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INTEGRATED USE OF INORGANIC AND ORGANIC FERTILIZERS ON YIELD OF WHEAT IN WHEAT-T.AUS/MUNGBEAN-T.AMAN CROPPING PATTERN

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Rice-wheat is one of the most important and widespread cropping systems in Asia covering about 22 million hectares of land. Rice-wheat cropping system has a capacity to produce more than 8 tons of cereal grain/ha per year removing 400 to 700 kg/ha nutrients from soil against the use of 440 kg/ha nutrients for rice-wheat cropping system (Islam, 1995; Kamal *et al.*, 1999; Prasad *et al.*, 1999). The rice-wheat cropping systems, therefore, cause a considerable depletion of soil nutrients clearly posing an alarming threat to the long-term productivity. Consequently, farmers are compelled to increase fertilizer doses each year to realize the same yield levels which had been obtained with relatively low amounts of fertilizers in the past (Ahlawat *et al.*, 1998; Islam *et al.*, 1999; Islam, 2002). In addition, deficiencies of a number of micronutrients, such as zinc, manganese and boron, and secondary nutrients like sulphur have been reported (Jahiruddin *et al.*, 1994; Islam *et al.*, 1999; Uddin *et al.*, 2002).

Despite national fertilizer recommendations in many developing countries, chemical exhaustion of soils still continues (Stoorvogel *et al*., 1993) as the use of inorganic fertilizer is restricted by such factors as marketing constraints and poor economic conditions of poor farmers (Laegreid *et al.*, 2001). The farmers of Bangladesh use only about 174 kg nutrients/ha annually (132 kg N, 17 kg P_2O_5, 17 kg K_{20}, 4 kg S, 2 kg Zn + B + others), as against the crop removal of about 250 kg/ha (Islam *et al.*, 2002). 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). Proper soil fertility management, therefore, is of prime importance in an endeavor to increase crop productivity. Soil fertility in many areas of Bangladesh has already been deteriorated over the years (Karim *et al.*, 1994; Ali *et al.*, 1997; Ishaque *et al.*, 1999), which is one of the reasons for stagnating, and in some cases, even reducing crop yields (Cassman *et al*., 1995; Panaullah *et al.*, 1999b). Application of balanced doses of chemical fertilizers and integrated use of cowdung, ash, and chemical fertilizers gave positive yield trend of rice in longterm experiment at BRRI farm (Saleque *et al*., 2004).

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Soil organic matter is an important factor to be considered in improving crop productivity. Because of the tropical climate, organic matter decomposition in Bangladesh soils is high. The need for proper soil organic matter management needs due attention in view of the low organic matter status of our soils (Ali *et al.*, 1997). The study was carried out to find out the integrated use of inorganic and organic fertilizers on yield and yield attributes of wheat.

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 yield attributes of wheat grown as the first crop. The study was continued in the same field having the same layout for three consecutive years. The physical and chemical characteristics of the soil of the experimental site are presented in Table I.

Table 1. Physical and chemical characteristics of the soils of experimental field.

Characteristics	Analytical data
Mechanical fractions (USDA system)	
a) Sand (2.00-0.05 mm)%	33
b) Silt (0.05-0.002 mm)%	47
c) Clay (<0.002 mm)%	20
Textural class	Silty clay loam
pH	6.9
CEC (cmol/kg soil)	11.7
Organic carbon (%)	1.01
Total N (%)	0.10
Available P (kg/g)	10.0
Exchangeable K (cmol/kg soil)	0.13
Available S (μg/g)	14.0
Available Zn (μg/g)	1.71
Available B (μg/g)	0.20

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, 5, Zn, and B for wheat (first crop of the pattern) were 80, 20, 50, 10, 1, and 1 kg/ha, respectively, for moderate yield goal (MYG) and 120, 30, 75, 15, 2, and 2 kg/ha for high yield goal (HYG).

The fertilizer doses for moderate yield goal (MYG) and high yield goal (HYG) of wheat 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, 5, Zn, B were applied as basal at final land preparation. The remaining 2nd, 3rd urea were top-dressed in two equal splits at the time of 1st irrigation (17-22 DAS) and at 2nd irrigation (50 DAS). Seeds of wheat @ 120 kg seed ha^{-1} were sown on 30 November 1999, 28 November 2000 and 03 December 2001 with row to row distance 20 cm. Harvesting of wheat crop was done in March. Yield data were collected from 4 m x 3 m area of each plot. Grains and straw were sun-dried and weighed adjusting at 14% moisture content and yields were converted to t/ha. The parameters on spike/meter, grains/spike, tillers/hill, grains/panicle, 1000-grain weight (g), grain yield (t/ha) and straw yield (t/ha) were recorded.

Treatment combinations.

1st crop-Rabi (Wheat)	2nd crop-Kharif-1 (T. Aus/Mungbean)	3rd crop-Kharif-1 (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	$T_{1.2}$: Mungbean residue not incorporated + Control
		$T_{1.2.2}$: Mungbean residue incorporated + Control
T_2: Nutrient rates on soil test basis (MYG) ($N_{80}P_{20}K_{50}S_{10}Zn_1$ B_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 + Inoc.	$T_{2.2}$: 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 (FIYG) ($N_{120}P_{30}K_{75}S_{15}Zn_2B_2$ kg/ha	$T_{3.1}$: T. Aus NPKS (HYG) (N_{90}P18K48S7.5 kg had)	T31: 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 +lnoc.	$T_{3.2.1}$: 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)
F_4: Nutrient rates on soil test basis (MYG) ($N_{80}P_{20}K_{50}S_{10}Zn_1B_1$ kg/ha) + CD (5 t/h) 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 + Inoc.	$T_{4.2.1}$: 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

The collected data were analyzed statistically and Duncan's Multiple Range Test (DMRT) using a computer IRRISTAT and M-stat package programmes (Freed, 1992) adjudged the means. The correlation co-efficient and regression analysis were done for different variables wherever needed using Microsoft EXCEL programme 1997.

Grain yield of wheat was significantly influenced due to fertilizer and manure treatments in all three years during 1999-2002 and the highest grain yield was always found with the application of recommended NPKSZn fertilizers for HYG (Table 2). In 1999-2000, the highest grain yield of 3.35 t/ha was obtained with recommended NPKSZnB (HYG) fertilizers. However, the grain yield recorded with NPKSZnB (MYG) fertilizers + cowdung (CD) was statistically identical to NPKSZnB (HYG) fertilizers. The yield recorded with NPKSZnB (MYG) fertilizers without cowdung failed to produce comparable yield with NPKSZnB (HYG). In 2000- 2001 trial, the highest grain yield (3.19 t/ha) was found with NPKSZnB (HYG) fertilizers was statistically similar to NPKSZnB (MYG) fertilizers plus cowdung. In 200 1-2002 trial, the highest grain yield (2.85 t/ha) noted with NPKSZnB (HYG) fertilizers was significantly higher over NPKSZnB (MYG) with and without cowdung.

The treatment of NPKSZnB (MYG) + CD gave high yield compared to NPKSZnB (MYG) treatment. The increased yield was due to release of nutrients from CD to the growing wheat plants. Similar result was observed by other workers (Zhu HongXun *e al.*, 1995; Hegde, 1998; Khatun, 1999; Panaullah *et al.*, 1999a; Rahman, 2001). The grain yield was lower in 2002 than 2000 and 2001 probably due to high temperature prevailing during the crop season and delayed sowing in December. Mungbean residue incorporation had advantage over mungbean residue removal (Fig. 1).

Table 2. Effects of integrated use of fertilizers and manure on the yields of wheat (cv. Kanchan) in Wheat-T. Aus/Mungbean-T. Aman rice cropping pattern.

Treatment	Grain yield (t/ha)				Straw yield (t/ha)			
	1999-2000	2000-2001	2001-2002	Mean	1999-2000	2000-2001	2001-2002	Mean
T_1:Control	1.02c	0.94c	0.66c	0.87d	2.93b	2.90c	2.35b	2.73c
T_2:NPKSZnB (MYG)	2.89b	2.75b	2.60b	2.75c	5.99a	5.62b	5.52a	5.71b
T_3:NPKSZnB (HYG)	3.35a	3.19a	2.85a	3.13a	7.34a	6.71a	5.94a	6.66a
T_4:NPKSZnB (MYG)+CD	3.23ab	3.06a	2.69b	2.99b	6.08a	5.89b	5.63a	5.87b
CV(%)	8.6	5.7	2.9	2.6	17.4	4.8	4.7	4.7

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

MYG: Moderate Yield Goal, HYG: High Yield Goal

NPKSZnB (MYG): 80 kg N, 20 kg P, 50 kg K, 10 kg S, 1 kg Zn, 1 kg B/ha

NPKSZnB (HYG): 120 kgN, 30kg P, 75 kg K, 15kg S, 2kg Zn, 2kg B/ha

CD: Cowdung, 5 t/ha1 (wet weight basis)

In all three years, the highest wheat straw yield was recorded with NPKSZnB (HYG) fertilizers (Table 2). The highest straw yields (7.34 t/ha) in the first year trial, 6.71 t/ha in second year trial and 5.94 t/ha in third year trial were noted with NPKSZnB (HYG) fertilizers.

The highest straw yields recorded in the 1^{st} and 3^{rd} year trials for NPKSZnB (HYG) were comparable with the straw yields for NPKSZnB (MYG) with and without cowdung, but in the second year trial, the straw yield was significantly higher for NPKSZnB (HYG) than for NPKSZnB (MYG) with or without cowdung. The straw yield recorded with NPKSZnB (MYG) with cowdung was statistically identical to NPKSZnB (MYG) without cowdung. Figure 1 displayed a beneficial residual effect of mungbean residue on wheat straw yield during second and third year trials.

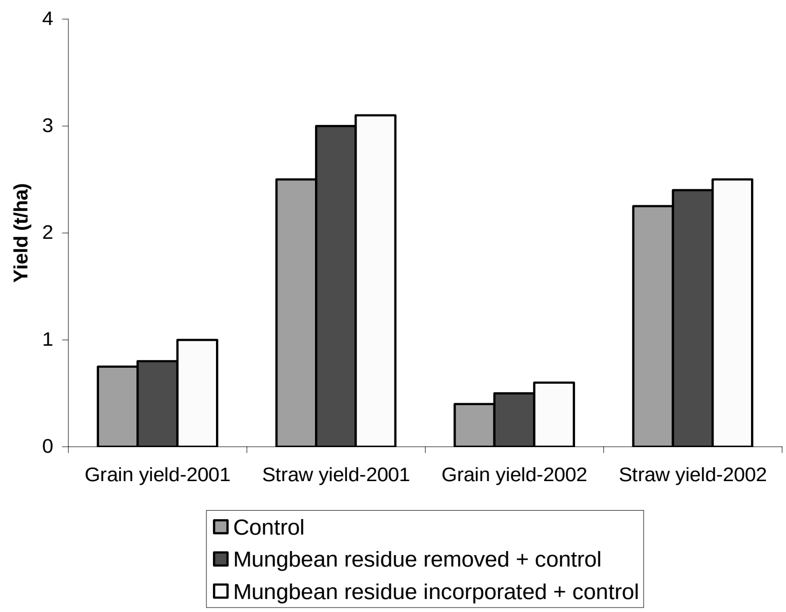

Fig. 1. Yield of wheat due to mungbean residue incorporation in T_1 treatment.

Spike/m^2 was significantly influenced by different treatments (Table 3). Spikes/m^2 of the crop ranged from 159 to 316 in 1st year trial, 143 to 311 in 2^{nd} year trial and 156 to 303 in 3^{rd} year trial over the treatments. The treatment T_3 which received nutrients (NPKSZnB) for HYG recorded the highest number of spikes/m^2 (316 in 1999-2000,311 in 2000-2001 and 303 in 2001-2002), which was statistically identical to those when fertilizers were applied for MYG plus cowdung in all the years.

The fertilizer and manure treatments also significantly influenced the number of grains/spike over control (Table 3). No significant differences in grains/spike were observed in different treatments except control in 1^{st} and 3^{rd} years. In the 2^{nd} year, NPKSZnB (HYG) recorded significantly higher grains/spike than NPKSZn (MYG) with or without cowdung. The HYG treatment received high amount of NPKSZnB and consequently resulted in high number of grains/spike as compared to MYG and MYG + CD treatments. However, addition of cowdung to NPKSZnB for MYG (T_4) had positive effect on grains/spike only in 2^{nd} year. Thousand-grain weights were not influenced by different treatments used in the experiment (Table 3). However, thousand-grain weights were relatively higher in control treatment. The 1000-grain weight is a genetic character, thus, nutrient management seldom changes it.

Table 3. Effects of integrated use of fertilizers and manure on the yield attributes of wheat (cv. Kanchan) in Wheat-T. Aus/Mungbean-T. Aman rice cropping pattern.

Treatment	Spike/m^2 (no.)	Grains/spike (no.)	1000-grain wt (g)
1999-2000			
T_1: Control	159c	20.2b	46.7
T_2: NPKSZnB(MYG)	295b	34.4a	45.6
T_3: NPKSZnB(HYG)	316a	36,la	44.4
T_4: NPKSZnB(MYG) + CD	306ab	35.8a	45.3
CV(%)	2.8	2.8	1.9
2000-2001			
T_1: Control	143b	17.7d	46.5
T_2: NPKSZnB(MYG)	302a	34.3c	45.3
T_3: NPKSZnB(HYG)	31 la	37.3a	44.8
T_4: NPKSZnB(MYG) + CD	303a	36.9b	45.3
CV **(%)**	4.9	0.6	0.5
2001-2002			
T_1: Control	156c	15.7b	41.9a
T_2: NPKSZnB(MYG)	293b	32.0a	39.8b
T_3 : NPKSZnB(HYG)	303a	32.7a	38 .4b
T_4: NPKSZnB(MYG) + CD	295ab	32.2a	39.3b
CV (%)	1.5	4.0	2.5

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

MYG: Moderate Yield Goal, HYG: High Yield Goal

NPKSZnB (MYG): 80 kg N, 20 kg P, 50 kg K, 10 kg S, 1 kg Zn, 1 kg B/ha

NPKSZnB (HYG): 120 kgN, 30kg P, 75kg K, 15kg S, 2kg Zn, 2kg B/ha

CD: Cowdung, 5 t/ha (wet weight basis)

Correlation coefficient among the plant characters revealed that the grain yield of wheat was positively correlated with straw yield, spikes/m^2 and grains/spike, but grain yield was negatively correlated with 1000-grain weight in all the years (Table 4).

Table 4. Correlation matrix among the plant characters of wheat (n=12).

Characters	Year	Correlation coefficient (r value)			
		Straw yield	Spike/m^2	Grains/spike	1000-grain wt
Grain yield	2000	0.893**	0.974**	0.976**	-0.790**
	2001	0.980**	0.984**	0.991**	-0.906**
	2002	0.988**	0.996**	0.989**	-0.845**
Straw yield	2000	-	0.914**	0.852**	-0.851**
	2001	-	0.962**	0.964**	-0.922**
	2002	-	0.990**	0.982**	-0.884**
Spikes/m^2	2000	-	-	0.983**	-0.736**
	2001	-	-	0.981**	-0.908**
	2002	-	-	0.990**	-0.835**
Grains/spike	2000		-	-	-0.706**
	2001		-	-	-0.918**
	2002		-	-	-0.824**

**Significant at 1% level

The grain and straw yield data revealed that significant yield improvement was achieved due to NPKSZnB fertilizers for HYG. The highest grain and straw yields of 3.13 and 6.66 t/ha (mean of 3 years) showing 266 and 145% yield increase, respectively, over control were obtained with the application of NPKSZnB (HYG) fertilizers (T_3). On the other hand, the lowest grain yield of 0.87 t/ha and straw yield of 2.73 t/ha were recorded in unfertilized control (T_1) plots. Inclusion of cowdung with NPKSZnB for MYG contributed a little to the grain and straw yield increase (8.7% high grain and 2.8% high straw over NPKSZnB for MYG fertilizers).

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