ISSN 0258-7122
Bangladesh J. Agril. Res. 37(2): 225-234, June 2012

MANAGEMENT OF ORGANIC MANURE AND INORGANIC FERTILIZER IN THE MAIZE-MUNGBEAN/DHAINCHA-T. AMAN RICE CROPPING PATTERN FOR INCREASED CROP PRODUCTION

M. H. RAHMAN[1], M. R. ISLAM[2], M. JAHIRUDDIN[2] AND M. Q. HAQUE[1]

Abstract

The study was conducted at the On Farm Research Division (OFRD) farm, Rangpur from 2002-2003 to 2004-2005 to see the effect of inorganic fertilizers along with organic manure and mungbean residue on soil properties and yield of crops. For the first crop (maize), there were five treatments. After harvest of maize, mungbean and dhaincha *(Sesbania)* seeds were sown as per treatments. For T. Aman rice (third crop), each of the treatments (T_2 and T_3 plots) were subdivided into six, so there were altogether 15 treatments. Integrated use of manure and inorganic fertilizers (IPNS basis) produced comparable seed yield of maize with the chemical fertilizers alone irrespective of moderate or high yield goal basis (MYG or HYG). The highest maize yield of 10.02 t/ha was obtained from the treatment $T_{5,}$ which produced significantly highest yield over all other treatments. During the growing period of mungbean, temperature coupled with rainfall encouraged vegetative growth of mungbean and as a result, pod formation was low. The incorporation of *Sesbania* biomass and mungbean residue along with inorganic fertilizers for MYG produced identical grain yields of T.Aman rice with the fertilizers alone for HYG. The highest grain yield 4.31 t/ha was found in IPNS dhaincha along with fertilizers for HYG treatment. There was no remarkable change in post harvest soil status during the growing period. It may be concluded that addition of mungbean residues or *Sesbania* biomass before T. Aman rice may ensure higher crop productivity and sustain soil fertility.

Keywords: Management, soil fertility, yield, organic manure and IPNS.

Introduction

Soil and fertilizer management is very complex and dynamic in nature. We are increasingly forced to meet up growing food needs from increase in yield from existing or even shrinking land areas. In this process, we are moving away from the traditional and rather static "soil dependent" agriculture to dynamic "fertilizer dependent" agriculture (BARC, 2005). Rice is the principal crop in Bangladesh. Almost every cropping pattern is rice based. Thus, rice area is fairly static over the years. Maize is a high yielding exhaustive crop and takes a lot of nutrients

[1]Soil Science Division, Bangladesh Institute of Nuclear Agriculture (BINA), Mymensingh, [2]Department of Soil Science, Bangladesh Agricultural University (BAU), Mymensingh, Bangladesh.

(450 kg/ha) to a target yield of 10 t/ha (BARC, 2005). Among the cereal crops in the world, maize occupies the third and first position in terms of acreage and production (Islam, 2003). Maize is an important food and feed crop being recognized recently in Bangladesh. The area and production of maize in Bangladesh is about 93 thousand hectares of land with production of 479 thousand metric tons (MMIS, 2005). Again, as cereal crop maize *(Zea mays)* area has increased tremendously because of higher grain yield coupled with high market demand as poultry feed. The crop production system with high yield target can not be sustainable unless nutrient inputs to soil are at least balanced against nutrient removed by crops (Rijpma and Jahiruddin, 2004). So, inclusion of a legume between maize and T.Aman rice deserves attention for obtaining higher yield without affecting soil fertility. Mungbean *(Vigna radiata)* can be a good option as a legume crop since it is a high value pulse so that seeds can be harvested and residue can be incorporated into soil as manure. Growing of mungbean after maize harvest would supply 14 kg N/ha to the subsequent T.Aman rice (Rahman, 2007). It is important to produce more food for its vast population through making the best use of inorganic fertilizers and organic manure including plant residues for higher crop productivity and to improve soil health.

Materials and Method

The experiment was conducted at the On Farm Research Division (OFRD) farm, Rangpur for consecutive three years from 2002 to 2005. The experiment was laid out in a randomized complete block design (RCBD) with three replications. For the first crop (maize), there were five treatments with a plot size (3.75 m x 4 m). After harvest of maize, mungbean and dhaincha *(Sesbania)* seeds were sown in T_2 (MYG) and T_3 (HYG) treatments. Each of the treatments were subdivided into six (6) plots having a plot size (3.75 m x 4 m) and plots as per treatments. For T.Aman rice (third crop), each of the treatments T_2 and T_3 plots were subdivided into six, so there were altogether 15 treatments. The details of treatment combination are presented in Table 1. Maize was sown in the second week of November and harvested in the second week of April. Pods of mungbean were plucked twice to obtain seed yield. Mungbean residues and dhaincha *(Sesbania)* biomass were incorporated to the soil as manure before transplanting of aman rice. Nitrogen content of the mungbean stover and dhaincha *(Sesbania)* was determined. Transplanted aman rice was harvested at full maturity. The yield and yield contributing characters of all the crops were recorded.

Table 1. Treatment details for Maize-Dhaincha/Mungbean-T.Aman rice pattern at OFRD farm, BARI, Rangpur.

1st crop- Rabi (Maize cv. Pacific 11)	2nd Crop-Kharif- I (Dhaincha/Mungbean)	3rd Crop-Kharif-II (T. Aman rice cv. BRRI dhan 33)
T_I: Control	T_I: Control	T_I: Control
T_2: Moderate Yield Goal (MYG)	$T_{2.1}$: Fallow	$T_{2.1}$: 100% N, 50%P, 100%K and 50% S (STB for MYG)
T_2: Moderate Yield Goal (MYG)	$T_{2.2}$: Dhaincha	$T_{2.2.1}$: Dhaincha incorporation + 100% N, 50%P, 100%K and 50%S (STB for MYG)
T_2: Moderate Yield Goal (MYG)	$T_{2.2}$: Dhaincha	$T_{2.2.2}$: Dhaincha incorporation + IPNS based N fertilizer, 50%P, 100%K and 50%S (STB for MYG)
T_2: Moderate Yield Goal (MYG)	$T_{2.3}$: Mungbean	$T_{2.3.1}$: Mungbean residue not incorporation + 100% N, 50%P, 100%K and 50%S (STB for MYG)
T_2: Moderate Yield Goal (MYG)	$T_{2.3}$: Mungbean	$T_{2.32}$: Mungbean incorporation + 100% N, 50%P, 100%K and 50%S (STB for MYG)
T_2: Moderate Yield Goal (MYG)	$T_{2.3}$: Mungbean	$T_{2.33}$: Mungbean residue incorporation + IPNS based N fertilizer, 50%P, 100%K and 50%S (STB basis for MYG)
T_3: High Yield Goal (HYG)	$T_{3.1}$: Fallow	$T_{3.1}$: 100% N, 50%P, 100%K and 50%S (STB for HYG)
T_3: High Yield Goal (HYG)	$T_{3.2}$: Dhaincha	$T_{3.2.1}$: Dhaincha incorporation + 100% N, 50%P, 100%K and 50%S (STB for HYG)
T_3: High Yield Goal (HYG)	$T_{3.2}$: Dhaincha	$T_{3.2.2}$: Dhaincha incorporation + IPNS based N fertilizer, 50%P, 100%K and 50%S (STB for HYG)
T_3: High Yield Goal (HYG)	$T_{3.3}$: Mungbean	$T_{3.3.1}$: Mungbean residue not incorporation + 100% N, 50%P, 100%K and 50%S (STB for HYG)
T_3: High Yield Goal (HYG)	$T_{3.3}$: Mungbean	$T_{3.3.2}$: Mungbean residue incorporation + 100% N, 50%P, 100%K and 50%S ((STB for HYG)
T_3: High Yield Goal (HYG)	$T_{3.3}$: Mungbean	$T_{3.3.3}$: Mungbean residue incorporation + IPNS based N fertilizer, 50%P, 100%K and 50% S (STB basis for HYG)
T_4: FYM 5t/ha + Inorganic fertilizer for MYG as IPNS basis	T_4: Fallow	T_4: 100% N, 50%P, 100%K and 50%S based on STB (MYG)
T_5: FYM 5t/ha + Inorganic fertilizer for HYG as IPNS basis	T_5: Fallow	T_5: 100% N, 50%P, 100%K and 50%S based on STB (HYG)

Weeding, thinning, mulching, spraying of fungicide and irrigation were given as and when necessary. Three composite soil samples were collected from 0-15 cm depth of the experimental plot before fertilization and after completion of three years' crop cycles. Collected samples were analyzed and compared with the initial soil status. Plant samples were also collected and analyzed in the laboratory following standard methods for the determination of different parameters/ nutrients.

Results and Discussion

Yield and yield components of maize

Results revealed that seed and stover yields of maize increased significantly due to application of inorganic fertilizers and organic manure (Table 2). Use of manure and fertilizers on IPNS basis produced higher seed yield of maize for both yield goals (MYG and HYG) compared to those with chemical fertilizers alone. The seed yield (mean of 3 years) ranged from 2.45 t/ha in T_1 (control) treatment to 10.02 t/ha in T_5 treatment (FYM along with inorganic fertilizers applied for HYG based on IPNS). The highest yield of 10.02 t/ha was obtained in treatment T_5 which produced significantly higher yield than treatment T_3. The lowest stover yields of maize were observed in T_1 (control) treatment. The highest stover yield of 12.28 t/ha was recorded in T_5 (HYG with IPNS) treatment which was comparable with T_3 (HYG) treatment.

Table 2. Effects of inorganic fertilizers and manure on the yield and yield attributes of maize.

Treat-ments	Plant height (cm)	Cobs/ plant (no.)	Cob length (cm)	Seeds/Cob (no.)	1000-seed wt (g)	Seed yield (t/ha)	Stover yield (t/ha)
T_1	I l6b	0.61b	11.1b	195b	221d	2.45e	3.45c
T_2	174a	1.09a	17.9a	398a	367c	8.27d	10.56b
T_3	180a	1.12a	18.5a	440a	401ab	9.50b	12.16a
T_4	178a	1.12a	18.5a	414a	381bc	8.84c	11.27b
T_5	185a	1.17a	19.2a	448a	418a	10.02a	12.28a
CV (%)	4.09	5.84	7.97	7.95	3.82	3.41	3.80
SE (±)	3.94	0.037	0.784	17.4	7.89	0.15	0.22

In a column, figure (s) followed by same letter do not differ significantly at 5% level by DMRT.

Application of different inorganic fertilizers and organic manures exerted significant effect on the yield attributes of maize (Table 2). Results indicated that all the treatments (except control) produced statistically identical plant height, cobs/plant, cob length, and seeds/cob. It appeared that the 1000-seed weight of maize ranged from 221 to 418 g. The highest 1000-seed weight was obtained from T_5 treatment which led the highest yield of the maize. Sharma and Bhardwaj (2005) reported that application of FYM @ 10 t/ha along with 25% of the recommended N had significant effect on maize seed yield. They also reported that yield contributing characters, such as cobs/plant, seeds/cob, and 1000-seed weight with higher doses of inorganic fertilizer alone or in combination with manure treatments resulting in higher yield of maize compared with lower doses.

Legume yields and nutrient added to the soil

Seed yields of mungbean (mean of 3 years) in treatments $T_{2.3}$ (MYG) and $T_{3.3}$ (HYG) were 0.41 and 0.46 t/ha, respectively (Table 3). The mungbean residues (dry basis) in the $T_{2.3}$ (MYG) and $T_{3.3}$ (HYG) treatments were 2.66 and 2.83 t/ha. The dhaincha *(Sesbania)* biomasses were 2.59 and 3.00 t/ha in the $T_{2.2}$ and $T_{3.2}$ treatments. After harvesting of maize, mungbean and dhaincha seeds were sown in the same plots where mungbean was grown. During the growing period of mungbean, temperature coupled with rainfall encouraged vegetative growth of mungbean; as a result pod formation was low. However, harvesting of mungbean seed gave additional cash for the farmers. Samanta *et al.* (1999) reported that temperature had tremendous influence on mungbean growth and observed high temperature favoured vegetative growth and consequently increased the stover yield. Three years' result showed that the annual addition of nutrients (NPKS) to soil from different sources were 73 kg for farmyard manure, 83.5 to 105.1 kg for dhaincha *(Sesbania)* and 79.8 to 89.8 kg for mungbean residue (Table 3). Incorporation of legume residues had supplied PKSZn nutrients from the same plot, so it is a recycling process but N was taken up from the soil as well as from atmosphere through biological N fixation by legume-rhizobium symbiosis. Zaman *et al.* (1995) reported that 60-day old dhaincha *(Sesbania)* plants produced 5.2 t/ha dry matter which yielded 135 kg N/ha.

Effects of fertilizers and manures on the yield and yield components of T.Aman rice

Application of manure and fertilizers significantly increased the grain and straw yields of T.Aman rice (Table 4). The highest grain yield 4.31 t/ha was found in the treatment $T_{3.2.2}$ (IPNS dhaincha along with fertilizers for HYG), which was statistically identical with $T_{3.2.1}$ (dhaincha incorporation along with fertilizer for HYG), $T_{3.3.2}$ (mungbean residue incorporation along with fertilizer for HYG), $T_{3.3.3}$ (IPNS mungbean residue with fertilizers for HYG) and T_5 (fertilizers for

HYG + residual FYM) treatments. The straw yield varied from 2.38 t/ha to 6.26 t/ha (Table 4). The highest 6.26 t/ha was obtained from $T_{3.3.3}$ treatment which was significantly different from other except $T_{3.2.1}$, $T_{3.2.2}$, $T_{3.3.2}$ and T_5 treatment. The lowest yield 2.58 t/ha was obtained with T, treatment. When farmyard manure applied in the first crop (maize) of the pattern, due to residual effect, it increased the yield of T.Aman rice by 3-8% (Data not shown). Ali (2003) reported that green manuring increased fertility status of soil which in turn was reflected on yield of rice. Brahmachari *et al.* (2005) reported that the productivity of rice was maximum when this crop in sequence received both organic and inorganic sources of nutrients (N_{40} P_{20} K_{30} + FYM @ 10 t/ha). Sarker (2005) obtained the highest grain yield from 100% fertilizer application which was comparable with 75% inorganic fertilizer along with legume residue incorporation.

Table 3. Seed, biomass yields of mungbean and dhaincha and nutrient added to the soil at OFRD farm, Rangpur.

Treatments	Yield (t/ha)	N %	P %	K %	S %	Annual addition of NPKS (kg/ha)
Mungbean seed						
$T_{2.3}$ (MYG)	0.41	3.14	0.42	0.42	0.13	
$T_{3.3}$ (HYG)	0.46	3.22	0.51	0.47	0.13	
Mungbean stover						
$T_{2.3}$ (MYG)	2.66	1.15	0.34	1.26	0.25	
		(31)	(9.2)	(33)	(6.6)	79.8
$T_{3.3}$ (HYG)	2.83	1.22	0.37	1.37	0.22	
		(34)	(10.4)	(39)	(6.4)	89.8
Dhaincha dry biomass						
$T_{2.2}$ (MYG)	2.59	1.57	0.41	1.10	0.15	
		(50)	(12.3)	(37)	(5.8)	105.1
$T_{3.2}$ (HYG)	3.00	1.35	0.41	1.24	0.19	
		(41)	(10.6)	(28)	(3.9)	83.5
Farmyard manure	5.00	1.12	0.34	1.14	0.15	
		(30)	(9.0)	(30)	(4.0)	73.0

Figures in parenthesis indicate the amount of added nutrients from different organic sources

It revealed that the yield components i.e. panicle length, tillers/hill, grains/panicle, and 1000-grain weight of T.Aman rice is presented in Table 4. Except 1000-grain weight all other yield attributes were significantly affected due to different treatments. Statistically significant variation was observed in panicle length with a few exceptions. The average number of tillers/hill ranged from 7.1 to 10.7. Highest number of tillers/hill was recorded in $T_{3.3.3}$ treatment (fertilizers for HYG along with MBR or dhaincha incorporation based on IPNS) and the lowest in control (T_1) treatment. The number of grains/panicle varied from 70 to 134, the highest result being recorded in $T_{3.2.1}$ treatment (mungbean residue or dhaincha biomass incorporation for HYG) and the lowest in control (T_I). The 1000-grain weight ranged from 20.29 g to 22.33 g but statistically no variation was observed. Integrated plant nutrition system (IPNS) based MBR or DH for HYG recorded the highest 1000-grain weight of T.Aman rice.

Table 4. Effects of combined use of inorganic fertilizers and crop residues/dhaincha green manure on the yield and yield attributes of T.Aman rice.

Treat-ments	Plant height (cm)	Panicle length (cm)	Tillers/ hill (no.)	Grains/ panicle (no.)	1000-grain wt (cm)	Grain yield (t/ha)	Straw yield (t/ha)
T_1	69d	13.1c	7.1g	70c	20.29	1.63g	2.38d
$T_{2.1}$	84abc	22.1b	9.4ef	127ab	21.68	3.27f	4.72c
$T_{2.2.1}$	84abc	22.8ab	10.2a-d	127ab	21.44	3.70cd	5.20bc
$T_{2.2.2}$	81c	22.1b	9.6c-f	120ab	21.56	3.46e-f	5.43abc
$T_{2.3.1}$	85abc	22.7ab	9.2f	126ab	21.41	3.39e-f	4.72c
$T_{2.3.2}$	87ab	23.3a	9.7c-f	127ab	22.23	3.72cd	5.29bc
$T_{2.3.3}$	87ab	22.8ab	10.0a-e	125ab	21.45	3.60de	5.34bc
$T_{3.1}$	86abc	21.9b	9.8b-f	122ab	22.06	3.91 bc	5.43a-c
$T_{3.2.1}$	86abc	22.7ab	10.3abc	134a	21.35	4.24a	5.89ab
$T_{3.2.2}$	83bc	22.8ab	10.5ab	132a	22.30	4.31a	5.85ab
$T_{3.3.1}$	87ab	22.2ab	9.5def	129a	21.52	3.99b	5.78ab
$T_{3.3.2}$	87ab	22.8ab	9.6c-f	123ab	21.41	4.22a	5.88ab
$T_{3.3.3}$	86abc	23.3a	10.7a	119ab	22.33	4.23a	6.26a
T_4	86abc	22.6ab	9.4ef	112b	21.34	3.54de	5.20bc
T_5	89a	22.9ab	9.5def	127ab	21.72	4.11ab	5.95ab
CV (%)	3.37	2.71	4.00	6.92	2.46	3.45	8.31
SE ±	1.65	0.345	0.223	4.84	NS	0.073	0.25

In a column, figure (s) followed by same letter do not differ significantly at 5% level by DMRT.

Changes in soil properties

The initial and post harvest soil analytical results are presented in Table 5. There were little changes in soil pH due to three years of cropping by using chemical fertilizers alone or in combination with organic manure or crop residues. Organic matter status was slightly increased due to application of organic manure or crop residue. The organic matter varied from 1.50 to 1.65% (initial level 1.59%). The increase in organic matter content in manure/crop residue treatments could be attributed to the direct effect from addition of organic matter coupled with better root growth and more stubbles addition after crop harvest. Khalequzzaman *et al.* (2005) reported that organic manure resulted in the improvement of organic carbon of the post harvest soil over the control. Total nitrogen was higher in the treatments where organic manure and crop residues were added. Islam *et al.* (2006) opined that nitrogen content slightly increased in residue management treatment but decreased in unincorporated plots.

Table 5. Changes in soil properties as influenced by the combined application of fertilizers and organic manure in the Maize-Mungbean/Dhaincha-T.Aman rice cropping pattern.

Treatment	pH	OM %	Total N %	P mg/kg	K me%	S mg/kg	Zn mg/kg
Initial soil							
	5.5	1.59	0.085	15.7	0.101	9.50	0.62
Post harvest soil (After 3 years)							
T_1	5.5	1.50	0.059	13.4	0.077	8.37	0.56
$T_{2.1}$	5.5	1.52	0.070	14.2	0.087	10.13	0.85
$T_{2.2.1}$	5.6	1.54	0.078	14.0	0.087	12.19	1.15
$T_{2.2.2}$	5.5	1.55	0.078	13.0	0.085	11.37	1.24
$T_{2.3.1}$	5.4	1.52	0.070	16.0	0.087	10.54	1.02
$T_{2.3.2}$	5.4	1.52	0.075	16.0	0.100	10.75	0.90
$T_{2.3.3}$	5.4	1.58	0.080	15.0	0.093	10.95	1.21
$T_{3.1}$	5.4	1.51	0.083	13.8	0.098	12.19	1.13
$T_{3.2.1}$	5.4	1.64	0.081	13.0	0.094	11.37	1.04
$T_{3.2.2}$	5.5	1.62	0.079	13.6	0.097	10.85	0.96
$T_{3.3.1}$	5.4	1.55	0.070	14.1	0.098	11.47	1.03
$T_{3.3.2}$	5.5	1.58	0.078	13.9	0.094	12.40	1.25
$T_{3.3.3}$	5.5	1.65	0.075	14.0	0.092	10.75	0.86
T_4	5.5	1.53	0.066	13.6	0.101	9.99	1.24
T_5	5.5	1.56	0.068	14.0	0.094	11.47	1.19

The available P varied from 13.0 to 16.0 mg/kg (initial status 15.7 mg/kg). In maximum cases, the available P content decreased. It also noted that mungbean residues incorporated plot had little higher available P compared with dhaincha manuring plot. The decrease in P content may be due to P fixation at lower pH. Increase of available P content in organic matter treated plots might be due to the decomposition of organic matter accompanied with the release of appreciable quantities of CO_2 which in turn helped increasing P availability. There was a decreased trend of K in all the treatments compared with initial soil. The exchangeable K level varied from 0.077 to 0.101 me per 100g (initial level 0.101). Higher uptake of K than its addition indicates K mining from soils. Addition of organic manure in combination with chemical fertilizers significantly increased the S status of soils. The S level ranged from 8.37 to 12.40 mg/kg (initial level 9.50 mg/kg). The increase in available S contents in soil was due to higher amount of addition through fertilizers and manures compared to that taken up by the crops in the pattern. Quayyum (1994) reported that a build up of S in soil in the legume based cropping pattern was noted. There was a build up of available Zn status of soils in all the treatments with fertilizer or fertilizer plus manure or crop residues application compared with initial soil. Qiao-lan *et al.* (2007) reported that the residual effect of Zn fertilization one year later was similar to a successive Zn fertilization for three years, and the rate of yield increase was quite similar.

Conclusion

Between the two cereals (Maize-T.Aman rice), cultivation of mungbean/sesbania and its incorporation in the soil may cause addition of organic matter, recycling of nutrients and made available for the crops ultimately improved organic matter status. Growing of mungbean reduced 14 kg N/ha and dhaincha reduced 19 kg N/ha to the subsequent T.Aman rice cultivation. Farmyard manure can be used as good source of soil organic matter. Considering soil fertility and crop yield, the legume residue incorporation along with chemical fertilizers based on IPNS was found to be the best treatment for T. aman rice. Therefore, we need to include mungbean residues or dhaincha manuring in the pattern for sustaining of soil fertility and improvement of crop productivity.

Acknowledgement

The authors gratefully acknowledge the partial financial support of Integrated Soil fertility and Fertilizer Management Project (SFFP/DANIDA) and Ministry of National Science & Information and Communication Technology (NSICT). They also express their sincere thanks to BINA authority for their support and providing GOB funded scholarship.

References

Ali, M. 2003. Role of legumes in cropping systems in the Indo-Gangetic Plains of India. *In:* Addressing Resource Conservation Issues in Rice-Wheat Systems of South Asia. Mathur, P. N., Chacko, E., Braganza, M. and Vijayakumar, S. eds. pp. 210-214.

BARC (Bangladesh Agricultural Research Council). 2005. Fertilizer Recommendation Guide. BARC Soils Pub. No. 45. Bangladesh Agril. Res. Coun., Dhaka, Bangladesh.

Brahmachari, K., S. S. Mondal, S. Pal and B. Sarkar. 2005. Effect of organic and inorganic sources of nutrients on yield and quality of crops under Jute *(Corchorus olitorious)*, rice *(Oryza sativa* L.) rapeseed *(Brassica campestris)* sequence. *J. Interacademica* **9** (1): 16-22.

Islam, M. N., M. M. Haque, A. Hamid and M. A. H. S. Jahan. 2006. Effects of nitrogen and phoshorus on growth and yield of maize-bush bean intercropping. *Bangladesh J. Agric. Environ*. **2** (2): 53-61.

Islam, M. S. 2003. Present status and prospects of hybrid maize in Bangladesh. Training Manual on Hybrid Seed Production of Maize. October 14-15, BARI, Joydebpur, Gazipur.

Khalequzzaman, M., A. Haque, M. A. Hashem and M. A. Sattar. 2005. Integrated use of various organic sources of nitrogen and urea on growth, yield and nutrient uptake by wheat. *J. Bangladesh Soc. Agric. Sci. Technol.* **2** (3 & 4): 157-160.

MMIS (Market Monitoring and Information System). 2005. Handbook of Agricultural Statistics, Ministry of Agriculture, Bangladesh.

Rahman, M. H. 2007. Improvement of crop productivity and sustenance of soil fertility by inclusion of legume in the Maize-Fallow-T.Aman rice cropping pattern. Ph. D. Dissertation. Dept. of Soil Sci. Bangladesh Agricultural University, Mymensingh.

Rijpma J. and M. Jahiruddin. 2004. Strategy and plan for use of soil nutrient balance in Bangladesh. Final Report of Short-term Assignment. SFFP/DANIDA.

Qiao-lan, W., W. Li-shu and Z. Zhu-qing. 2007. The using conditions and developing directions of fertilizer-zinc for irrigated rice in China. In Conf. Proc.: Zinc Crops 2007: Improving Crop Production and Human Health, Istanbul, Turkey.

Quayyum, M. A. 1994. Productivity of some rainfed early kharif crops and crop combinations and their effects on subsequent transplant aman rice. Ph. D. Thesis. Dept. Agron., BAU, Mymensingh pp. 134-150.

Samanta, S. C., M. H. Rashid, P. Biswas and M. A. Hasan. 1999. Performance of five cultivars of mungbean under different dates of sowing. *Bangladesh J. Agril. Res.* **24**(3): 521-527.

Sarker, M. J. U. 2005. Effects of brown manure from food legumes on transplant aman rice and their residual effects on succeeding wheat. Ph.D. Dissertation, Dept. of Soil Science, Bangladesh Agricultural University, Mymensingh.

Sharma and Bhardwaj. 2005. Direct and residual effect of rock phosphate enriched organics on yield in Maize-Wheat cropping in an acid soil. *Indian J. Soil Sci.* **53**(2): 264-266.

Zaman, S. K., N. I. Bhuiyan and M. A. Samad. 1995. Age of green manure crops. An important aspect of biomass production and N accumulation. *Bangladesh J. Agric. Sci.* **22:** 107-112.