

**SEED YIELD, NUTRIENT BALANCE AND ECONOMICS OF
MUNGBEAN CULTIVATION AS INFLUENCED BY DIFFERENT
NUTRIENTS MANAGEMENT UNDER AEZ-28**

M. A. H. S. JAHAN¹, M. A. R. SARKAR², N. C. D. BARMA³
M. N. A. MONDAL⁴ AND M. N. S. FERDOUSI⁵

Abstract

A field experiment was conducted at Regional Wheat Research Centre of the Bangladesh Agricultural Research Institute, Joydebpur, Gazipur, Bangladesh for 2 consecutive years during 2007 and 2008 to find out the optimum nutrient management practice for seed yield, nutrient balance and economics of mungbean. Twelve nutrient management treatments were tested in RCBD with 3 replications. Treatments were without CRI T₁=HYG (0-24-40-48-24-3-1.2), T₂=MYG (0-20-36-40-20-2-1), T₃=IPNS (5000-9-37-36-21-3-1.2), T₄=STB (0-20-36-40-22-2-1), T₅=FP (0-6-5-4-0-0-0), T₆=CON (0-0-0-0-0-0-0) and with CRI T₇=HYG+CRI, T₈=MYG+CRI, T₉=IPNS+CRI, T₁₀=STB+CRI, T₁₁=FP+CRI, T₁₂=CON+CRI kg ha⁻¹ CDNPKSZnB for mungbean. The maximum seed yield of mungbean was obtained from STB+CRI (1.57 t ha⁻¹) followed by IPNS+CRI (1.54 t ha⁻¹), STB (1.54 t ha⁻¹), IPNS (1.52 t ha⁻¹), HYG+CRI (1.44 t ha⁻¹) and HYG (1.41 t ha⁻¹) in 2007. Similar trend was found in 2008. Numerically higher yield and yield contributing parameters were noticed in CRI plots than without CRI. N and K balance were found negative in all the treatments. P, S, Zn and B balance were found positive in case of HYG, MYG, IPNS and STB along with or without CRI nutrient managements. While in case of FP and CON, the balance was shown almost negative. The maximum gross return and margin was obtained from STB+CRI followed by STB. Slightly higher BCR (3.00) was recorded from STB followed by STB+CRI (2.91).

Keywords: Mungbean, Seed yield, Economics, Nutrient balance and Crop Residue Incorporation.

Introduction

Bangladesh is a small country of 0.148 million sq.km and it has to feed about 145 million people of this country (BBS, 2012). In order to produce more food within a limited area, two most important techniques are to be adopted, which is to increase the productive efficiency of the individual crop depending on how well

¹Principal Scientific Officer, Regional Wheat Research Center, Bangladesh Agricultural Research Institute (BARI), Joydebpur, Gazipur, ²Professor, Department of Agronomy, Bangladesh Agricultural University (BAU), Mymensingh, ³Chief Scientific Officer, Regional Wheat Research Center, BARI, Joydebpur, Gazipur, ⁴Chief Scientific Officer, Regional Agricultural Research Station, BARI, Ishurdi, Pabna, ⁵SASP, PBI, BP, Dhaka, Bangladesh.

it utilizes the basic resources especially, water and nutrients. Bangladesh grows different types of pulse crops. Among the mungbean is one of the important one for its short duration character (Ahmed *et al.*, 1978). In our country mungbean ranks third in respect of acreage and production while it ranks first in respect of market price. Mungbean grain contains 51% carbohydrate, 26% protein, 10% moisture, 4% mineral and 3% vitamins (Kaul, 1982). Moreover, its residues have capacity to improve the soil fertility thus increase the productivity of land. The average yield of mungbean is 0.69 t ha⁻¹ which is very low compared to other mungbean growing countries. There are many reasons of low yield of mungbean of which optimum fertilizer from both organic and inorganic sources along with crop residue management are important which affect the yield contributing characters and seed yield of mungbean. Therefore, the present study was undertaken with the objectives to find out the optimum nutrient management practice for seed yield, apparent nutrient balance in soil and economics of mungbean 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). Mungbean was grown in the same location. 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 ($\mu\text{g g}^{-1}$) 3.76, exchangeable K (meq 100 g⁻¹) 0.15, available S ($\mu\text{g g}^{-1}$) 9.91, available Zn ($\mu\text{g g}^{-1}$) 0.24 and available B ($\mu\text{g g}^{-1}$) 0.16. Morphological characters are Grey Terrace soils, medium high land, not well drained, above flood level and grey soil colour. From the initial status of the soil, it was observed that physical characters are silty loam to loam having more or less near neutral soil pH with very low to low soil fertility level. Mungbean (BARI Mug 6), variety was tested in *Kharif-I* season during 2007 and 2008. Twelve nutrient management treatments were tested in RCBD with 3 replications. Treatments were T₁=HYG (0-24-40-48-24-3-1.2), T₂=MYG (0-20-36-40-20-2-1), T₃=IPNS (5000-9-37-36-21-3-1.2), T₄=STB (0-20-36-40-22-2-1), T₅=FP (0-6-5-4-0-0-0), T₆=CON (0-0-0-0-0-0-0), T₇=HYG+CRI, T₈=MYG+CRI, T₉=IPNS+CRI, T₁₀=STB+CRI, T₁₁=FP+CRI, T₁₂=CON+CRI kg ha⁻¹ CDNPKSZnB for mungbean. The previous crop was potato and total foliage (haulm) as residue of potato was incorporated before mungbean sowing. The rates for N, P, K, S, Zn and B application were calculated based on the soil test value following the soil test interpretation (BARC, 2005). Accordingly, the full or 100% rate of N, P, K, S, Zn and B 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, 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.

For HYG, MYG and IPNS management recommended cowdung was adjusted into chemical nutrient and added according to the thumb rule i.e. 1 ton decomposed cowdung contains 3 kg N, 0.6 kg P, 2.4 kg K and 0.6 kg S (BARC, 2005). The sources of N, P, K, S, Zn and B were urea, triple super phosphate (TSP), muriate of potash (MoP), gypsum, zincsulphate and boric acid, respectively. The farmers' practice (FP) for fertilizer rates was determined on the basis of data collected through interviewing thirty (30) farmers from adjacent locality. It appeared that the farmers generally did not use S, Zn and B fertilizers. Residue of previous potato crop was in-situ incorporated to the soil for crop residue incorporation plots only. Total fresh residue was chopped just after harvest and ploughed down to the soil by spade for decomposition in respective CRI plots with available moisture consequently that was decomposed. Moreover a light irrigation was applied for germination of mungbean seed which enhanced the decomposition of residue. Turn Around Time (TAT) was about 10-15 days potato harvest and mungbean sowing. Seeds were sown on 5-7 March each year in 30 cm of continuous solid lines @ 40 kg ha⁻¹ and seeds were covered with soil. The whole amount of urea TSP, MoP, gypsum, zincsulphate and boric acid were applied at the time of final land preparation as per treatment. The mungbean field was then irrigated at 15 and 30 days after germination. Weeding and plant protection measures were followed as and when necessary. Mungbean was harvested on 25-31 May each year. The crops were harvested at full maturity. An area of 10 m² in each plot was harvested to record seed and biomass yields. A sub-sample of 200 g dry biomass for each of crop was collected for chemical (nutrient uptake) analysis. The data on the yield contributing characters were

recorded from 10 randomly selected plants for mungbean. For dry biomass yield, total fresh biomass yield was measured from the harvested area. Then a sub-sample from each plot was collected and weighed to record fresh weight. The sub-samples were dried in an oven for 72 hours at 70°C. Oven dry of each sample was recorded and expressed as dry biomass yield (t ha⁻¹). Apparent nutrient balance (added-uptake) was calculated using the following formula.

$$X_a = (X_f + X_r + X_i + X_b + X_{cri}) - X_{rem}$$

Where

- X_a = Apparent gain (+) or loss (-) of nutrient (kg ha⁻¹)
 X_f = Nutrient added through inorganic sources (kg ha⁻¹)
 X_r = Nutrient added through rainfall (kg ha⁻¹). (Not considered)
 X_i = Nutrient added through irrigation water (kg ha⁻¹). (Not considered)
 X_b = Nutrient added through BNF (kg ha⁻¹). (Not considered)
 X_{cri} = Nutrient added through crop residue incorporation (kg ha⁻¹).
 X_{rem} = Nutrient removed by crops and loss through different systems (kg ha⁻¹).

Data were analyzed statistically by the F-test to examine whether the treatment effects were significant. The mean comparisons of the treatments were evaluated by DMRT (Duncan's Multiple Range Test).

Table 1. Total addition of extra nutrients into the soil through crop residues incorporation in mungbean (kg ha⁻¹yr⁻¹) during 2007 & 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

On an average of two years, major plant nutrients like N (6 to 18 kg ha⁻¹ yr⁻¹), P (4 to 12 kg ha⁻¹ yr⁻¹), K (17 to 44 kg ha⁻¹ yr⁻¹), S (4 to 10 kg ha⁻¹ yr⁻¹) and minor nutrients like Zn (0.05 to 0.15 kg ha⁻¹ yr⁻¹) and B (0.03 to 0.11 kg ha⁻¹ yr⁻¹) were added into the soil through crop residues incorporation. The amount was varied depend on irrespective treatment as well as the crop growth. That was an approach for conservation agriculture which might have played a vital role for

sustaining soil health like fertility and productivity. This approach might be helpful for a long run.

Results and discussion

Plants population

The number of plants m^{-2} did not vary significantly by different nutrient management treatments in both the years (Table 2).

Plant height

The nutrient management treatments without or with crop residues incorporation significantly influenced the plant height in both the years. The significantly taller plant was recorded under HYG with crop residues incorporation (37.2 cm) followed by remaining nutrient management treatments except, FP without CRI, control without and with CRI (28.4 cm). The treatment HYG+CRI produced the tallest plant (42.1 cm) which was statistically identical to HYG (41.6 cm), IPNS+CRI (41.1 cm) and STB+CRI (40.6 cm). The plant height under different nutrient management ranged from 30.3 cm to 36.1 cm whereas lowest (28.1 cm) in control in Table 2. However, the trend of plant height was observed more or less similar over the years that might be due to similar nutrient management but tendency is taller plant in CRI incorporation treatment might be due to crop residue effect (Naser *et al.*, 2001).

Pods plant⁻¹

Number of pods plant⁻¹ differed significantly due to application of nutrients without or with crop residues incorporation in 2007 (Table 2). The significant more number of pods plant⁻¹ (12.13) was obtained from STB+CRI followed by STB (12.10), IPNS+CRI (12.01), IPNS (11.98), HYG+CRI (10.83) and HYG (10.80). The lowest number was found in control (4.80) treatment. In 2008, the trend of number of pods plant⁻¹ due to nutrient management treatments was similar previous year.

The highest number of pods plant⁻¹ was obtained from the treatment STB without or with crop residues incorporation that might be due to proper nutrient management followed by IPNS and HYG without or with CRI. Similar findings were reported by Singh and Pareek (2003) where the highest number of pods plant⁻¹ was recorded with nutrient applied @ P_2O_{545} kg ha⁻¹ in mungbean. In another field experiment, Quayyum *et al.* (2002) also reported that STB nutrient $N_{20} P_{20} K_{20}$ gave the highest number of pods plant⁻¹ in wheat-mungbean- T. Aman rice cropping pattern.

Pod length

The nutrient management packages had significant effect on the length of pod in 2007. However, the nutrient management treatments HYG, MYG, IPNS, and STB without and with CRI showed statistically identical length of pod with exception of MYG without CRI. While in 2008, the maximum length of pod (9.65 cm) was obtained under STB+CRI which were statistically identical to all treatments except control. The minimum length of pod was recorded under control without CRI in both the years (Table 2).

However, the length of pod was more or less similar over the years might be due to the effect of similar nutrient management.

Seeds pod⁻¹

Different nutrient management treatments showed significant effect on seeds pod⁻¹ (Table 2). Among the treatments, STB+CRI gave the maximum seeds pod⁻¹ (9.81) followed by HYG and IPNS without or with CRI, and were statistically identical. Number of seeds pod⁻¹ was the lowest (5.37) in control in 2007. During 2008, most of the nutrient management treatments except, MYG, FP and control without or with CRI were statistically identical and varied from 9.53 to 10.43. The maximum number of seeds pod⁻¹ (10.43) was obtained under STB+CRI followed by STB (10.42). FP showed lower seeds pod⁻¹ in both the years.

The higher number of seeds pod⁻¹ in case of CRI treatment might be due to the effect of the crop residues incorporation. Similar trend was observed over the years because the nutrient management treatments were same in both the years. Similar findings were reported by Siag and Yadav (2003) where the maximum number of seeds pod⁻¹ was obtained when nutrient was applied @ S₄₀ kg ha⁻¹ in mungbean.

Seed weight

The nutrient management treatments HYG, IPNS and STB without and with CRI produced significantly higher 1000-seed weight that ranged from 45.77 to 47.57 g. Among the treatments, STB+CRI gave the maximum 1000-seed weight (47.57 g). The lowest 1000-seed weight (35.17 g) was recorded under the control treatment. Similar trend was found in 2008 but the values were higher than the previous year that might be due to crop residue incorporation (Table 2).

This observation might be due to residual effect of the crop residues although it was statistically identical in other crop in rice Naser *et al.*, 2001. In another field study, Singh and Pareek (2003) reported the maximum 1000-seed weight by using nutrient @ P₂O₅ 45 kg ha⁻¹ on mungbean.

Seed yield

Most of the nutrient management treatments except MYG, FP and control without or with crop residue incorporation were statistically identical for seed yield in 2007. All those treatments yielded 1.41 to 1.57 t ha⁻¹ and were superior to MYG, FP and control with or without crop residue incorporation. The treatment STB+CRI produced the highest seed yield (1.57 t ha⁻¹). On the other hand, MYG without or with CRI produced 1.24 and 1.26 t ha⁻¹, respectively. FP produced lower yield in the range of 0.63 to 0.64 t ha⁻¹. The lowest yield was 0.33 t ha⁻¹ in control plot. In 2008, the trend of seed yield due to nutrient management treatments was similar to the findings of previous year.

Moreover, it was observed that the nutrient management treatments like, HYG, IPNS and STB without or with crop residues incorporation gave higher seed yield. These results might be due to the cumulative effect of higher number of pods plant⁻¹, seeds pod⁻¹ and 1000-seed weight. Among the treatments, STB produced the highest yield while lowest seed yield in control. However, the seed yield was numerically higher, though not statistically significant in all the treatments along with crop residues incorporation than without CRI might be due to effect of crop residue incorporation as well as more soil microbial activities for having conservation agriculture. Similar results were reported by Akhterruzzaman *et al.* (2009) where they observed the highest seed yield of mungbean with STB nutrient (N₂₂ P₉ K₁₁ S₂ kg ha⁻¹) in wheat-mungbean-T. Aman rice cropping pattern in high Ganges river floodplain soil. Timsina *et al.* (2006 a) reported the maximum seed yield from STB nutrient @ N₂₀ P₂₀ K₂₀ in wheat-mungbean-T. Aman rice cropping pattern in northern part of Bangladesh. In addition, Chowdhury *et al.* (2002) revealed that STB nutrient N₁₅ P₁₅ K₀ S₁₀ kg ha⁻¹ gave the highest mungbean seed yield in wheat-mungbean-T. Aman rice cropping pattern. Moreover, these results were also in agreement with other authors (Saha *et al.*, 2000; Quayyum *et al.*, 2001 and 2002; Singh *et al.*, 2003).

Dry biomass yield

The maximum dry biomass yield (2.36 t ha⁻¹) was obtained from HYG+CRI, which was statistically identical to HYG (2.32 t ha⁻¹), IPNS+CRI (2.29 t ha⁻¹), IPNS (2.27 t ha⁻¹), STB+CRI (2.14 t ha⁻¹) and STB (2.10 t ha⁻¹). The trend was similar to the previous year with some exception in 2008. HYG+CRI produced the highest biomass yield (2.51 t ha⁻¹), which was statistically identical to a number of treatments. The lowest biomass yield of 0.97 and 1.01 t ha⁻¹ was recorded in control treatment in 2007 and 2008 (Table 2).

Table 1. Crop characters, yield components and yield of mungbean as influenced by different nutrient management during 2007 and 2008.

Nutrient manage	Number of plants m ⁻²		Plant height (cm)		Number of pods plant ⁻¹		Length of pod (cm)		Number of seeds pod ⁻¹		1000-seed weight (g)		Seed yield (t ha ⁻¹)		Biomass yield (t ha ⁻¹)	
	2007	2008	2007	2008	2007	2008	2007	2008	2007	2008	2007	2008	2007	2008	2007	2008
HYG	32.0	32.3	36.5 ab	41.6 a	10.80 ab	11.30 ab	7.60 ab	8.12 a	9.49 ab	9.53 ab	45.77 ab	50.15 ab	1.41 ab	1.48 ab	2.32 a	2.47 ab
MYG	32.0	32.2	33.2 abc	32.4 bc	9.07 b	9.51 b	6.83 bc	8.09 a	8.73 b	7.77 bc	39.37 bc	43.42 bc	1.24 b	1.30 b	1.85 c	2.00 bc
IPNS	32.5	32.3	36.1 ab	36.1 b	11.98 a	12.48 a	8.65 ab	9.15 a	9.69 a	10.31 a	47.48 a	52.03 a	1.52 a	1.69 a	2.27 a	2.42 ab
STB	32.6	32.8	34.8 ab	35.3 b	12.10 a	12.61 a	8.87 a	9.61 a	9.78 a	10.42 a	47.51 a	52.25 a	1.54 a	1.71 a	2.10 ab	2.25 ab
FP	32.0	32.2	31.9 bc	30.3 cd	5.90 c	6.18 c	7.23 ab	7.83 a	6.87 c	7.33 c	39.17 bc	43.52 bc	0.63 c	0.71 c	1.42 d	1.51 d
CON	31.7	32.0	28.4 c	28.1 d	4.80 c	5.01 c	5.13 c	5.35 b	5.37 d	5.57 c	35.17 c	38.31 c	0.33 d	0.38 d	0.97 e	1.01 e
HYG+CRI	32.1	32.7	37.2 a	42.1 a	10.83 ab	11.34 ab	7.77 ab	8.42 a	9.51 ab	9.61 ab	45.81 ab	50.23 ab	1.44 ab	1.51 ab	2.36 a	2.51 a
MYG+CRI	32.3	32.3	34.3 ab	34.5 bc	9.10 b	9.54 b	7.30 ab	8.31 a	8.76 b	7.81 bc	39.43 bc	43.52 bc	1.26 b	1.32 b	1.88 bc	2.02 abc
IPNS+CRI	31.9	32.7	37.0 ab	41.1 a	12.01 a	12.60 a	8.70 ab	9.17 a	9.70 a	10.32 a	47.52 a	52.07 a	1.54 a	1.70 a	2.29 a	2.49 ab
STB+CRI	32.3	33.0	36.1 ab	40.6 a	12.13 a	12.73 a	9.13 a	9.65 a	9.81 a	10.43 a	47.57 a	52.37 a	1.57 a	1.73 a	2.14 a	2.30 ab
FP+CRI	32.0	32.2	32.3 abc	32.9 bc	6.00 c	6.21 c	7.27 ab	7.95 a	6.91 c	7.36 c	39.20 bc	43.60 bc	0.64 c	0.72 c	1.45 d	1.65 cd
CON+CRI	31.9	32.2	28.8 c	28.1 d	4.83 c	5.03 c	5.17 c	5.39 b	5.43 d	5.59 c	35.50 c	38.51 c	0.36 d	0.41 d	1.02 e	1.03 e
CV (%)	5.25	8.43	5.91	4.90	8.84	9.19	9.93	9.80	4.11	9.89	6.46	5.85	7.51	10.27	6.96	9.63
Lev. 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.

HYG=0-24-40-48-24-3-1-2, MYG=0-20-36-40-20-2-1, IPNS=5000-9-37-36-21-3-1-2, STB=0-20-36-40-22-2-1, FP=0-6-5-4-0-0-0, CON=0-0-0-0-0-0-0, CD, N, P, K, S, Zn, B (kg ha⁻¹), respectively and CRI= Crop Residue Incorporation.

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.

From the results of two years, it was found that HYG, IPNS and STB nutrient management treatments without or with CRI gave higher dry biomass yield. These results might be due to the effect of proper nutrient management, while MYG and FP gave and low biomass yield might be due to the effect of respective nutrient management. The lowest biomass yield was noticed in control as influenced no nutrient added into the soil i.e. native nutrient effect. However, over all the trend was more or less similar over the years might be due to applying the same nutrient management treatments. Chowdhury *et al.* (2002) reported that STB nutrient $N_{15} P_{15} K_0 S_{10}$ kg ha⁻¹ produced the highest dry biomass yield in wheat-mungbean-T. *Aman* rice cropping pattern.

Apparent nutrient uptake and balance

Total nutrient uptake (seed+ biomass) of N P K S Zn and B was significantly influenced by different nutrient management treatments in 2007 and 2008 for mungbean (statistically analyzed but not shown here) and balance (two years mean) (not statistically analyzed) was calculated normally and discussed below (Fig. 1-6).

Nitrogen

From the mean data it was observed that the added of nutrient ranged from 0 to 41 kg ha⁻¹yr⁻¹ (40% of applied chemical/cowdung/crop residues nutrient N was considered effective) while uptake ranged from 26 to 93 kg ha⁻¹yr⁻¹ among different treatments (Fig.1). Maximum uptake was found in STB (93 kg ha⁻¹yr⁻¹) followed by STB+CRI (91 kg ha⁻¹yr⁻¹). Minimum uptake was estimated in CON (26 kg ha⁻¹yr⁻¹). The apparent nutrient balance was found negative in all treatments ranging from -26 to -73 kg ha⁻¹yr⁻¹. The highest negative balance was found in STB (-73 kg ha⁻¹yr⁻¹) followed by HYG and IPNS (-65 kg ha⁻¹yr⁻¹). The lowest negative balance was observed in CON+CRI (-21 kg ha⁻¹yr⁻¹).

Fig. 1, shows 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). 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 crop residues (6 to 18 kg ha⁻¹yr⁻¹) as shown (Table 2). Present findings are also in agreement with some other researchers (Timsina *et al.*, 2001 and 2006 (b)).

Phosphorus

The added phosphorus was in the range from 0 to 52 kg ha⁻¹yr⁻¹ in respective of different treatments. The uptake was ranged from 5 to 19 kg ha⁻¹yr⁻¹. The

treatments STB +CRI showed the highest uptake ($19 \text{ kg ha}^{-1}\text{yr}^{-1}$) followed by IPNS+CRI ($18 \text{ kg ha}^{-1}\text{yr}^{-1}$). The lowest uptake was found in CON and CON+CRI ($5 \text{ kg ha}^{-1}\text{yr}^{-1}$). The negative balance was found in CON+CRI and CON -1 and -5 $\text{kg ha}^{-1}\text{yr}^{-1}$, respectively and FP ($-5 \text{ kg ha}^{-1}\text{yr}^{-1}$) nutrient management treatments from mean data shown in Fig. 2. On the other hand, remaining treatments showed positive balance in the range of $3\text{-}35 \text{ kg ha}^{-1}\text{yr}^{-1}$. Maximum positive balance was found in HYG+CRI ($35 \text{ kg ha}^{-1}\text{yr}^{-1}$) followed by IPNS+CRI ($33 \text{ kg ha}^{-1}\text{yr}^{-1}$). Minimum positive balance was noticed in FP+CRI ($3 \text{ kg ha}^{-1}\text{yr}^{-1}$).

From the figure 2, it was observed that the except FP and CON without or with crop residue incorporation treatments showed positive balance due to addition of higher amount of phosphorus nutrient with lower nutrient uptake that might be due to total dry matter content as well as the variation of concentration of the nutrient of the crops. Similar results were also found by Saleque *et al.* (2006).

Potassium

The quantity of added nutrient (K) was in the range of 0 to $90 \text{ kg ha}^{-1}\text{yr}^{-1}$ and uptake by the crop varied from 21 to $65 \text{ kg ha}^{-1}\text{yr}^{-1}$. Maximum uptake was found in IPNS+CRI and STB+CRI ($65 \text{ kg ha}^{-1}\text{yr}^{-1}$) followed by IPNS and STB ($64 \text{ kg ha}^{-1}\text{yr}^{-1}$). Minimum uptake was observed in CON ($21 \text{ kg ha}^{-1}\text{yr}^{-1}$). Among the nutrient managements, all treatments showed negative balance in the range of -4 to $-29 \text{ kg ha}^{-1}\text{yr}^{-1}$ except HYG+CRI, MYG+CRI, IPNS+CRI and STB+CRI. The positive balance ranged from 14 to $31 \text{ kg ha}^{-1}\text{yr}^{-1}$. Maximum positive balance was observed in HYG+CRI ($31 \text{ kg ha}^{-1}\text{yr}^{-1}$) and minimum was found in both STB+CRI ($14 \text{ kg ha}^{-1}\text{yr}^{-1}$) as shown in Fig. 3. This result is also agreement with Panaullah *et al.* (2006) but differed from Rahman *et al.*, 2002.

Sulphur

From the mean data it was observed that quantity of added nutrient ranged from 0 to $33 \text{ kg ha}^{-1}\text{yr}^{-1}$ and the uptake ranged from 4 to $15 \text{ kg ha}^{-1}\text{yr}^{-1}$ with irrespective treatments. Among the treatments, maximum uptake was observed in STB+CRI ($15 \text{ kg ha}^{-1}\text{yr}^{-1}$) followed by IPNS+CRI ($13 \text{ kg ha}^{-1}\text{yr}^{-1}$). Minimum uptake was found in CON and CON+CRI ($4 \text{ kg ha}^{-1}\text{yr}^{-1}$). The negative balance as observed in FP and CON with and without CRI treatments was -1 to $-8 \text{ kg ha}^{-1}\text{yr}^{-1}$. Remaining treatments showed positive balance ranged from 8 to $22 \text{ kg ha}^{-1}\text{yr}^{-1}$ shown in Fig. 4. Among the treatments, the maximum positive balance was observed in HYG+CRI ($22 \text{ kg ha}^{-1}\text{yr}^{-1}$) that was followed by IPNS+CRI ($20 \text{ kg ha}^{-1}\text{yr}^{-1}$). The minimum positive balance was found in MYG ($8 \text{ kg ha}^{-1}\text{yr}^{-1}$).

From the above results it was observed that only two treatments such as FP and CON with and without CRI showed negative balance (two years mean) due to addition of low or no nutrient in the soil as uptake was high which might be due

to total dry matter accumulation and variation of nutrient concentration of respective treatments. Rest of the treatments showed positive balance that might be due to addition of high amount of nutrient. The 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 3 kg ha⁻¹ and uptake was in the range 0.06 to 0.20 kg ha⁻¹yr⁻¹ with different treatments shown in Fig 5. Maximum uptake was observed in IPNS (0.21 kg ha⁻¹yr⁻¹) that was followed by a number of treatments like STB, STB+CRI and IPNS+CRI (0.20 kg ha⁻¹yr⁻¹). Minimum uptake was found in CON and CON+CRI (0.06 kg ha⁻¹yr⁻¹). The highest negative balance was noticed in FP (-0.10 kg ha⁻¹yr⁻¹) and the lowest in CON+CRI (-0.01 kg ha⁻¹yr⁻¹). Other treatments showed positive balance ranged from 1.80 to 2.96 kg ha⁻¹yr⁻¹. Among the treatments, maximum positive balance was noticed in HYG+CRI (2.96 kg ha⁻¹yr⁻¹) which was followed by IPNS+CRI (2.93 kg ha⁻¹yr⁻¹). Minimum positive balance was observed in STB (1.80 kg ha⁻¹yr⁻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 production and nutrient concentration variation in respective treatments consequently the balance became negative. On the other hand, rest of the treatments had positive balance. Similar results were reported by Basak *et al.* (2008) in Groundnut-T. *Aus*-T. *Aman* rice cropping pattern.

Boron

The range of added boron was 0-1.20 kg ha⁻¹yr⁻¹ and uptake ranged from 0.04 to 0.15 kg ha⁻¹yr⁻¹. The uptake was the highest in STB (0.15 kg ha⁻¹yr⁻¹). The CON and CON+CRI (0.04 kg ha⁻¹yr⁻¹) had the lowest uptake. The minimum negative balance was found in FP+CRI and CON+CRI (-0.01 kg ha⁻¹yr⁻¹) and the maximum was in FP (-0.07 kg ha⁻¹yr⁻¹) in Fig. 6. Other treatments showed positive balance ranged from 0.86 to 1.17 kg ha⁻¹yr⁻¹. The highest positive balance was found in HYG+CRI (1.17 kg ha⁻¹yr⁻¹). The lowest positive balance was observed in STB (0.86 kg ha⁻¹yr⁻¹). Similar results were reported by Bhuiyan (2004) in Wheat-T. *Aus*/ Mungbean- T. *Aman* rice cropping pattern.

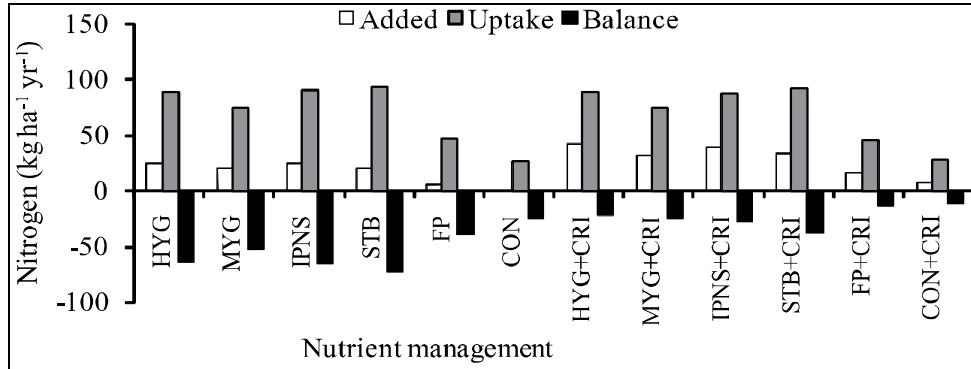


Fig. 1. Apparent N balance of mungbean as influenced by different nutrient management at (two years mean)

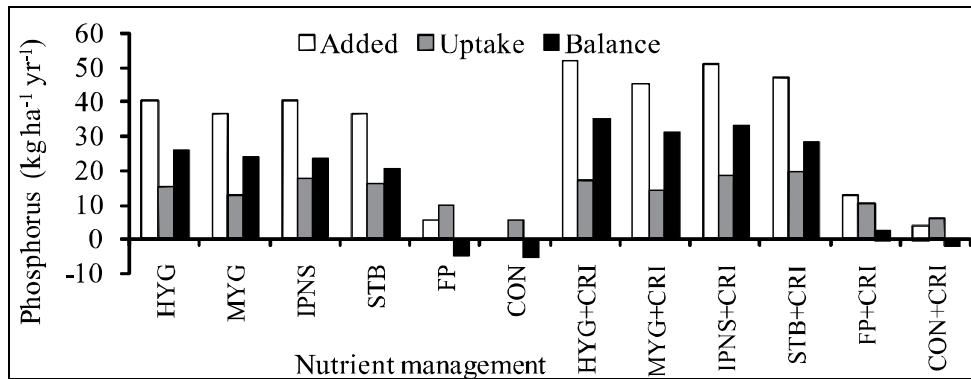


Fig. 2. Apparent P balance of mungbean as influenced by different nutrient management (two years mean)

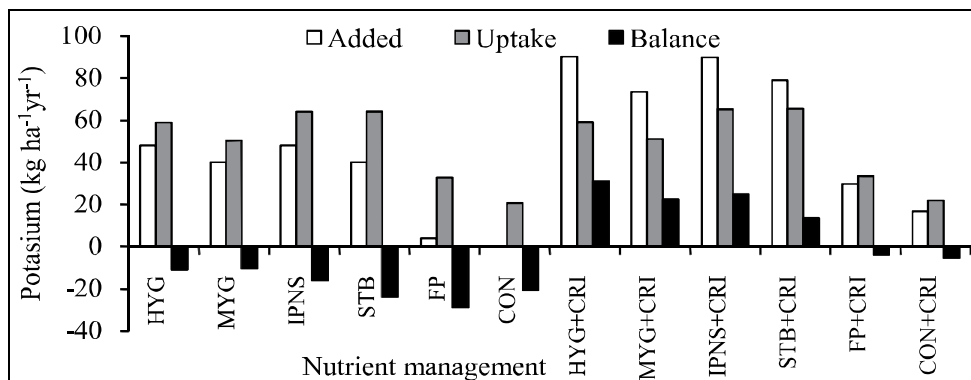


Fig. 3. Apparent K balance of mungbean as influenced by different nutrient management two years mean)

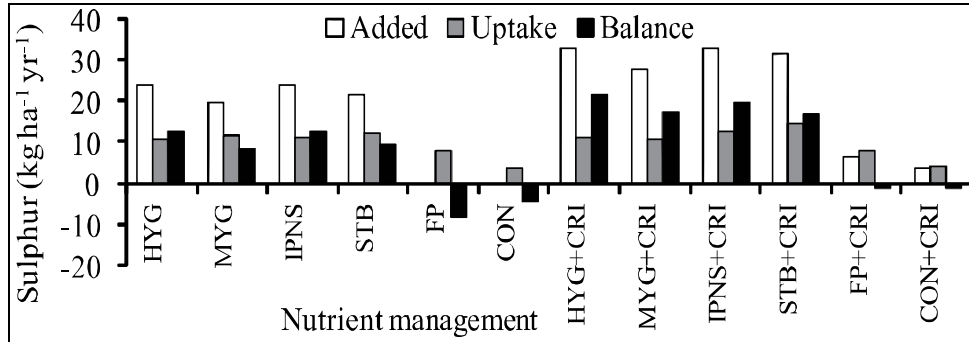


Fig. 4. Apparent S balance of mungbean as influenced by different nutrient management (two years mean)

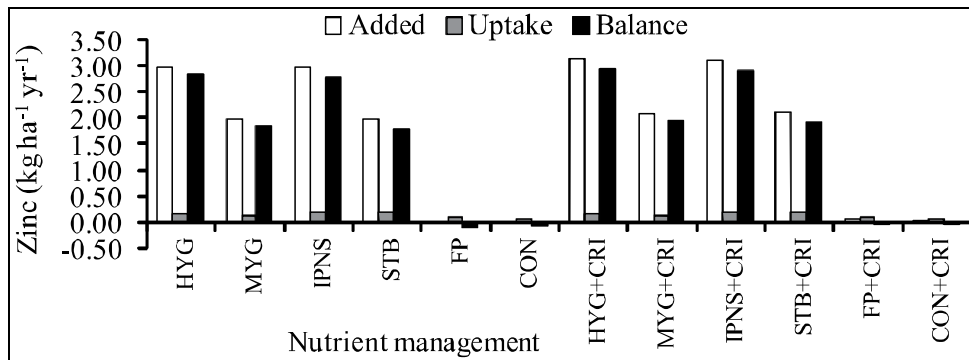


Fig. 5. Apparent Zn balance of mungbean as influenced by different nutrient management (two years mean).

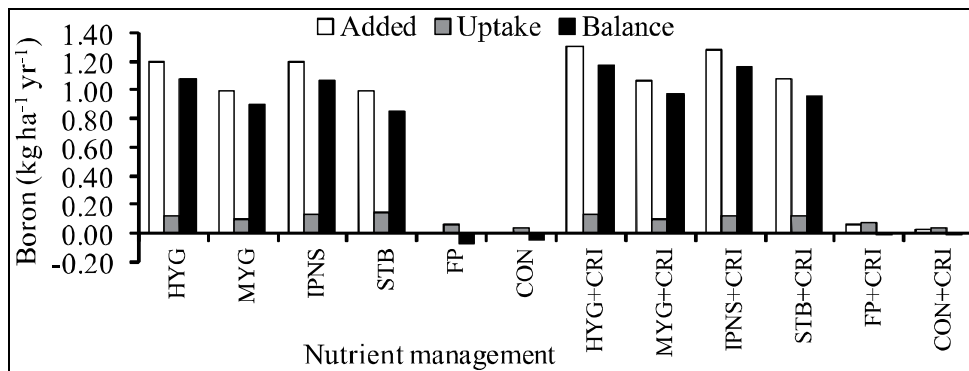


Fig.6. Apparent B balance of mungbean as influenced by different nutrient management (two years mean).

Economics of mungbean cultivations influenced by different nutrient management

Average of two years result showed that STB+CRI nutrient management gave the highest gross return (Tk. 41859 ha⁻¹) followed by STB (Tk. 41224 ha⁻¹), IPNS+CRI (Tk. 40981 ha⁻¹), and IPNS (Tk. 40844 ha⁻¹) nutrient management treatments due to higher yield. Table 3 revealed that STB+CRI nutrient management produced the highest net return (Tk. 27470 ha⁻¹) followed by STB (Tk. 27463 ha⁻¹), IPNS (Tk. 25394 ha⁻¹), and IPNS+CRI (Tk. 24908 ha⁻¹) due to lower total costs. In STB nutrient management, the cost of crop residue was not considered in the calculation that resulted in low total cost. Due to higher yield obtained STB nutrient management was much profitable (BCR, 3.00) compared to other nutrient managements like STB+CRI (2.91), IPNS (2.64), and IPNS+CRI (2.55). Control plots produced the lowest gross return, net return and BCR due to low yield. The overall economic performance of the aforesaid mungbean is sustainable and feasible considering applied STB nutrient management. The other best alternative nutrient managements were STB+CRI, IPNS, and IPNS+CRI. Nevertheless, STB+CRI nutrient management also gave higher net return compared to other nutrient managements like STB. Many scientists (Ali *et al.*, 2009 a and b; Biswas *et al.*, 2004, 2007, 2008; Zaman *et al.*, 2007 a and b) also 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 mungbean production as well as economic point of view.

Table 3. Economic performance of potato as influenced by different nutrient management (mean of 2006-07 and 2007-08).

Nutrient management	Total cost (Taka)	Gross return (Taka)	Net return (Taka)	BCR
	1	2	3=(2-1)	4=(2/1)
HYG	14788	37044	22256	2.51
MYG	13705	32232	18527	2.36
IPNS	15450	40844	25394	2.64
STB	13761	41224	27463	3.00
FP	8115	17117	9002	2.11
CON	7287	9123	1836	1.26
HYG+CRI	15355	37052	21696	2.41
MYG+CRI	14210	32363	18153	2.28
IPNS+CRI	16072	40981	24908	2.55
STB+CRI	14389	41859	27470	2.91
FP+CRI	8527	17387	8859	2.04
CON+CRI	7542	9880	2338	1.31

Here, HYG=0-24-40-48-24-3-1.2, MYG=0-20-36-40-20-2-1, IPNS=5-9-37-36-21-3-1.2, STB=0-20-36-40-22-2-1, FP=0-6-5-4-0-0-0, 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. BCR=Benefit-cost ratio ; MBCR=Marginal benefit-cost ration

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 residue-0.25 (Tk. kg⁻¹) (dry basis) .

Mungbean seed -25 (Tk. kg⁻¹) and Biomass-0.25 (Tk. kg⁻¹) (dry basis)

Conclusion

Soil test based (0-20-36-40-22-2-1 CDNPKSZnB kg ha⁻¹) and integrated plant nutrient system (5-9-37-36-21-3-1.2 CDNPKSZnB kg ha⁻¹) along with or without crop residue incorporation could be suitable for getting higher seed yield with profitable cultivation of mungbean keeping sustainable good soil health.

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