goals (MYG and HYG), STB based fertilizer dose for HYG plus 5 t/ha cowdung (IPNS) and fertilizer dose for Fertilizer Recommendation Guide'97 (FRG '97). Average of three years' results showed that recommended fertilizer dose based on the FRG '97 was more economic than all other fertilizer doses for the whole pattern. But the treatment Integrated Plant Nutrition Systems based on fertilizer management with cowdung for high yield goal produced the maximum grain and straw yields in the first crop. Application of cowdung had no significant effect on the yield of succeeding crops. The variable cost was higher for the treatment consisting of cowdung due to additional cost of cowdung. The highest marginal rate of return 1626% was obtained from recommended fertilizer based on the FRG '97.

Key Words: Balanced fertilization, cropping pattern, yield, economics.

Introduction

Fertilizer is one of the most important factors to increase the productivity of crops (Anon., 1997). In Bangladesh, fertilizers are generally recommended for each crop without considering the residual effect of fertilizers applied to the previous crops. Nitrogenous fertilizers have very little residual effect on the following crops as it is lost through leaching, volatilization, denitrification, etc. But the fertilizers like phosphate, potash, zinc, and sulphur have considerable residual effect on the subsequent crops. Intensive use of high yielding varieties of crops has led to a sharp increase in removal of plant nutrients. In 1996, 421-71 - 457-44 million tons of NPKS were removed in grain and straw, while in the same

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year 507- 119-114-13 million tons of NPKS, respectively, were added in the form of inorganic fertilizers (Fokhrul and Haque, 1998). The gap between nutrient removal and supplies is likely to widen further due to a number of reasons like pressure on land, increased demand for cereal food grain, fertilizer availability and price. The nutrient requirement in near future could not be met by natural sources alone. Mineral fertilizer inputs are the crucial factors to the over all nutrient balance in intensive cropping systems. Organic matter content of most of the soils of Bangladesh is very low (0.8 to 1.8%) as compared to desired (2.5% and above) levels (Hossain *et al.*, 1995). Fertilizers have been responsible for nearly 50% yield increases registered in recent years (Fokhrul and Haque, 1998). But the current fertilizer use in Bangladesh is highly imbalanced because of its limited availability and unfavourable fertilizer, produce price ratio and its use is rarely decided by local recommendation. Bhuiya and Akanda (1982) reported that organic materials in combination with chemical fertilizers showed excellent response to rice cultivation. Imbalanced use of inorganic fertilizers and soil nutrient mining has resulted in declining soil fertility and therefore, stagnating or decreasing of crops yields. Balanced fertilization carry different meanings considering the nutrient input-output relationship in soil plant system, ratio of fertilizer products and balanced in cost and return of fertilization. Fertilizers is one the most important factors of increasing the productivity of crops. But due to high cost of fertilizers and economic condition of Bangladeshi farmers, its use should be economized. One of the alternatives to economize the use of chemical fertilizers is to incorporate crop residues or apply farmyard manure in combination with chemical fertilizers (Sarker *et al.*, 1996). Now, it is felt that with the introduction of modern varieties of crops and use of relatively high quantity of fertilizer, it needs to develop fertilizer management practices for proper management of soil health and also for nutrient balanced that is economically viable. The present research work was, therefore, undertaken to find out the effect of chemical fertilizers and organic manure on the productivity and profitability of Potato-Boro-T. *aman* Rice cropping pattern.

Materials and Method

The experiment was conducted over three consecutive years at the farmers' fields of Farming System Research and Development site, Kushumhati, Sherpur during the period from November 2003 to October 2006. The soil belongs to the general soil type of non-Calcareous Dark Grey Floodplain under the AEZ of Old Brahmaputra Floodplain (AEZ 9). The land was medium high with loamy to clay loam soil texture. Before conducting the experiment, the soil sample was analyzed. The soil was characteristically acidic (pH 5.0-6.2) having organic matter of 0.55-1.31% (low), total N 0.051-0.079% (very low), exchangeable K 0.06-0.13 me/100 g soil (very low), exchangeable Ca 1.09-1.75 rne/100 g soil (low), exchangeable Mg 0.13-0.56 me/100 g soil (medium), available P 4.25-7.53

ppm (very low), available S 4.39-10.14 ppm (low), available Zn 0.25-0.56 (very low). Potato cv. Diamant, *boro* cv. BRRI dhan-28 and T. *aman* cv. BRRI dhan-33 were grown as the test crops.

The cropping pattern of the experiment was Potato-Boro-T. *aman* rice. There was turn around time of 5-15 days between two crops. Each crop was grown for three seasons in the same layout. The experiment was laid out in a randomized complete block design with six dispersed replications. The unit plot size was 5 m × 8 m. There were six treatments. The description of the treatments is presented in Table 1. Six different packages were tested and the details of the treatments were as follows:

Table 1. Treatment-wise fertilizer doses for crops under Potato-Boro-T. *aman* cropping pattern at Farming System Research and Development site, Kushumhati, Sherpur.

Treatments	Potato						Boro				T. *aman*			
	N	P	K	S	Zn	CD	N	P	K	S	N	P	K	S
	kg/ha													
ED_1 (Estimated mineral fertilizer dose based on the soil test value for MYG)	104	22	84	12	3	0	104	11	42	8	72	8	32	5
ED_2 (Estimated mineral fertilizer dose based on the soil test value for HYG)	147	32	120	19	4	0	147	15	*59*	12	98	10	41	6
IPNS (Integrated plant nutrient system basis fertilizer management with CD for HYG	132	27	105	19	4	5 t/ha	147	15	59	12	98	10	41	6
FRG'97 (Recommended fertilizer based on Fertilizer Recommendation Guide' 97	90	15	50	10	1	0	100	12	40	7	60	8	30	4
FP (Farmer's practice)	120	20	80	0	0	0	112	25	45	18	60	10	0	0
Control	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Note: CD= Cowdung, MYG= Moderate yield goal, HYG= High yield goal, FRG= Fertilizer Recommendation Guide.

In all the crops N, P, K, S, and Zn were applied through urea, triple super phosphate, muritate of potash, gypsum, and zinc sulphate, respectively. The seeds of potato variety Diamant were sown in lines on 18-22 November in three consecutive years. Seeds were sown at the rate of 1,500 kg/ha and spacing was 60 cm *x* 25 cm. Entire amount of TSP, MP, gypsum, and zinc sulphate and one half amount of urea was applied at final land preparation and remaining one-half urea was top dressed at 30-35 days after seeding (DAS) before earthing up. Two

irrigations were done at 20-25 and 45-50 DAS. Phostoxin tablet was applied for rat control. Ridomil gold MZ was applied for late blight control. The crop was harvested on 27-31 January in three consecutive years.

After potato harvest, the second crop *boro* rice *(Oryza sativa)* was transplanted on the same plot on 1-4 February. Thirty-five-day old seedlings were used in the three consecutive years. Spacing was 25 cm x 20 cm. Except N, the full dose of other fertilizers were applied during final land preparation. The N-fertilizer was top dressed in two equal splits at 25 and 55 days after transplanting (DAT). Two weedings were done at 25 and *55* DAT. Dimecron insecticide was applied for stem borer control. The crop was harvested on 19-25 May at full maturity in three consecutive years.

Third crop T. *aman* rice *(Oryza sativa)* was transplanted on 24-28 July. Thirty-five-day old seedlings were used in the three consecutive years. Spacing was 20 cm × 15 cm. Except N the full dose of other fertilizers were applied during final land preparation. The N-fertilizer was top dressed in two equal splits at 30 and 45 DAT. Two weedings were done at 20 and 45 DAT. Dimecron insecticide was applied for controlling rice stem borer. The crop was harvested on 12-16 November at full maturity in the three consecutive years.

Ten plants were randomly collected prior to harvest from each plot excluding border plants after attaining the maturity of the crops to collect data on yield attributes. Data on grains/tuber and straw yield were recorded from $6m^2$ area. Collected data were analyzed statistically and the means were separated by DMRT. The cost and return analysis were done considering the prices of nutrients, products and additional costs only.

Results and Discussion

Yield and yield contributing characters of potato

Yield attribute of potato *(solanum tuberosum)* viz, tubers/plant and tuber weight/plant varied significantly with different nutrient management packages (Table 2). The highest number of tubers/plant (6.71) was obtained from IPNS treatment and it *was* statistically identical to ED_1 and ED_2, but different from other treatments. The lowest number of tubers/plant (2.43) was found from control treatment. The highest tuber weight/plant (445.9 g) was recorded from IPNS treatment and it was statistically significant from other treatments except ED_2 and FRG ’97. Control treatment produced the lowest tuber weight/plant (86.2 g). The highest tuber yield (28.49 t/ha) was obtained from IPNS treatment. ED_1, ED_2 and FRG’97 produced the identical tuber yield. The lowest tuber yield was obtained in control treatment. The highest tubers/yield was mainly associated with the highest number of tubers/plant and tuber weight/plant. These results are in agreement with the findings of Sarkar *et al.* (1996), Zaman *et al.* (2000) and Upadhayay and Grewal (1987).

Yield and yield contributing charaters of *boro* rice

All the characters of *boro* rice significantly differed among the treatments (Table 2). Maximum number of effective tillers/m^2 (400.0) was found in ED_2 and it was similar to IPNS and ED_1 but different from other treatments. The minimum number of effective tillers/m^2 (179.50) was recorded from control treatment. The maximum number of grains/spike (112.02) was recorded from ED_2 and it was statistically identical to IPNS and FRG'97 treatment, but different from other treatments. Control treatment produced the minimum number of grains/panicle (37.12). Similar trend was found in case of 1000-grain weight. The highest grain yield 6.50 t/ha was obtained from ED_2 (Estimated fertilizer dose based on soil test value for HYG) and it was statistically identical to IPNS treatment, but different from other treatments. The higher grain yield was mainly associated with higher number of effective tillers/m^2, grains/panicle and 1000-grain weight. Application of cowdung has no direct effect on the yield of succeeding crops. Rahim *et al.* (1995) also reported that different kinds of manure could not influence the grain yield of transplanted *aman* rice significantly as compared to recommended doses of mineral fertilizer. Sharma and Mitra (1991) reported that oragnic matter failed to increase rice yield but uptake of nutrient increased significantly. Here, the treatment Integrated Plant Nutrition System (IPNS) had no significant influence on the other tested crops. These might be due to the third crop of the pattern where cowdung was applied in the first crop. The highest straw yield (7.50 t/ha) was noticed from ED_2 treatment and it was statistically at par with IPNS treatment but different from other treatments. Control treatment produced the lowest straw yield (2.35 t/ha).

Yield and yield contributing characters of T. *aman*

All the characters of T. *aman* rice significantly differed among the treatments (Table 2). The maximum number effective tillers/m^2 (325.2) was found in ED_2, which was statistically identical with IPNS but different from other treatments. The minimum number of effective tillers/m^2 (79.5) was recorded from control treatment. Similar trend was found in case of grains/panicle and 1000-grain weight. The highest grain yield (5.54 t/ha) was obtained from ED_2 (Estimated fertilizer dose based on soil test value for HYG), which was statistically different from other treatments except IPNS based fertilizer treatment. The highest grain yield was mainly associated with the highest number of effective tillers/m^2, grains/panicle and 1000-grain weight. Application of cowdung has no direct effect on the yield of succeeding crops. Rahim *et al.* (1995) also reported that different kinds of manure could not influence the grain yield of transplanted *aman* rice significantly as compared to recommended doses of mineral fertilizer. Sharma and Mitra (1991) reported that organic matter failed to increase rice yield but uptake of nutrient increased significantly. Here, the treatment Integrated Plant Nutrition System (IPNS) had no significant influence on the other tested crops. These might be due to the third crop of the pattern where cowdung was applied

in the first crop. The highest straw yield (6.56 t/ha) was noticed from ED_2 treatment, which was statistically at par with IPNS treatment but different from other treatments. Control treatment produced the lowest straw yield (1.67 t/ha).

Rice equivalent yield

For comparison among the treatments, potato yield was converted into rice equivalent yield on the basis of prevailing market price of individual crop. The highest rice equivalent yield was recorded from IPNS treatment due to the highest yield of potato, *boro* rice and T. *aman* crops. ED_2 and ED_1 failed to show higher rice equivalent yield than IPNS. Farmer's practice showed lower rice equivalent yield due to lower yield of all the three crops (Table 3).

Table 2. Effects of different nutrient management practices on the yield components of crops in the Potato-Boro-T. *aman* rice cropping system (pooled).

Treatments	Potato		Boro			T. *aman*		
	Tubers/ plant (no.)	Tuber wt./plant (no.)	Plants/ m^2 (no.)	Grains/ panicle (no.)	1000-grain wt (g)	Plants/m^2 (no.)	Grains/ panicle (no.)	1000-grain wt (g)
ED_1	5.57ab	405.5b	381.9ab	90.14b	23.20b	290.5b	100.04b	26.95b
ED_2	5.93 ab	414.2 ab	400.0 a	112.02 a	26.75 a	325.5 a	120.50 a	33.84 a
IPNS	6.71a	445.9a	391.8ab	105.89a	25.95a	314.3a	114.72a	31.58a
FRG'97	5.19b	410.3ab	356.7b	100.47a	25.25a	282.8b	95.25b	28.86b
FP	4.33c	360.6c	311.05c	90.74b	22.05b	276.5b	83.79c	23.72c
Control	2.43 d	86.2 d	179.50 d	37.12 c	18.10 c	79.5 c	25.46 d	20.01 d
F	**	**	**	**	**	**	**	**
CV(%)	10.88	9.37	8.34	9.12	6.58	9.84	7.65	10.24

Figures in column having similar letter(s) do not differ significantly as per DMRT.

Table 3. Effects of different nutrient management practices on the yield of crops in the Potato-Boro-T. *aman* rice cropping system (pooled).

Treatments	Yield (t/ha)			Rice equivalent yield (t/ha)	Straw yield (t/ha)	
	Potato	Boro	T. ainan		Boro	T.*aman*
ED_1	23.68b	5.39b	4.08b	28.41	6.l0b	5.l0b
ED_2	25.91 b	6.50 a	5.54 a	32.77	7.50 a	6.13 a
IPNS	28.49 a	6.01 a	5.32 a	34.12	7.35 a	6.04 a
FRG'97	24.30b	5.68b	4.25b	29.37	6.35b	5.19b
FP	18.15c	4.95c	3.16c	22.63	5.25c	4.11 c
Control	8.93 d	1.21 d	1.09 d	9.44	2.35 d	1.43 d
F	**	**	**	-	**	**
CV(%)	10.09	11.81	9.97	-	10.85	10.56

Figure in colunm having similar letter(s) do **not** differ significantly as per DMRT.

Cost and return analysis

The cost and return analysis of crops grown in Potato-Boro-T. *aman* rice cropping system has been presented in Table 4. The highest gross return (347895 Tk./ha) was obtained from IPNS (Integrated Plant Nutrition System for high yield goal) which was about 4% higher than ED_2, 20% than ED_1, 17% than FRG'97 and 51% higher than farmer's practice. Among the fertilizer treatment, the lowest gross return was recorded from farmer's practice. But the highest MRR *(%)* 1626 was found in treatment FRG'97 and it was followed by IPNS and ED_2. Gross margin was also found maximum (327633 Tk./ha) in IPNS followed by ED_2 and FRG'97 treatment and the lowest MRR *(%)* 408 was found in ED_2 treatment. The treatment IPNS failed to produce higher MRR(%) because of higher price of cowdung. BARI (2000), Ali *el al.* (2003) and Rahman *et al.* (2004) also reported similar results. The lowest gross margin (96290 Tk./ha) was noticed from control treatment.

Table 4. Cost and return analysis of different management practices in Potato-Boro-T. *aman* cropping system (Pooled).

Treatments	Gross return (Tk./ha)	Variable cost (Tk./ha)	Gross margin (Tk./ha)	BCR	MRR (%)
ED_1	289740	13351	276389	21.70	Discard
ED_2	334495	18660	315835	17.93	408
IPNS	347895	20262	327633	17.17	736
FRG'97	299470	11771	287699	25.44	1626
FP	230980	12068	218912	19.14	Discard
Control	96290	0	96290	-	-

Products and by-products were considered to calculate gross return and fertilizer cost, application and additional cost were considered to calculate variable cost.

Products and inputs.
Products (Tk./kg):
Potato = 8.00, Boro and T.*aman* rice = 10.00, rice straw = 1.00
Inputs (Tk./kg):
Urea = 6.00, TSP = 15.00, MP = 14.00, Gypsum = 4.00, Zinc Sulphate = 65.00, Cowdung = 0.50

Nutrient uptake and balance

The amount of N, P, K, and S absorbed by potato, boro and T. *aman* rice at the farmers' fields are presented in Table 5. The amounts varied widely with the treatments. Mineral uptake by the crop was mainly influenced by biomass production. Nitrogen replacement through chemical fertilizer and cowdung addition either singly or in combination was not enough to balance N removal by

crops since much of the applied N was lost from the soil. The N balance thus was negative: -72.93 to -177.1 kg N/ha appeared to have been removed in excess of the amounts added (Table 5). The K and S balances were not favourable as expected. But in case of P, it was evident that this element was removed in large excess of the amount added as fertilizer. This may lead to P depletion in the long run. Ishaque *et al.* (1998) found similar results in farmers' fields of Gazipur.

Table 5. Effect of different fertilizer nutrients management practices on the nutrient balance in Potato-Boro-T. *aman* rice cropping system.

Treatment	Nutrient uptake (kg/ha)				Nutrient added (kg/ha) (Inorganic + Organic)				Apparent nutrient balance (kg/ha			
	N	P	K	S	N	P	K	S	N	P	K	S
ED_1	254.1	44.0	290.8	27.7	280	41	158	25	-156.1	-3.0	-132.8	-2.7
ED_2	308.2	53.1	351.7	33.4	392	57	220	37	-171.0	+3.9	-131.7	+3.4
IPNS	304.5	52.7	348.6	33.2	392	57	220	37	-167.3	+4.3	-128.6	+3.8
FRG'97	264.6	45.7	302.6	28.8	250	35	120	21	-177.1	-10.4	-182.6	-7.8
FP	210.1	362	162.2	22.8	292	55	125	18	-107.9	+18.8	-37.2	-4.8
Control	72.93	12.8	84.23	8.12	-	-	-	-	-72.93	-12.8	-84.23	-8.1

* 35% of applied fertilizer manure N was considered effective

Conclusion

From the three years' study and foregoing discussion, it may be concluded that the recommended fertilizer dose based on the fertilizer recommendation guide'97 was profitable on the whole pattern basis than all other fertilizer combinations used in the study and this dose of fertilizer package may be used for Potato-Boro-T. *aman* cropping pattern under Sherpur region (AEZ-9). IPNS gave higher yield only in the first crop *i.e.*, potato, but the succeeding crop has no influence by adding cowdung in the previous crops. But IPNS is too much helpful to maintain soil health and sustaining crop production though the economic return was in some cases lower than the recommended dose based on the Fertilizer Recommendation Guide'97.

References

Ali M. R., M. S. Rahman, M. A. Mannan, M. M. Hossain and M. Kadir. 2003. Balanced fertilization with inorganic fertilizers in Mustard-Boro-T. Aman cropping pattern. *Bangladesh J. Prog. Sci. & Tech.* **1**(1): 33-37.

Anonymous. 1997. Fertilizer Recommendation Guide, Bangladesh Agricultural Research Council, Farmgate, Dhaka. p. 185.

BARI (Bangladesh Agricultural Research Institute). 2000. Annual Report for 1999-2000. Bangladesh Agril. Res. Inst., Joydebpur, Gazipur, Bangladesh. pp. 249-253.

Bhuiya M. R. and M. S. Akanda. 1982. Effect of different sources of organic materials alone and in combination with two fertilizer levels on growth parameters and composition of rice. *Bangladesh J.Agril.* **7**(3-4): 32-39.

Fokhrul, M. I. and M. F. Haque. 1998. Balanced fertilization with inorganic fertilizers in some dominant cropping patterns. Proceedings of the national workshop on integrated nutrient management for crop production and soil fertility. pp. 1-22.

Hossain M. A, A. B. M. Salahuddin, S. K. Roy, S. Nasreen and M. A. Ali. 1995. Effect of green manuring on the growth and yield of transplanted *aman* rice. *Bangaldesh J. Agril. Sci.* **22**(1):21-29.

Ishaque, M., G. M. Panaullah, N. Bhuyian and P. K. Saha. 1998. integrated nutrient management with inorganic fertilizer and green/organic manures for Boro-T. *aman* rice cropping pattern. In proceedings "National Workshop on Integrated Nutrient Management for Crop Production and Soil Fertility" held on 24-25 March, 1998 at BARI, Gazipur, Bangladesh. pp. 111-114.

Rahman, M.S, F. R. Khan, M. R. Ali, M. Biswas and M. M. Hoque. 2004. Effeci of organic and inorganic fertilizers on Mustard-boro-T. *aman* cropping pattern irrigated medium highland. *Bangladesh J. Prog. Sci.* & *Tech.* **2**(2): 105-108.

Rahim, M. A., M. Shahidullah and A. K. M. Rahman. 1995. Effect of different kinds of manures on the performance of T. *aman*-Boro rice cropping pattern. Research Report, 1994-95. On -Farm Research Division. Agricultural Research Station. Bogra pp. 22- 27.

Sarkar N. I., S. Zaman, M. S. Islam, B. M. Islam and M. A. Mannaf. 1996. Effect of fertilizers alone and in combination with cowdung on the grewth and yield of potato. *Bangladesh J. Agril. Res.* **21**(2): 275-282.

Sarkar, N. I., S. Zaman, M. S. Islam, H. Bari and A. T. M. Shamsuddin. 1996. Effect of chemical fertilizers and organic manure on the growth and yield of potato in Non-Calcareous Grey Floodplain Soil. *Progress. Agric.* **7**(1): 63-68.

Sharma A. R and B. N. Mittra. 1991. Direct and residual effect of organic materials in rice *(Orgza Sativa)* based cropping system. *Indian J. Argon.* **36**(3): 299-303.

Upadhayay N. C. and J. S. Grewal. 1987. Effect of phosphorus, potassium and farmyard manure application on potato yield, nutrient uptake and soil fertility. *Mysore J. Agric. Sci.* **21**(3):279-282.

Zaman S., M. Saifullah and S. M. Nabi. 2000. Response of potato to chemical fertilizers and organic manure in Old Meghan Estuarine Floodplain. *Bangladesh J. Agril. Res.* **25**(3): 521-527.