ISSN 0258-7122
Bangladesh J. Agril. Res. 36(4): 697-710, December 2011

EFFECTS OF INTEGRATED USE OF FERTILIZERS AND MANURE ON YIELD AND NUTRIENT UPTAKE OF T.AUS RICE AND MUNGBEAN IN THE WHEAT-T.AUS RICE/MUNGBEAN-T.AMAN RICE CROPPING PATTERN

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Abstract

An experiment was carried out at the Bangladesh Agricultural University (BAU) Farm, Mymensingh from *rabi* season of 1999 to *kharif-II* season of 2002 in the Old Brahmaputra Floodplain Soils (AEZ 9, Aeric Haplaquept) of Bangladesh to investigate the effect of integrated use of organic and inorganic fertilizers on yield and nutrient uptake of T.Aus rice and mungbean in the Wheat-T. Aus/Mungbean-T.Aman cropping pattern. There were four treatments for wheat- T_1: Control, T_2: NPKSZnB (MYG), T_3: NPKSZnB (HYG) and T_4: NPKSZnB (MYG) + CD. The nutrient rates for four treatments of wheat were $N_0P_0K_0S_0Zn_0B_0$ kg/ha for T_1, $N_{80}P_{20}K_{50}S_{10}Zn_1B_1$ kg/ha for T_2, $N_{120}P_{30}K_{75}S_{15}Zn_2B_2$ kg/ha for T_3 and $N_{80}P_{20}K_{50}S_{10}Zn_1B_1$ kg/ha + CD (5 t/ha) for T_4. In T. Aus/Mungbean one-third plot of each treatment was cultivated by T. Aus rice and the rest two-thirds plot by mungbean. The rates of N, P, K, and S for T. Aus rice were, respectively, 60, 12, 32 and 5 kg/ha for MYG, and 90, 18, 48 and 7.5 kg/ha for HYG. The corresponding rates of P, K, and S for mungbean were 10, 13, and 5 kg/ha for average yield goal (AYG). The results showed that grain (3.46 t/ha) and straw yields (5.19 t/ha) of T. Aus rice increased significantly due to application of fertilizers. The highest mean seed yield of 0.56 t/ha and stover yield of 1.99 t/ha in mungbean were obtained from PKS plus inoculum plus residual NPKSZnB for HYG treatment. The N, P, K, S, Zn, and B uptake by T.Aus/Mungbean remarkably increased with increasing supply of nutrients. The highest uptake of N, P, K, S, Zn, and B by the crops was noted in the treatment T_3 that received HYG fertilizers in T. Aus rice. The removal of N ranged from 27.3 to 63.2 kg/ha and 29.8 to 48.1 kg/ha, P from 5.62 to 15.80 kg/ha and 2.60 to 4.69 kg/ha, K from 35.8 to 71.8 kg/ha and 21.9 to 37.4 kg/ha, S from 4.08 to 10.26 kg/ha and 2.12 to 4.11 kg/ha, Zn from 44 to 132 g/ha and 56 to 101 g/ha, B from 17 to 70 g/ha and 7 to 16 g/ha by T.Aus rice and mungbean, respectively. Application of cowdung along with chemical fertilizers resulted in markedly higher uptake of nutrients. The application of NPKS (HYG) fertilizers remarkably increased the crop yield. The lowest grain yield and the lowest nutrient uptake were noted in control plots receiving no fertilizer or manure.

Keywords: T.Aus rice, mungbean, fertilizers, yield, uptake.

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Introduction

Rice-wheat is one of the widespread cropping systems in Bangladesh covering an area of 650,000 ha in Bangladesh (Morris *et al*., 1997; Bhuiyan *et al*., 2010). This cropping system has a capacity to produce more than 8 tons of cereal grain per ha per year removing 400 to 700 kg/ha nutrients from soil against the application of 440 kg/ha nutrients (Prasad *et al.*, 1999; Bhuiyan *et al*., 2010). Thus, farmers need to increase fertilizer doses each year to sustain the same yield levels which had been obtained with relatively low amounts of fertilizers in the past (Islam, 2002). In addition, deficiencies of a number of micronutrients, such as zinc, manganese and boron, and secondary nutrients like sulphur have been reported (Uddin *et al*., 2002). These nutrient deficiencies have resulted in the decline of yields of rice or/and wheat as well as a reduction in factor productivity at a number of locations where long-term trials have been conducted (Haque *et al*., 2002). However, there were no declining yield trends in high-N applications, but yields declined in control treatments (Yadav *et al*., 2000).

A crop production system with high yield targets cannot be sustainable unless nutrient inputs to soil are at least balanced against nutrient removal by crops (Bhuiyan *et al*., 1991). The use of chemical fertilizers as a supplemental source of nutrients has been increasing steadily in Bangladesh, but usually these are not applied in balanced proportions by most of the farmers (BARC, 1997). Based on their extensive review, Rijmpa and Jahiruddin (2004) reported that the overall N balances of Bangladesh soil were negative (-10 to –100 kg N/ha per yr), the P balances were near zero and the K balances were highly negative (-100 to –225 kg/ha per yr). The apparent balance of N in rice-wheat system was also found negative (Timsina *et al*., 2001). Application of balanced doses of chemical fertilizers and integrated use of cowdung, ash, and chemical fertilizers gave positive yield trend of rice in long-term experiment at BRRI farm (Saleque *et al*., 2004).

Mungbean is a common grain legume grown in the summer to utilize the gap between winter and rainy season crops. Incorporation of mungbean residues after picking pods has been found as effective as green manuring with other legumes, such as *Sesbania* in increasing the productivity of a rice-wheat system (Ahlawat *et al.*, 1998). This study was carried out to find out the effects of organic and inorganic fertilizers on yield and nutrient uptake of T.Aus rice and mungbean in the Wheat-T. Aus/Mungbean/T.Aman cropping pattern.

Materials and Method

A pattern based experiment was launched in *rabi* season of 1999 at the Bangladesh Agricultural University Farm, Mymensingh, Bangladesh to find out

the integrated use of inorganic and organic fertilizers on yield and nutrient uptake by T.Aus rice and mungbean in Wheat-T.Aus rice/Mungbean-T.Aman cropping sequence. The study was continued in the same field having the same layout for three consecutive years. The soil had pH 6.9, CEC 11.7 cmol/kg soil, organic carbon 1.01%, total N 0.10%, available P 10.0 μg/g, exchangeable K 0.13 cmol/kg soil, available S 14.0 μg/g, available Zn 1.71 μg/g and available B 0.20 μg/g having silty clay loam in texture.

Treatment and experimental design: The experiment comprised of four treatments for the first crop (wheat), eight for the second crop (T.Aus and Mungbean) and 12 for the 3rd crop (T.Aman), and was laid out in a randomized complete block design with three replications. The plot size was 5m x 4m. The application rates of N, P, K, S, Zn, and B for wheat were 80, 20, 50, 10, 1, and 1 kg/ha for moderate yield goal (MYG) and 120, 30, 75, 15, 2 and 2 kg/ha for high yield goal (HYG). The rates of N, P, K, and S for T.Aus rice were 60, 12, 32, and 5 kg/ha for MYG and 90, 18, 48 and 7.5 kg/ha for HYG. The corresponding rates of P, K, and S for mungbean (also second crop of the pattern) were 10, 13 and 5 kg/ha, respectively, for average yield goal (AYG). The rates of N, P, K, and S for T.Aman rice (third crop of the pattern) were 60, 12, 32, and 5 kg/ha for MYG and 90, 18, 48, and 7.5 kg/ha for HYG.

Fertilizer application: The fertilizer doses for moderate yield goal (MYG) and high yield goal (HYG) of wheat, T.Aus rice, and T.Aman rice, and for average yield goal (AYG) of mungbean were decided on soil test basis (STB) using Fertilizer Recommendation Guide (BARC, 1997). For the treatment T_4, the fertilizer dose was same as of T_2 but decomposed cowdung @ 5 t/ha (fresh weight basis) was applied before sowing wheat. One third of urea N and full doses of P, K, S, Zn, B were applied as basal at final land preparation. The remaining $^2/_3^{rd}$ urea were top-dressed in two equal splits at the time of 1st irrigation (17-22 DAS) and at 2nd irrigation (50 DAS).

Sowing/transplanting: Thirty days old seedlings of T.Aus rice was transplanted in the experimental plots within 1st week of May. A distance of 20 cm x 20 cm was maintained. Three seedlings were used in each hill. Seeds of mungbean were sown on 11 May 2000, 27 March 2001 and 28 March 2002. Sowing was done @ 35 kg seed/ha.

Harvesting: T.Aus rice was harvested in last week of July in each year and mungbean were harvested in last week of July in 1st year and last week of June in 2nd and 3rd year. Yield data were collected from 4m x 3m area of each plot. Grains/seed and straw/stover were dried and weighed adjusting at 14% moisture content and yields were converted to t/ha. The yield and yield attributing data were recorded.

Treatment combinations

1st crop-*rabi* (Wheat)	2nd crop-*kharif*-I (T.Aus/Mungbean)	3rd crop-*kharif*-II (T.Aman)
T_1: Control ($N_0P_0K_0S_0Zn_0B_0$ kg/ha)	$T_{1.1}$: T. Aus: Control	$T_{1.1}$: Control
	$T_{1.2}$: Mungbean: Control	$T_{1.2.1}$: Mungbean residue not incorporated + Control
		$T_{1.2.2}$: Mungbean residue incorporated + Control
T_2: Nutrient rates on soil test basis (MYG) ($N_{80}P_{20}K_{50}S_{10}Zn_1B_1$ kg/ha)	$T_{2.1}$: T. Aus NPKS (MYG) ($N_{60}P_{12}K_{32}S_5$ kg/ha)	$T_{2.1}$: NPKS (MYG) ($N_{60}P_{12}K_{32}S_5$ kg/ha)
	$T_{2.2}$: Mungbean PKS ($P_{10}K_{13}S_5$ kg/ha) + *Rhizobium* inoculum	$T_{2.2.1}$: Mungbean residue not incorporated + NPKS (MYG) ($N_{60}P_{12}K_{32}S_5$ kg/ha)
		$T_{2.2.2}$: Mungbean residue incorporated + Reduced dose of inorganic fertilizers (MYG) ($N_{32}P_9K_5S_3$ kg/ha)
T_3: Nutrient rates on soil test basis (HYG) ($N_{120}P_{30}K_{75}S_{15}Zn_2B_2$ kg/ha)	$T_{3.1}$: T. Aus NPKS (HYG) ($N_{90}P_{18}K_{48}S_{7.5}$ kg/ha)	$T_{3.1}$: NPKS (HYG) ($N_{90}P_{18}K_{48}S_{7.5}$ kg/ha)
	$T_{3.2}$: Mungbean PKS ($P_{10}K_{13}S_5$ kg/ha) + *Rhizobium* inoculum	$T_{3.2.1}$: Mungbean residue not incorporated + NPKS(HYG) ($N_{90}P_{18}K_{48}S_{7.5}$ kg/ha)
		$T_{3.2.2}$: Mungbean residue incorporated + Reduced dose of inorganic fertilizers (HYG) ($N_{59}P_{15}K_{17}S_5$ kg/ha)
T_4: Nutrient rates on soil test basis (MYG) ($N_{80}P_{20}K_{50}S_{10}Zn_1B_1$ kg/ha) + CD (5 t/ha) on wet weight basis	$T_{4.1}$: T. Aus NPKS (MYG) ($N_{60}P_{12}K_{32}S_5$ kg/ha)	$T_{4.1}$: NPKS (MYG) ($N_{60}P_{12}K_{32}S_5$ kg/ha) + CD (5 t/ha) on wet weight basis
	$T_{4.2}$: Mungbean PKS ($P_{10}K_{13}S_5$ kg/ha) + *Rhizobium* inoculum	$T_{4.2.1}$: Mungbean residue not incorporated + NPKS(MYG) ($N_{60}P_{12}K_{32}S_5$ kg/ha) + CD (5 t/ha) on wet weight basis
		$T_{4.2.2}$: Mungbean residue incorporated + Reduced dose of inorganic fertilizers (MYG) ($N_{31}P_9K_3S_3$ kg/ha) + CD (5 t/ha) on wet weight basis

Chemical analysis of plant samples: Grain/seed and straw/stover samples of T. Aus rice and mungbean were analyzed for determination of N, P, K, S, Zn, and B concentrations.

Nitrogen: The plant samples (0.1 g grain, 0.2 g straw) were digested with conc. H_2SO_4, hydrogen peroxide and K_2SO_4-catalyst mixture (K_2SO_4: $CuSO_4$. $5H_2O$: Se = 10: 1: 0.1) at 200^oC for one and a half-hour.

Other nutrients: The plant samples were digested in nitric-perchloric acid solution (5:1) for one and a half-hour at 200^0C. After digestion, it was diluted to 50 ml with distilled water. After proper dilution of this extract P, K, S, Zn, and B concentrations in the digest were determined. Phosphorus was determined by vanado-molybdate blue colour method (Yoshida *et al*., 1976). Potassium, S, Zn, and B concentrations in the digest were determined by the method of Page *et al*. (1982) and (Yoshida *et al*., 1976).

Nutrient uptake: Nitrogen, P, K, S, Zn, and B uptake by T.Aus rice and mungbean was computed from their respective chemical concentration and dry matter yields.

All the data were statistically analyzed by F-test and the differences between treatment means were adjudged by Duncan's Multiple Range Test (DMRT).

Results and Discussion

Grain yield of T.Aus rice

Fertilizer and residual manure treatments significantly influenced the grain yield of T.Aus rice (Table 1). The highest mean grain yield (3.46 t/ha) recorded by NPKS (HYG) application was significantly higher over other treatments. The treatments which received NPKS (MYG) and NPKS (MYG) + residual cowdung (5 t/ha) gave identical yields. The lowest grain yields were noted in control. The results indicated that NPKS for HYG treatment gave high yield compared to NPKS for MYG. Again, the results also indicated that NPKS for MYG + residual CD treatment had some apparent residual effect on T.Aus rice yield. Similar favourable residual effects of cowdung on rice yield were observed by Islam (1995) and Khatun (1999).

Straw yield of T.Aus rice

Like grain yield, the straw yield of T.Aus rice was significantly influenced by the application of fertilizer and residual manure treatments (Table 1). The highest straw yields (5.19 t/ha) recorded with NPKS (HYG) fertilizers were significantly higher than NPKS (MYG) and NPKS (MYG) + residual cowdung. The lowest straw yields (2.85 t/ha) were noted in control ($T_{1.1}$). Generally, NPKS (HYG) gave high yield compared to NPKS (MYG) + residual cowdung. Similarly,

NPKS (MYG) + residual cowdung gave high straw yield compared to NPKS (MYG). This result indicated the contribution of residual cowdung to the straw yield of rice.

Table 1. Effects of different fertilizer management packages on the yields (average of 3 years) of T. Aus rice (cv. BR26) and mungbean (cv. BARI Mung-2).

Treatment	T. Aus rice	
	Grain yield (t/ha)	Straw yield (t/ha)
$T_{1.1}$: Control	1.48c	2.85c
$T_{2.1}$: $N_{60}P_{12}K_{32}S_5$ kg/ha (Moderate Yield Goal)	2.92b	4.75b
	3.46a	5.19a
$T_{3.1}$: $N_{90}P_{18}K_{82}S_{7.5}$ kg/ha (High Yield Goal)	3.03b	4.83b
#$T_{4.1}$: Same as $T_{2.1}$		
CV (%)	3.6	1.6
Treatment	Mungbean	
	Seed yield (t/ha)	Stover yield (t/ha)
$T_{1.2}$:Control	0.42b	1.37c
*$T_{2.2}$: $P_{10}K_{13}S_5$ kg/ha + Inoculum	0.53a	1.90b
**$T_{3.2}$: $P_{10}K_{13}S_5$ kg/ha + Inoculum	0.56a	1.99a
***$T_{4.2}$: $P_{10}K_{13}S_5$ kg/ha + Inoculum	0.55a	1.91b
CV (%)	3.8	0.7

In a column, the figure(s) having same letter are not significantly different at 5% level of probability by DMRT

#Cowdung was applied to the first crop (wheat)

*NPKSZnB (MYG) was applied to the first crop (wheat)

**NPKSZnB (HYG) was applied to the first crop (wheat)

***NPKSZnB (MYG) + CD was applied to the first crop (wheat)

The yield data of the present study indicated that for obtaining higher yield of T.Aus rice, the NPKS for HYG need to be applied in BAU soil (low N, P, K, and medium S status). Addition of cowdung in preceding crop like wheat had a little residual effect on T.Aus rice.

Seed yield of mungbean

Effects of different fertilizer and residual manure treatments on the seed yield of mungbean were significant (Table 1). The highest seed yields (0.56 t/ha) recorded in the treatment PKS + Inoculum + residual NPKSZnB (HYG) was

statistically identical to PKS + Inoculum, and PKS + Inoculum + residual cowdung treatments. The lowest seed yield (0.42 t/ha) obtained in control treatment was significantly different from all other treatments.

Stover yield of mungbean

Stover yield was significantly influenced by the different treatments used in the experiment (Table 1). The highest mean stover yield of 1.99 t/ha was recorded in PKS + Inoculum + residual NPKSZnB (HYG) treatment. The lowest stover yield was noted in control treatment.

Nutrient uptake by T.Aus rice

Total N uptake by grain + straw was markedly influenced due to fertilizer and residual manure treatments (Table 2). The highest N uptake was always recorded with NPKS fertilizers (HYG) and the lowest value was observed in control. In 2000, the highest N uptake (63.48 kg/ha) noted with NPKS (HYG) fertilizers was not significantly different from NPKS (MYG) and NPKS (MYG) + residual cowdung. In the following year, the highest N uptake under NPKS (HYG) was not comparable with other treatments. In 2002 growing season, the uptake followed a similar trend as observed in 2000 and 2001; and the highest N uptake recorded by NPKS (HYG) was identical to NPKS (MYG) + residual cowdung only. The lowest N uptake (28.65 kg/ha in 2000, 26.96 kg/ha in 2001 and 26.26 kg/ha in 2002) was observed in control treatment.

Total P uptake by the crop varied markedly due to fertilizer and residual manure treatments over the years (Table 2). The highest total P uptake of 15.67 kg/ha in 2000, 16.05 kg/ha in 2001 and 15.69 kg/ha in 2002 was recorded with NPKS (HYG) fertilizers. In 2000 and 2002, the total P uptake recorded with NPKS (MYG) and NPKS (MYG) + residual cowdung was not significantly different from the highest value. However, in 2001, the uptake recorded with NPKS (HYG) fertilizers was statistically higher from all other treatments. The lowest P uptake ranged from 5.41 to 5.85 kg/ha, recorded in control over the years.

Total K uptake by grain and straw of T.Aus rice was significantly affected by fertilizer and residual cowdung (Table 2). The highest K uptake of 71.91 kg/ha in 2000, 72.48 kg/ha in 2001 and 71.02 kg/ha in 2002 were found with NPKS (HYG) fertilizers. In the first and third year trials, the highest K uptake was identical to NPKS (MYG) and NPKS (MYG) + residual cowdung, but in second year trial, it was significantly different from all other treatments.

Table 2. Effects of different fertilizer management packages on N, P, K, S, Zn, B uptake by T.Aus rice.

Treatment	N Uptake (kg/ha)			
	2000	2001	2002	Mean
$T_{1.1}$: Control	26.65b	26.96c	26.26	27.29c
$T_{2.1}$: $N_{60}P_{12}K_{32}S_5$ kg/ha (Moderate Yield Goal)	56.67a	50.69b	51.27a	53.08b
	63.48a	63.57a	62.56a	63.20a
$T_{3.1}$: $N_{90}P_{18}K_{82}S_{7.5}$ kg/ha (High Yield Goal)	58.49a	53.34b	55.05ab	55.63b
#$T_{4.1}$: Same as $T_{2.1}$				
	P Uptake (kg/ha)			
	2000	2001	2002	Mean
$T_{1.1}$: Control	5.85b	5.60c	5.41b	5.62c
$T_{2.1}$: $N_{60}P_{12}K_{32}S_5$ kg/ha (Moderate Yield Goal)	13.43a	12.37b	12.33a	12.71b
	15.67a	16.05a	15.69a	15.80a
$T_{3.1}$: $N_{90}P_{18}K_{82}S_{7.5}$ kg/ha (High Yield Goal)	14.13a	12.83b	13.51a	13.49b
#$T_{4.1}$: Same as $T_{2.1}$				
	K Uptake (kg/ha)			
	2000	2001	2002	Mean
$T_{1.1}$: Control	37.33b	35.12c	35.90b	35.78d
$T_{2.1}$: $N_{60}P_{12}K_{32}S_5$ kg/ha (Moderate Yield Goal)	63.88a	62.41b	62.79a	63.03c
	71.91a	72.48a	71.02a	71.80a
$T_{3.1}$: $N_{90}P_{18}K_{82}S_{7.5}$ kg/ha (High Yield Goal)	65.49a	64.41b	65.27a	65.06b
#$T_{4.1}$: Same as $T_{2.1}$				
	S Uptake (kg/ha)			
	2000	2001	2002	Mean
$T_{1.1}$: Control	4.12b	4.14c	3.97b	4.08c
$T_{2.1}$: $N_{60}P_{12}K_{32}S_5$ kg/ha (Moderate Yield Goal)	9.05a	8.83b	8.85a	8.91b
	9.77a	10.33a	10.67a	10.26a
$T_{3.1}$: $N_{90}P_{18}K_{82}S_{7.5}$ kg/ha (High Yield Goal)	9.24a	9.12ab	9.41a	9.26b
#$T_{4.1}$: Same as $T_{2.1}$				
	Zn Uptake (kg/ha)			
	2000	2001	2002	Mean
$T_{1.1}$: Control	0.046c	0.044c	0.045c	0.045d
$T_{2.1}$: $N_{60}P_{12}K_{32}S_5$ kg/ha (Moderate Yield Goal)	0.101b	0.097b	0.099b	0.099c
	0.130a	0.133a	0.132a	0.132a
$T_{3.1}$: $N_{90}P_{18}K_{82}S_{7.5}$ kg/ha (High Yield Goal)	0.108b	0.101b	0.205ab	0.105b
#$T_{4.1}$: Same as $T_{2.1}$				

Table 2. Cont'd.

	B Uptake (kg/ha)			
	2000	2001	2002	Mean
$T_{1.1}$: Control	0.017c	0.017c	0.017c	0.017d
$T_{2.1}$: $N_{60}P_{12}K_{32}S_5$ kg/ha (Moderate Yield Goal)	0.049b	0.047b	0.049b	0.048c
$T_{3.1}$: $N_{90}P_{18}K_{82}S_{7.5}$ kg/ha (High Yield Goal)	0.069a	0.071a	0.069a	0.070a
#$T_{4.1}$: Same as $T_{2.1}$	0.054b	0.050b	0.052b	0.052b

In a column, the figure(s) having same letter are not significantly different at 5% level of probability by DMRT

#Cowdung was applied to the first crop (wheat)

Total S uptake by T.Aus rice was highly influenced due to application of exclusive inorganic fertilizer or residual cowdung (Table 2). The maximum S uptake was found in the treatment receiving NPKS (HYG) fertilizers, the minimum being in control. In 2000 and 2002 trials, the highest S uptake of 9.77 and 10.67 kg/ha recorded with NPKS (HYG) was statistically alike to that found with NPKS (MYG) with or without residual cowdung. In 2001, the highest S uptake of 10.33 kg/ha observed with NPKS (HYG) was statistically at par with NPKS (MYG) + residual cowdung only.

There was a marked variation in Zn uptake by T.Aus rice due to various treatments (Table 2). In all the years, the highest Zn uptake was recorded with NPKS (HYG) fertilizers. The maximum Zn uptake of 0.130, 0.133 and 0.132 kg/ha with corresponding minimum uptake of 0.046, 0.044 and 0.044 kg/ha in control was recorded in 2000, 2001, and 2002 trials, respectively. In third year trial, the maximum uptake was identical to NPKS (MYG) + residual cowdung. In first and second year trials, the maximum Zn uptake was significantly higher than those of all other treatments.

Total B uptake by T.Aus rice was significantly influenced due to treatments (Table 2). The B uptake varied from 0.017 to 0.069 kg/ha in 2000, 0.017 to 0.071 kg/ha in 2001, and 0.017 to 0.069 kg/ha in 2002 trials. It was observed that the B uptake was always maximum with NPKS (HYG) and minimum in control. In all the trials, the highest B uptake was significantly higher than the rest of the treatments.

Nutrient uptake by mungbean

Total N uptake by mungbean seed plus stover was markedly influenced due to different treatments (Table 3). The highest N concentration was resulted from PKS + Inoculum + residual NPKSZnB for HYG treatment. The highest N uptake of 56.05 kg/ha in 2000 and 44.27 kg/ha in 2001 found with the above treatment

was identical to other treatments except control. In 2002, the highest N uptake in mungbean crop (43.99 kg/ha) found with the same treatment was statistically at par with PKS + Inoculum + residual cowdung treatment only. The N uptake recorded in PKS + Inoculum, and PKS + Inoculum + residual cowdung treatment was statistically identical with each other.

Table 3. Effects of different fertilizer management packages on N, P, K, S, Zn, B uptake by mungbean.

Treatment	N Uptake (kg/ha)			
	2000	2001	2002	Mean
$T_{1.2}$: Control	34.53b	27.01b	27.74c	29.76c
*$T_{2.2}$: $P_{10}K_{13}S_5$ kg/ha (AYG) + Inoculum	53.41a	39.70a	39.28b	44.13b
**$T_{3.2}$: $P_{10}K_{13}S_5$ kg/ha (AYG) + Inoculum	56.05a	44.27a	43.99a	48.10a
***$T_{4.2}$: $P_{10}K_{13}S_5$ kg/ha (AYG) + Inoculum	54.78a	41.33a	41.16ab	45.56ab
	P Uptake (kg/ha)			
	2000	2001	2002	Mean
$T_{1.2}$: Control	3.16c	2.54c	2.09c	2.60c
*$T_{2.2}$: $P_{10}K_{13}S_5$ kg/ha (AYG) + Inoculum	4.70b	3.76b	3.62b	4.09b
**$T_{3.2}$: $P_{10}K_{13}S_5$ kg/ha (AYG) + Inoculum	5.01a	4.90a	4.15a	4.69a
***$T_{4.2}$: $P_{10}K_{13}S_5$ kg/ha (AYG) + Inoculum	4.83ab	4.30b	3.82ab	4.32b
	K Uptake (kg/ha)			
	2000	2001	2002	Mean
$T_{1.2}$: Control	28.52c	22.39c	19.89c	21.93c
*$T_{2.2}$: $P_{10}K_{13}S_5$ kg/ha (AYG) + Inoculum	38.41b	31.00b	29.35b	32.92b
**$T_{3.2}$: $P_{10}K_{13}S_5$ kg/ha (AYG) + Inoculum	41.97a	36.81a	33.51a	37.43a
***$T_{4.2}$: $P_{10}K_{13}S_5$ kg/ha (AYG) + Inoculum	39.54b	33.40b	30.26ab	34.40ab
	S Uptake (kg/ha)			
	2000	2001	2002	Mean
$T_{1.2}$: Control	2.39c	1.86c	2.12c	2.12c
*$T_{2.2}$: $P_{10}K_{13}S_5$ kg/ha (AYG) + Inoculum	4.05b	3.12b	3.24b	3.47b
**$T_{3.2}$: $P_{10}K_{13}S_5$ kg/ha (AYG) + Inoculum	4.56a	3.69a	4.09a	4.11a
***$T_{4.2}$: $P_{10}K_{13}S_5$ kg/ha (AYG) + Inoculum	4.13b	3.25b	3.64b	3.67b

Table 3. Cont'd.

	Zn Uptake (kg/ha)			
	2000	2001	2002	Mean
$T_{1.2}$: Control	0.045b	0.070b	0.054c	0.056b
*$T_{2.2}$: $P_{10}K_{13}S_5$ kg/ha (AYG) + Inoculum	0.064a	0.101a	0.096b	0.087a
**$T_{3.2}$: $P_{10}K_{13}S_5$ kg/ha (AYG) + Inoculum	0.070a	0.115a	0.116a	0.100a
***$T_{4.2}$: $P_{10}K_{13}S_5$ kg/ha (AYG) + Inoculum	0.066a	0.106a	0.102b	0.091a
	B Uptake (kg/ha)			
	2000	2001	2002	Mean
$T_{1.2}$: Control	0.006c	0.007c	0.007c	0.007c
*$T_{2.2}$: $P_{10}K_{13}S_5$ kg/ha (AYG) + Inoculum	0.011b	0.013b	0.012b	0.012b
**$T_{3.2}$: $P_{10}K_{13}S_5$ kg/ha (AYG) + Inoculum	0.014a	0.017a	0.016a	0.016a
***$T_{4.2}$: $P_{10}K_{13}S_5$ kg/ha (AYG) + Inoculum	0.012b	0.013b	0.013ab	0.013b

In a column, the figure(s) having same letter are not significantly different at 5% level of probability by DMRT

*NPKSZnB (MYG) was applied to the first crop (wheat)

**NPKSZnB (HYG) was applied to the first crop (wheat)

***NPKSZnB (MYG) + CD was applied to the first crop (wheat)

Total P uptake by mungbean was highly influenced due to treatments (Table 3). The total P uptake varied from 3.16 to 5.01 kg/ha in 2000, 2.54 to 4.90 kg/ha in 2001 and 2.09 to 4.15 kg/ha in 2002. In general, the treatment of PKS + Inoculum + residual NPKSZnB (HYG) showed the highest P uptake. In the first and third year trials, the highest P uptake was statistically higher than PKS + Inoculum but not higher than PKS + Inoculum + residual cowdung. In second year trial, the P uptake by PKS + Inoculum + residual NPKSZnB (HYG) treatment was significantly higher than PKS + Inoculum, and PKS + Inoculum + residual cowdung. It indicated that PKS + inoculum with residual fertilizers showed positive effect on P uptake by mungbean.

Total K removal by mungbean during 2000-2002 is presented in Table 3. The residual effect of applied nutrients to wheat exerted significant effect on the total K uptake by mungbean. The K uptake ranged from 23.52 to 41.96 kg/ha in 2000, 22.39 to 36.81 kg/ha in 2001 and 19.89 to 33.51 kg/ha in 2002. The highest K uptake recorded in PKS + Inoculum + residual NPKSZnB (HYG) treatment was

significantly higher than PKS + Inoculum, and PKS + Inoculum + residual cowdung in 2000 and 2001 years. In 2002, the highest K uptake was observed in the same treatment which can be compared to PKS + Inoculum + residual cowdung treatment. Cowdung had no residual effect on K uptake by mungbean. The highest S uptake of 4.56 kg/ha in 2000, 3.69 kg/ha in 2001 and 4.09 kg/ha in 2002 found in the treatment of PKS + Inoculum + residual NPKSZnB (HYG) was significantly different from all other treatments (Table 3).

Sulphur uptake by PKS + Inoculum + residual CD treatment was comparable with PKS + Inoculum treatment (Table 3). The data indicated that the nutrients (HYG) applied to preceding crop recorded high S uptake compared to nutrients (MYG) with lower amount of NPKSZnB. The results also indicated that nutrients used for HYG in wheat had positive residual effect on S uptake by mungbean but residual cowdung had no positive effect on mungbean.

Total Zn uptake was significantly affected by the treatments (Table 3). In 2000 and 2001 trials, the uptake due to different treatments except the control treatment was not significantly different showing a narrow range between 0.064 to 0.070 kg/ha in 2000 and 0.101 to 0.115 kg/ha in 2001. In 2002 trial, the highest Zn uptake of 0.116 kg/ha noted in PKS + Inoculum + residual NPKSZnB (HYG) treatment was significantly different from other treatments. The Zn uptake indicated that nutrients applied in wheat targeting for HYG had residual effect on Zn uptake of mungbean in 2002.

Total B uptake by mungbean was positively influenced due to different treatments (Table 3). The figure showed that the B uptake was the highest with the PKS + Inoculum + residual NPKSZnB (HYG) treatment and significantly different from that recorded in all other treatments in 2000 and 2001. In 2002, the highest B uptake noted with same treatment was similar to PKS + Inoculum + residual cowdung.

Conclusion

The overall result indicated that grain and straw yields of T.Aus rice increased significantly by the application of fertilizers. The application of chemical fertilizers, NPKS (HYG) remarkably increased the crop yield. The highest mean grain and straw yield of T.Aus were obtained from NPKS (High Yield Goal) treatment, while the highest mean mungbean seed and stover yield were obtained from PKS plus inoculum plus residual NPKSZnB for HYG treatment. The lowest yield and uptake of nutrients was noted in control plots receiving no fertilizer or manure. The results showed that N, P, K, S, Zn, and B uptake by T.Aus rice/Mungbean remarkably increased with increasing supply of nutrients. It was observed that the highest uptake of N, P, K, S, Zn, and B by the

crops was noted in the treatment T_3 that received HYG fertilizers in T.Aus rice. The annual removal of N ranged from 27.3 to 63.2 kg/ha and 29.8 to 48.1 kg/ha, P from 5.62 to 15.80 kg/ha and 2.60 to 4.69 kg/ha, K from 35.8 to 71.8 kg/ha and 21.9 to 37.4 kg/ha, S from 4.08 to 10.26 kg/ha and 2.12 to 4.11 kg/ha, Zn, from 44 to 132 g/ha and 56 to 101 g/ha, B from 17 to 70 g/ha and 7 to 16 g/ha by T. Aus rice and mungbean, respectively. Application of cowdung along with chemical fertilizers resulted in remarkable higher uptake of nutrients. Application of fertilizers (MYG) + CD showed higher N, P, K, S, Zn, and B uptake than that with MYG treatment.

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