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GRAIN YIELD, NUTRIENT BALANCE AND ECONOMICS OF T. *AMAN* RICE CULTIVATION AS INFLUENCED BY NUTRIENTS MANAGEMENT

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Abstract

A field experiment was conducted at Regional Wheat Research Centre of the Bangladesh Agricultural Research Institute, Joydebpur, Gazipur, Bangladesh during 2007 and 2008. The objectives were to find out the optimum nutrient management practice for grain yield, nutrient balance and economics of T. *Aman* rice. Twelve nutrient management treatments (with and without CRI) were tested in RCBD with 3 replications. Treatments were T_1=HYG (0-80-16-44-12-2-0), T_2=MYG (0-56-12-32-8-1.5-0), T_3=IPNS (5000-65-13-32-9-2-0), T_4=STB (0-68-15-37-11-2-0), T_5=FP (0-39-7-12-0-0-0), T_6=CON (0-0-0-0-0-0-0), T_7=HYG+CRI(Crop residue incorporation), T_8=MYG+CRI, T_9=IPNS+CRI, T_{10}=STB+CRI, T_{11}=FP+CRI, T_{12}=CON+CRI kg ha^{-1} CDNPKSZnB for T. *Aman* rice. On an average, maximum grain yield of T. *Aman* rice was obtained from STB+CRI (5.24 t ha^{-1}) followed by IPNS+CRI (5.13 t ha^{-1}), STB (5.12 t ha^{-1}), IPNS (5.03 t ha^{-1}), HYG+CRI (4.50t ha^{-1}) and HYG (4.41 t ha^{-1}). Numerically but not statistically higher yield and yield contributing parameters were noticed in CRI plots than without CRI. Except N and K remaining nutrient balance like P S Zn and B were found positive in case of HYG, MYG, IPNS and STB along with or without CRI nutrient managements while FP and CON (Control) showed negative balance. The maximum BCR was observed in STB (3.25) followed by STB+CRI (3.14) and IPNS (2.98) and similar trend was observed in MBCR.

Keywords: T. *Aman* rice, yield, nutrient balance, nutrient management and crop residue incorporation

Introduction

Bangladesh is a country of 0.148 million sq.km and it has to feed about 150 million people (BBS, 2012). In order to produce more food within a limited area, two most important technique is to be adopted, which is to increase the productive efficiency of the individual crop depending on how well it utilizes the basic resources especially, the limiting ones, water and nutrients. Bangladesh is the fourth largest producer and consumer of rice in the world. Rice is the staple

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food in Bangladesh. Rice is extensively grown in Bangladesh which covers 75% of the total cropped area and about 60% labor is engaged in rice production. Rice alone contributes around 10% to the GDP. Rice alone contributes about 95% to the total food grain production(BER,2010).It provides 75% of the calories and 55% of the proteins in the average daily diet of the people (Bhuiyan *et al*., 2002).The national mean yield (2.60 t ha^{-1}) of rice in Bangladesh is lower than the potential national yield (5.40 t ha^{-1}) and world average yield (3.70 t ha^{-1}) (Pingali*et al*., 1997).The lower yield of transplanted *Aman* rice has been attributed to several reasons, one of them being imbalanced nutrients management. Crop residue is a vital natural resource for conserving and sustaining soil productivity. It is the primary substrate for replenishment of soil organic matter. Upon mineralization, crop residue supplies essential plant nutrients (Walters *et al*., 1992). Additionally, residue incorporation can improve physical and biological conditions of the soil and prevent soil degradation (Nyborg *et al*., 1995). Incorporation of crop residues of either rice straw or wheat straw increased the yield and yield components of rice and nutrient uptake and also improved the physico-chemical properties of the soil, which provided better soil environment for crop growth. Increasing levels of NPK application increased the yield-attributing characters and nutrient uptake by both the crops, which ultimately increased the grain and straw yields (Das *et al.,* 2003). Therefore, the present study was undertaken to find out the optimum nutrient management practice for grain yield, apparent nutrient balance in soil and economics of T. *Aman* rice cultivation under AEZ-28.

Materials and Method

The experiment was carried out at the Regional Wheat Research Centre of Bangladesh Agricultural Research Institute Joydebpur, Gazipur. The experimental field of Gazipur belongs to the agro-ecological zone of Modhupur Tract (AEZ-28). The initial soil of the experimental field was analyzed for chemical properties before setting up the experiment. The initial soil status was pH 6.48, OM (%) 1.07, Total N (%) 0.055, available P(µg g^{-1}) 3.76, exchangeable K (meq 100 g^{-1}) 0.15, available S(µgg^{-1}) 9.91, available Zn(µg g^{-1}) 0.24 and available B(µg g^{-1}) 0.16. Morphological characters are Grey Terrace soils, medium high land, not well drained, above flood level and grey soil clour. Physiological characters are silty loam to loam having more or less near neutral soil pH with very low to low soilfertility. T. *Aman* rice variety (BRRIdhan39) was tested in *Kharif*-II season during 2007 and 2008, respectively. Twelve nutrient management treatments were tested in RCBD with 3 replications. Treatments were T_1=HYG (0-80-16-44-12-2-0), T_2=MYG (0-56-12-32-8-1.5-0), T_3=IPNS (5000-65-13-32-9-2-0), T_4=STB (0-68-15-37-11-2-0), T_5=FP (0-39-7-12-0-0-0), T_6=CON (0-0-0-0-0-0-0), T_7=HYG+CRI, T_8=MYG+CRI, T_9=IPNS+CRI, T_{10}=STB+CRI, T_{11}=FP+CRI, T_{12}=CON+CRI kg ha^{-1}

CDNPKSZnB for T. *Aman* rice.(Here, HYG= High Yield Goal, MYG= Moderate Yield Goal, IPNS= Integrated Nutrient Management System, STB= Soil Test Based, FP= Farmers Practice, CON= Control, CD= Cowdung and CRI= Crop Residue Incorporated). The previous crop mungbean was cultivated which was demarked individually plot earlier in the whole experimental area and in case of CRI plots, total biomass (except pod) of mungbean was incorporated as residue before T. *Aman* rice transplanting. In second year, the land was used for any rabi crop after harvest of T. Aman rice. The rates for N, P, K, S, and Zn application were calculated based on the soil test value following the soil test interpretation (FRG, BARC, 2005). The rate for each element was considered as 100%. Accordingly, the full or 100% rate of N, P, K, S, and Zn for each crop was applied. In case of Integrated Plant Nutrient System (IPNS) treatment the amount of nutrients available in cowdung (CD) was deducted from the total amount of chemical fertilizers and adjusted accordingly. The rates for chemical fertilizers were fixed on soil test basis (STB) with a high yield goal (HYG) for specific crop basis as per BARC (FRG, BARC, 2005). The exact fertilizer nutrient for making the recommendation was computed with the following formula:

$$F_r = U_f - \frac{C_i}{C_s} \times (S_t - L_s)$$

Where

F_r = Fertilizer nutrient required for a given soil test value

U_f = Upper limit of the recommended fertilizer nutrient for the respective soil test value interpretation (STVI) class

C_i = Units of class intervals used for fertilizer nutrient recommendation

C_s = Units of class intervals used for STVI class

S_t = Soil test value

L_s = Lower limit of the soil test value within STVI class.

The sources of N, P, K, S, and Zn were urea, triple super phosphate (TSP), muriate of potash (MoP), gypsum, and zincsulphate, respectively. The farmers' practice (FP) for fertilizer rates was determined on the basis of data collected through interviewing thirty (30) farmers from adjacent locality. Total residue was chopped just after harvest and ploughed down to the soil by spade for decomposition in respective CRI plots. Thirty-day old seedlings were transplanted from 1-7 July each year. Three seedlings per hill were used following a spacing of 20cm x 15cm.The whole amount of TSP, MoP, gypsum and zincsulphate were applied at the time of final land preparation as per treatment. Urea was applied into three splits at 15, 30 and 45 days after transplanting. Intercultural operations like weeding, irrigation and pest control measures were taken as and when necessary. T. Aman rice was harvested on 25-31 October each year.

The crops were harvested from 10 m2 at full maturity. A sub-sample of 200 g dry biomass for each of crop was collected for chemical (nutrient uptake) analysis. The sub-samples were dried in an oven for 72 hours at 700C. Apparent nutrient balance (added-uptake) was calculated by using the following formula.

Xa = (Xf + Xr+ Xi+ Xb+Xcri)-Xrem, Where

Xa = Apparent gain (+) or loss (-) of nutrient (kg ha^{-1})

Xf = Nutrient added through inorganic sources (kg ha^{-1})

Xr = Nutrient added through rainfall (kg ha^{-1}). (Not considered)

Xi = Nutrient added through irrigation water (kg ha^{-1}). (Not considered)

Xb= Nutrient added through BNF (kg ha^{-1}). (Not considered)

Xcri= Nutrient added through crop residue incorporation (kg ha^{-1}).

Xrem= Nutrient removed by crops and loss through different systems (kg ha^{-1}).

The data were analyzed statistically by the F-test andthe mean comparisons of the treatments were evaluated by DMRT (Duncan's Multiple Range Test).

Results and Discussion

Plant population

Plant population was not influenced significantly by different nutrient management treatments in both the years (Table 2).

Plant height

The nutrient management treatments without or with CRI influenced the plant height significantly in both theyears. The plant height was statistically identical except control without or with crop residues incorporation (Table 2). In a field study, Basak *et al.* (2008 a) recorded the highest plant height with STB nutrient in T. *Aman* rice of Mustard-*Boro* rice-T. *Aman* rice cropping pattern and Awal *et al.* (2007) also reported similar result in T. *Aman* rice on Wheat-Jute-T. *Aman* rice cropping pattern.

Panicles number

Number of panicles m^{-2} differed significantly due to application of nutrients in soil both the years. The highest number of panicles m^{-2} was 250 under STB with crop residues integration, which was statistically identical with STB (249),

IPNS+CRI (245), IPNS (243), HYG+CRI (240) and HYG (237) in 2007. In 2008, the trend was similar. From the two years results, it was observed that the maximum panicles m^{-2} obtained from HYG, IPNS and STB, without or with CRI nutrient management treatments compared to other treatments. STB was the best among those treatments might be due to proper nutrient was added into the soil resulted maximum number of panicles m^{-2} followed by IPNS and HYG, respectively. The lowest panicles m^{-2} was found in control due to lack of proper nutrient. Increased number of panicles m^{-2} was found in all the treatments along with CRI than without CRI which might be due to the crop residual effect (Maskina *et al*., 1987). Ali *et al*. (2003) stated that STB nutrient gave the highest panicles m^{-2} in T. *Aman* rice in Mustard-*Boro* rice-T. *Aman* and Basak *et al.* (2008) stated similar findings in T. *Aman* rice of Mustard-*Boro* rice-T. *Aman* rice cropping pattern.

Grains panicle^{-1}

The nutrient management treatments HYG, IPNS and STB without or with CRI produced higher number of grains panicle^{-1} which ranged from 78 to 88 in both the years. From the two years results, it was revealed that the nutrient management treatments HYG, IPNS and STB along with or without CRI produced the maximum number of grains panicle^{-1}. Among those treatments, STB gave the best performance that might be due to appropriate nutrient dose applied into the soil, while the nutrient applied was higher in case of HYG. Control produced the minimum grains panicle^{-1} due to no addition of nutrient into the soil. However, the increasing trend was observed in all the treatments along with CRI than without CRI which might be due to the effect of crop residues (Naser *et al*., 2001). However, there was no significant difference between with or without CRI. These findings were similar to the findings of Zaman *et al*., 2007 a & b; Awal *et al*., 2007.

Sterile spikelet panicle^{-1}

The number of sterile spikelets panicle^{-1} differed significantly due to application of different nutrients without or with incorporation of crop residues. The highest number of sterile spikelets panicle^{-1} was 57 under control without CRI followed by with control with CRI (57). In case of other nutrient management treatments the number of sterile spikelets panicle^{-1} ranged from 32 to 42. The lowest sterile spikelets panicle^{-1} (32) was obtained with HYG treatment without CRI. Similar trend was found in 2008 (Table 3).The highest number of sterile spikelets panicle^{-1} in case of control without or with CRI might be due to the absence of proper nutrients in the soil. HYG, IPNS and STB without or with CRI produced the minimum number of sterile spikelets panicle^{-1}.

Table 1. Total addition of extra nutrients into the soil through previous crop (mungbean) residues incorporation in T. *Aman* rice (kg ha^{-1}yr^{-1}) during 2007 and 2008 (assuming nitrogen mineralization rate 40%).

Nutrient management	Kg ha^{-1}		Kg ha^{-1}		Kg ha^{-1}		Kg ha^{-1}		Kg ha^{-1}		Kg ha^{-1}	
	N		P		K		S		Zn		B	
	2007	2008	2007	2008	2007	2008	2007	2008	2007	2008	2007	2008
HYG+CRI	17	18	11	12	41	44	9	9	0.14	0.15	0.10	0.11
MYG+CRI	11	12	8	9	32	35	8	8	0.11	0.08	0.08	0.07
IPNS+CRI	13	15	10	11	40	44	9	9	0.13	0.14	0.09	0.09
STB+CRI	13	14	10	11	37	40	9	10	0.11	0.12	0.09	0.08
FP+CRI	9	10	7	8	24	28	6	7	0.08	0.09	0.07	0.07
CON+CRI	6	6	4	4	17	17	4	4	0.05	0.05	0.04	0.03

Grain weight

Different nutrient management treatments over the years did not influence 1000-grain weight significantly (Table 3).

Grain yield

The grain yield irrespective of treatment was found slightly higher in 2008 than 2007 (Table 3). It was observed that HYG, IPNS and STB nutrient management treatments without or with crop residues incorporation produced the maximum grain yield and those were statistically identical over the years. Among those treatments, STB gave the highest yield, which might be due to the combined effect of higher number of tillers m^{-2}, panicles m^{-2} and grains panicle^{-1}. MYG and FP without or with CRI gave average and low grain yield, respectively might be due to the effect of moderate and low number of tillers m^{-2}, panicles m^{-2} and grains panicle^{-1}. The lowest grain yield was found in control treatment. However, the grain yield in all the treatments with CRI was found superior to without CRI that might be due to the effect of conservation agriculture, more soil microbial activities through crop residual incorporation resulting the yield was increased (Kavimadan *et al*., 1987 and Ladha *et al*., 1987). Moreover, the overall trend was similar in both the years. These results are in agreement with that of Akhteruzzaman *et al*. (2009). On an average, maximum grain yield (5.24 t ha^{-1}) was recorded from STB+CRI followed by IPNS+CRI, STB and IPNS. It is noted that STB, IPNS and incorporation of residues played vital role in increasing grain yield as well as improved of soil health. Timsina *et al*. (2006 a) reported the highest grain yield with STB nutrient in T. *Aman* rice on rice-wheat system. Similar findings were also reported by many scientists (Quayyum *et al*., 2001 and 2002; Chowdhury *et al*., 2002; Basak *et al*., 2008 a; Roy *et al*., 2008; Ali *et al*., 2003).

Straw yield

The significantly highest straw yield was 6.43 t ha^{-1}in HYG+CRI which was identical to IPNS+CRI (6.29 t ha^{-1}), HYG (6.26 t ha^{-1}), IPNS (6.13 t ha^{-1}). MYG treatment yielded similar to STB. FP gave low straw yield without or with crop residue incorporation. The lowest straw yield was 1.44 t ha^{-1} under control without CRI. In 2008, the trend was similar to the previous year. However, the highest straw yield was 6.92 t ha^{-1} under HYG+CRI and the lowest was 1.69 t ha^{-1} in control without CRI (Table 3).Among the treatments, HYG gave the maximum straw yield which was followed by IPNS and STB, which might be contributed through plant height and biomass. The straw yield was higher in all the treatments along with CRI than without CRI, might be due to the residual effect of the crop (Thakur and Singh, 1987; Kavimadan *et al*. 1987 and Ladha *et al*. 1987).

Table 2. Plants m^{-2}, plant height, panicles m^{-2} and of grains panicle^{-1} of T. *Aman* rice as influenced by different nutrient management during 2007 and 2008.

Nutrient management	Plants m^{-2}		Plant height (cm)		Panicles m^{-2}		Grains panicle^{-1}	
	2007	2008	2007	2008	2007	2008	2007	2008
HYG	32.0	32.8	114.2 a	119.9 a	237 abc	249 ab	78 ab	82 ab
MYG	32.0	32.8	106.7 a	112.4 a	217 c	230 bc	67 bc	71 bc
IPNS	32.3	33.1	110.9 a	116.7 a	243 a	256 a	82 a	86 a
STB	32.0	33.3	108.9 a	115.7 a	249 a	261 a	83 a	87 a
FP	32.0	32.7	106.3 a	112.1 a	194 d	207 d	51 d	55 d
CON	31.6	32.6	88.1 b	93.8 b	151 e	164 e	25 e	29 e
HYG+CRI	32.2	33.1	114.5 a	120.3 a	240 ab	251 ab	79 a	83 a
MYG+CRI	32.6	33.1	109.9 a	114.7 a	219 bc	232 bc	67 c	71 bc
IPNS+CRI	32.3	33.2	111.3 a	117.1 a	245 a	257 a	84 a	88 a
STB+CRI	32.4	33.5	111.0 a	116.7 a	250 a	263 a	85 a	88 a
FP+CRI	32.3	33.1	107.2 a	112.9 a	196 d	209 d	53 d	570 d
CON+CRI	31.7	32.8	89.7 b	95.4 b	153 e	166 e	26 e	30 e
CV (%)	2.60	4.48	3.93	3.73	6.08	5.85	7.07	6.65
Level of sig	NS	NS	**	**	**	**	**	**

Table 3. Number of sterile spikelets panicle^{-1},1000-grain weight, grain yield and dry straw yield of T. *Aman* rice as influenced by different nutrient management during 2007 and 2008.

Nutrient management	Number of sterile spikelets panicle^{-1}		1000-grain weight (g)		Grain yield (t ha^{-1})		Straw yield (t ha^{-1})	
	2007	2008	2007	2008	2007	2008	2007	2008
HYG	32 d	34 d	21.95	23.40	4.31 ab	4.51 ab	6.26 a	6.75 a
MYG	40 bcd	42 bcd	22.55	23.73	3.50 b	3.70 b	4.22 bc	4.71 bc
IPNS	42 bc	44 bc	21.95	23.53	4.93 a	5.13 a	6.13 a	6.62 a
STB	33 cd	35 cd	22.35	23.35	5.02 a	5.22 a	5.36 ab	5.85 ab
FP	33 cd	35 cd	22.29	23.47	2.41 c	2.61 c	2.88 d	3.37 d
CON	57 a	59 a	22.09	23.13	1.21 d	1.31 d	1.44 e	1.69 e
HYG+CRI	32 d	34 d	22.42	23.60	4.35 ab	4.55 ab	6.43 a	6.92 a
MYG+CRI	40 bcd	42 bcd	22.22	23.27	3.54 b	3.73 b	4.25 bc	4.76 bc
IPNS+CRI	42 b	44 b	22.75	23.93	5.03 a	5.23 a	6.29 a	6.78 a
STB+CRI	33 cd	35 cd	22.69	23.87	5.14 a	5.34 a	5.42 a	5.91 ab
FP+CRI	33 cd	35 cd	22.69	23.87	2.43 c	2.64 c	2.92 d	3.41 d
CON+CRI	57 a	58 a	22.17	23.13	1.26 d	1.36 d	1.46 e	1.75 e
CV (%)	8.71	8.34	3.90	3.71	9.76	9.29	10.92	10.05
Level of sig	**	**	NS	NS	**	**	**	**

In a column, mean values having common letter(s) do not differ significantly whereas mean values with dissimilar letter(s) differ significantly as per DMRT.

T_1=HYG (0-80-16-44-12-2-0), T_2=MYG (0-56-12-32-8-1.5-0), T_3=IPNS (5000-65-13-32-9-2-0), T_4=STB (0-68-15-37-11-2-0), T_5=FP (0-39-7-12-0-0-0), T_6=CON (0-0-0-0-0-0-0), CD, N, P, K, S and Zn (kg ha^{-1}), respectively and CRI= Crop Residue Incorporation.

Apparent nutrient uptake and balance

Nitrogen

From the mean data it was observed that the added of nutrient ranged from 0 to 55 kg $ha^{-1}yr^{-1}$ (40% of applied chemical/cowdung/crop residues nutrient N was considered effective) while uptake ranged from 25 to 116 kg $ha^{-1}yr^{-1}$among different treatments (Fig.1). Maximum uptake was found in IPNS+CRI (116 kg $ha^{-1}yr^{-1}$) followed by STB+CRI (115 kg $ha^{-1}yr^{-1}$). Minimum uptake was estimated in CON (25 kg $ha^{-1}yr^{-1}$). The apparent nutrient balance was found negative in all treatments ranging from -20 to -82 kg $ha^{-1}yr^{-1}$. The highest negative balance was found in STB (-82 kg $ha^{-1}yr^{-1}$) followed by IPNS (-68 kg $ha^{-1}yr^{-1}$). The lowest negative balance was observed in CON+CRI (-20 kg $ha^{-1}yr^{-1}$). Fig. 1, showed that the nitrogen balance was negative as the uptake was higher compared to added nitrogen (40% of applied chemical/cowdung/crop residues nutrient N was considered effective). Nitrogen replenishment through chemical fertilizer, cowdung addition, crop residue incorporation either singly or in combination was not enough to balance N removal by crop; so much of the applied N was lost from the soil through depletion. The N balance thus was negative in all treatments appeared to have been removed in excess of the quantity added in soil. However, the N balance was less negative in those treatments where crop residues were incorporated than without incorporation which might be due to addition of extra N came from previous crop residues (6 to 18 kg $ha^{-1}yr^{-1}$) as shown (Table 1). Present findings are also in agreement with the observation of Timsina *et al*., 2001, 2006 (b) and Rahman *et al.*, 1998.

Phosphorus

The added phosphorus was in the range from 0 to 28 kg $ha^{-1}yr^{-1}$in respective of different treatments. The uptake was ranged from 5 to 26 kg $ha^{-1}yr^{-1}$. The treatment IPNS+CRI showed maximum uptake (26 kg $ha^{-1}yr^{-1}$) followed by STB+CRI (25 kg $ha^{-1}yr^{-1}$). The lowest uptake was found in CON and CON+CRI (5 kg $ha^{-1}yr^{-1}$). Only control plot along with or without CRI treatments showed negative balance ranged from -1 to -5 kg ha^{-1} yr^{-1} and remaining all the treatments showed positive balance ranged from 1 to 7 kg ha^{-1} yr^{-1}(Fig. 2). From the figure 2, it was observed that except control plots along with or without CRI treatments, all treatments showed positive balance due to addition of higher amount of phosphorus while uptake was lower that might be due to total dry matter content as well as the variation of concentration of the nutrient of the crops. In HYG, MYG, IPNS, STB and FP along with or without CRI treatments the balance appeared positive with trace amount due to addition of adequate nutrient into the soil whereas uptake was a little bit lower. However, the positive balance was higher in those treatments where the crop residue were incorporated with soil than without incorporated treatments which might be due to addition of extra nutrient in the range of 4-12 kg $ha^{-1}yr^{-1}$from the mean data (Table 1). Similar results were also found by Saleque *et al*. (2006).

Potassium

The quantity of added nutrient (K) was in the range of 0 to 87 kg $ha^{-1}yr^{-1}$and uptake by the crop varied from 22 to 116 kg $ha^{-1}yr^{-1}$. Maximum uptake was found in STB+CRI (116 kg $ha^{-1}yr^{-1}$) followed by IPNS (104 kg $ha^{-1}yr^{-1}$). Minimum uptake was observed in CON (22 kg $ha^{-1}yr^{-1}$). Among the nutrient managements, all treatments showed negative balance in the range of -1 to -66 kg $ha^{-1}yr^{-1}$. Maximum negative balance was observed in STB (-66 kg $ha^{-1}yr^{-1}$) and minimum was found in MYG+CRI (-1 kg $ha^{-1}yr^{-1}$) as shown in Fig. 3. However, the negative balance was shown lower in those treatments where crop residues were incorporated than without incorporated plots. It might happen due to addition of extra nutrient in the range of 17 to 44kg $ha^{-1}yr^{-1}$from the mean data through crop residues incorporation (Table 1). This result is also agreement with Panaullah *et al*. (2006).

Sulphur

From the mean data it was observed that quantity of added nutrient ranged from 0 to 21 kg $ha^{-1}yr^{-1}$and the uptake ranged from 4 to 19 kg $ha^{-1}yr^{-1}$ with irrespective treatments. Among the treatments, maximum uptake was observed in STB+CRI (19 kg $ha^{-1}yr^{-1}$) followed by IPNS+CRI and HYG+CRI (17 kg $ha^{-1}yr^{-1}$). Minimum uptake was found in CON (4 kg $ha^{-1}yr^{-1}$). The negative balance was observed in FP and CON with and without CRI treatments was -1 to -8 kg $ha^{-1}yr^{-1}$. Remaining treatments showed positive balance ranged from 1 to 4 kg $ha^{-1}yr^{-1}$(Fig.4). Among the treatments, the maximum positive balance was observed in HYG+CRI and IPNS+CRI (4 kg $ha^{-1}yr^{-1}$) followed by MYG+CRI (2 kg $ha^{-1}yr^{-1}$). This result is in agreement with Khan *et al.* (2005).

Zinc

The amount of nutrient added in different nutrient treatment was in the range of 0 to 2.15 kg ha^{-1} and uptake was in the range 0.12 to 0.65 kg $ha^{-1}yr^{-1}$with different treatments shown in Fig 5. Maximum uptake was observed in STB (0.65 kg $ha^{-1}yr^{-1}$) that was followed by IPNS (0.64 kg $ha^{-1}yr^{-1}$). Minimum uptake was found in CON (0.12 kg $ha^{-1}yr^{-1}$). The highest negative balance was noticed in FP (-0.31 kg $ha^{-1}yr^{-1}$) and the lowest in CON+CRI (-0.08 kg $ha^{-1}yr^{-1}$). Other treatments showed positive balance ranged from 1.12 to 1.61 kg $ha^{-1}yr^{-1}$. Among the treatments, maximum positive balance was noticed in HYG+CRI (1.61 kg $ha^{-1}yr^{-1}$) followed by IPNS+CRI (1.54 kg $ha^{-1}yr^{-1}$). Minimum positive balance was observed in MYG (1.12 kg $ha^{-1}yr^{-1}$). From the mean data of two years, it was noticed that farmers' practice and control treatments showed negative balance of zinc. Because there was poor and no nutrient (native nutrient was available only in the soil) was added into the soil whereas a considerable amount of nutrient was removed by the crop through total dry matter weight and nutrient concentration variation in respective treatments consequently the balance became negative. Similar results were reported by Bhuiyan (2004) in wheat-T. *Aus*/Mungbean-T.*Aman* rice cropping pattern and Basak *et al*. (2008) in Groundnut-T.*Aus*-T.*Aman* rice cropping pattern.

Boron

The range of added boron was 0 to 0.11 kg $ha^{-1}yr^{-1}$and uptake ranged from 0.04 to 0.27 kg $ha^{-1}yr^{-1}$. The uptake was the highest in both IPNS and STB (0.27 kg ha^{-1}) and the lowest uptake in CON (0.04 kg $ha^{-1}yr^{-1}$) in Fig. 6. The highest negative balance was found in both IPNS and STB (-0.27 kg $ha^{-1}yr^{-1}$) and the lowest negative balance was observed in CON+CRI (-0.01 kg $ha^{-1}yr^{-1}$). From the above results, it was observed that the balance was negative in all the treatments due to no addition of born nutrient in the soil from external sources (native boron available in the soil only). Although some amount of nutrient was removed by the plants for total dry matter production and variation of nutrient concentration (concentration table was not shown here). Similar results were reported by Bhuiyan (2004) in Wheat-T. *Aus*/ Mungbean- T. *Aman* rice cropping pattern.

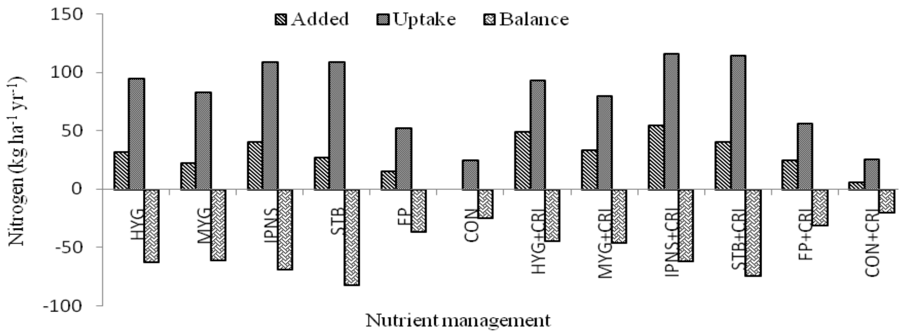

Fig. 1. Apparent N balance of T. *Aman* rice as influenced by different nutrients management (two years mean).

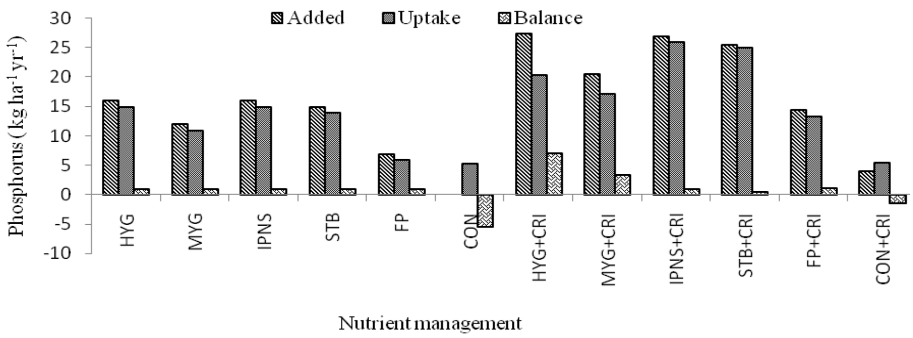

Fig. 2. Apparent P balance of T. *Aman* rice as influenced by different nutrients management (two years mean).

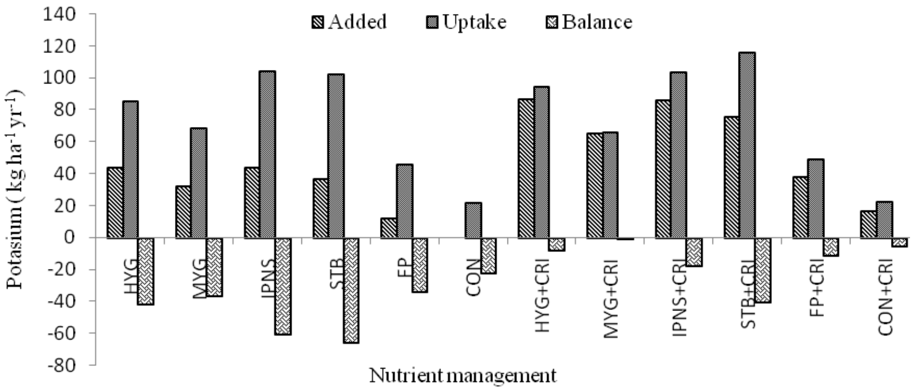

Fig. 3. Apparent K balance of T. *Aman* rice as influenced by different nutrients management (two years mean).

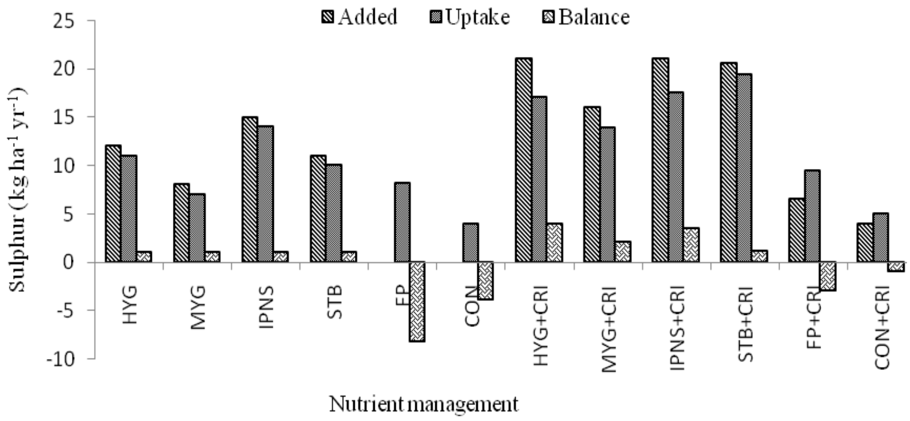

Fig. 4. Apparent S balance of T. *Aman* rice as influenced by different nutrients management (two years mean).

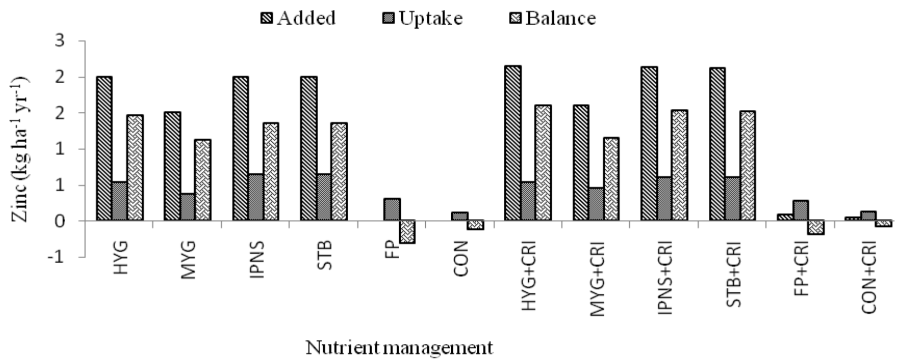

Fig. 5. Apparent Zn balance of T. *Aman* rice as influenced by different nutrients management (two years mean).

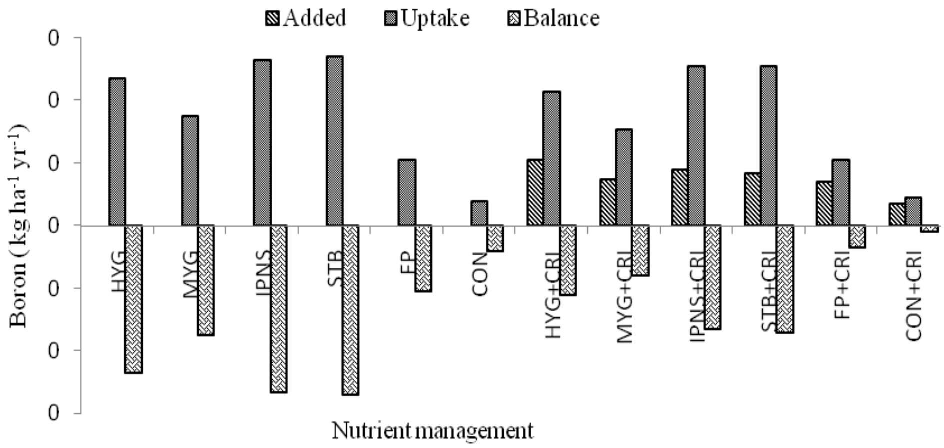

Fig. 6. Apparent B balance of T. *Aman* rice as influenced by different nutrients management (two years mean).

Economics of mungbean cultivation as influenced by different nutrient managements

Average of two years result showed that STB+CRI nutrient management gave the highest gross return (Tk. 55738 ha^{-1}) followed by IPNS+CRI (Tk. 54568 ha^{-1}), STB (Tk.54420 ha^{-1}) and IPNS (Tk. 53520 ha^{-1}) nutrient management treatments due to higher yield. Similar trend was followed in gross margin and net return. Due to higher yield obtained from STB nutrient management, higher BCR (3.25) followed by STB+CRI (3.14), IPNS (2.98) and IPNS+CRI (2.87). Similarly, the highest MBCR was found in STB (9.97) followed by STB+CRI (8.23) due to comparatively lower variable cost. Control plots produced the lowest gross return, gross margin, net return and BCR due to low yield (Table 4). The overall economic performance of the aforesaid of T. *Aman* rice is sustainable, considering applied STB nutrient management. STB+CRI nutrient management also gave higher gross margin, net return and BCR compared to other nutrient managements like STB. Many scientists (Ali *et al*., 2009; Biswas *et al*., 2004, 2007, 2008; Zaman *et al*., 2007 a & b) also reported that conducted similar type of experiments with different cropping patterns without crop residue incorporation into the soil and found more or less similar results. However, STB and IPNS nutrient managements along with and without crop residue incorporation might be suitable for T. *Aman* rice production in economic point of view.

Table 4. Economic performance of T. *Aman* rice as influenced by different nutrient managements (mean of 2007 and 2008).

Nutrient management	Total cost (Taka)	Variable Cost (Taka)	Gross return (Taka)	Gross margin (Taka)	Net return (Taka)	BCR	MBCR (over control)
	1	2	3	4=(3-2)	5=(3-1)	6=(3/1)	7
HYG	17310	4661	46903	42242	29593	2.71	7.19
MYG	16033	3384	38233	34849	22200	2.38	7.35
IPNS	17972	5323	53520	48197	35548	2.98	7.54
STB	16767	4118	54420	50302	37653	3.25	9.97
FP	14412	1763	26663	24900	12251	1.85	7.54
CON	12649	0	13383	13383	734	1.06	CON
HYG+CRI	18330	5681	47333	41652	29003	2.58	5.98
MYG+CRI	16963	4314	38603	34289	21640	2.28	5.85
IPNS+CRI	18987	6338	54568	48230	35581	2.87	6.50
STB+CRI	17797	5148	55738	50590	37941	3.14	8.23
FP+CRI	15172	2523	26933	24410	11761	1.78	5.37
CON+CRI	13179	530	13903	13373	724	1.06	0.98

HYG=0-80-16-44-12-2-0, MYG=0-56-12-32-8-1.5-0, IPNS=5-65-13-32-9-2-0, STB=0-68-15-37-11-2-0, FP=0-39-7-12-0-0-0, CON=0-0-0-0-0-0-0, CD (t ha^{-1}), N, P, K, S, Zn, B (kg ha^{-1}), respectively and CRI= Crop Residue Incorporation.

Input and output prices: Urea-6.50 (Tk. kg^{-1}), TSP-19.00, MP-15.00, Gypsum-4.60, Zincsulphate-65.00, Boric acid-100, Cowdung-0.32 and Crop reside-0.50 (dry basis), (Tk. kg^{-1}) Rice grain-10 and Rice straw-0.50 (dry basis)

Conclusion

Soil test based and integrated plant nutrient system nutrient management along with or without crop residue incorporation could be suitable for getting economically higher grain yield of T. *Aman* rice keeping improvement soil health.

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