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Economics of fertilizer use in the Maize-Mungbean/Dhaincha-T.aman rice cropping pattern

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Abstract

Field experiments were conducted over three years during 2001-2004 and 2002-2005 at BAU farm, Mymensingh and OFRD farm, Rangpur, respectively, using farm yard manure (FYM), dhaincha (*Sesbania*) and mungbean residue along with inorganic fertilizers. For the first crop (maize), there were five treatments i.e. T_1: Control, T_2: Moderate Yield Goal (MYG), T_3: High Yield Goal (HYG), T_4: FYM 5t/ha + Inorganic fertilizer for MYG as IPNS basis, T_5: FYM 5t/ha + Inorganic fertilizer for HYG as IPNS basis. Each year, FYM was applied to maize crop and GM/MBR was applied before transplanting of aman rice. 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) in both locations. After harvest of maize, mungbean and dhaincha (*Sesbania*) seeds were sown as per treatments. For T. aman rice (third crop), each of the plots of T_2 and T_3 treatments were subdivided into six, so there were altogether 15 treatments. At both locations, the incorporation of *Sesbania* biomass and mungbean residue along with inorganic fertilizers for MYG gave identical grain yields of T. aman rice with the fertilizers alone applied for HYG. There was an inverse relationship between the higher dose of fertilizer application and marginal benefit cost ratio (MBCR) at both the locations. Considering gross margin and marginal benefit-cost ratio (MBCR), legume residue incorporation along with inorganic fertilizers (IPNS basis) was found to be the best treatment ($T_{3.3.3}$).

Keywords: Economics, Fertilizer use, Cropping pattern, Organic manure, IPNS

Introduction

Fertilizer is a key component in the agricultural production systems of Bangladesh. Its use efficiency is also becoming much more important in the market economy of agricultural products. We are moving away from the traditional and rather static “soil dependent” agriculture to dynamic “fertilizer dependent” agriculture (BARC, 2005). Earlier, the farmers of the country are using fewer amounts of fertilizers. Now, they are using more than four different types of chemical fertilizers but in imbalanced proportion. On the other hand, now-a-days fertilizer is a very costly and scarce input in agricultural system. The farmers are reluctant and in some cases using negligible quantities of animal manures or crop residues because most of these materials are being used for cooking, house building and cattle 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). In case of economic analysis, gross margin and marginal benefit-cost ratio (MBCR) is a tool of partial budget analysis. Marginal benefit-cost ratio is the ratio of marginal or added benefits and marginal or added costs. In some areas of this country the farmers are using over doses of inorganic fertilizers without considering their economical benefit. Therefore, the present study was untaken to find out the suitable combination of inorganic and organic fertilizers which is environment friendly and economically viable for sustaining soil fertility with higher crop productivity.

Materials and Methods

Field experiments were conducted over three years during 2001-2004 and 2002-2005 at BAU farm, Mymensingh and OFRD, farm, Rangpur, respectively, using farm yard manure (FYM), dhaincha (*Sesbania*) and mungbean residue along with inorganic fertilizers. The experiment was laid out in a randomized complete block design (RCBD) with three replications. For the first crop (maize), there were five treatments i.e. T_1: Control, T_2: Moderate Yield Goal (MYG), T_3: High Yield Goal (HYG), T_4: FYM 5t/ha + Inorganic fertilizer for MYG as IPNS basis, T_5: FYM 5t/ha + Inorganic fertilizer for HYG as IPNS basis. After harvest of maize, mungbean and dhaincha (*Sesbania*) seeds were sown in plots as per treatments. 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. For T. aman rice (third crop), the treatments were T_1: Control; $T_{2.1}$: 100%N, 50%P, 100%K and 50%S (STB for MYG); $T_{2.2.1}$: Dhaincha incorporation+100%N, 50%P, 100%K and 50%S (STB for MYG); $T_{2.2.2}$: Dhaincha incorporation+IPNS based N fertilizer, 50%P, 100%K and 50%S (STB for MYG); $T_{2.3.1}$: Mungbean residue not incorporation+100%N, 50%P, 100%K and 50%S (STB for MYG); $T_{2.3.2}$: Mungbean incorporation+100%N, 50%P, 100%K and 50%S (STB for MYG); $T_{2.3.3}$: Mungbean residue incorporation+IPNS based N fertilizer, 50%P, 100%K and 50%S (STB basis for MYG); $T_{3.1}$: 100%N, 50%P, 100%K and 50%S (STB for HYG); $T_{3.2.1}$: Dhaincha incorporation+100%N, 50%P, 100%K and 50%S (STB for HYG); $T_{3.2.2}$: Dhaincha incorporation+IPNS based N fertilizer, 50%P, 100%K and 50%S (STB for HYG); $T_{3.3.1}$: Mungbean residue not incorporation+100%N, 50%P, 100%K and 50%S (STB for HYG); $T_{3.3.2}$: Mungbean residue incorporation+100%N, 50%P, 100%K and 50%S (STB for HYG); $T_{3.3.3}$: Mungbean residue incorporation+IPNS based N fertilizer, 50%P, 100%K and 50%S (STB basis for HYG); T_4: 100%N, 50%P, 100%K and 50%S based on STB (MYG); T_5: 100%N, 50%P, 100%K and 50%S based on STB (HYG). Yield and added benefit of all crops due to different treatments were calculated. Partial budget analysis was computed for each cropping pattern considering average of three years result. The following items were considered for the computation of variable cost: fertilizers, seeds, crops, organic manure, crop residues, weeding, labour wages for chopping and incorporation of organic manure and crop residues, harvesting and threshing. The official wage rate for the agricultural labour was considered for labour wage calculation. Added cost and added benefit were computed. A partial budget analysis was done to calculate the changes in benefit for a proposed change in the farm operation. It is useful to think of partial budgeting as a type of marginal analysis as it is best adapted to analyzing relatively small changes in the whole farm plan (Kay, 1981).

To compare different treatments combination with one control treatment the following equation was applied.

$$MBCR\,(over\ control) = \frac{Gross\ \ return\,(T_i) - Gross\ \ return\,(T_0)}{VC\,(T_i) - VC\,(T_0)}$$

$$= \frac{\text{Added}\ \ \text{benefit (over control)}}{Added\ \ \cos t\ (over\ control)}$$

Where, $T_i = T_1, T_{2.1},$ .... T_4, T_5 treatments
T_0 = Control treatment
VC= Variable cost
Gross return = Yield x price

Equivalent yield of component crops was determined following the method of Anjaneyulu *et al.* (1982)

$$\text{Maize Equivalent yield (MEY)} = Ym + \frac{Yi \times Pi}{Pm}$$

Where, Ym = Yield of maize (t ha^{-1})
Yi =Yield of rice/mungbean (t ha^{-1})
Pi = Price of rice/mungbean (Tk ha^{-1})
Pm = Price of maize (Tk ha^{-1})

Results and Discussion

Yield of crops

The highest maize equivalent yield of 21.5 t ha^{-1} and 19.5 t ha^{-1} (Tables 1 & 2) was recorded in $T_{3.3.3}$ (fertilizers for HYG along with mungbean residues based on IPNS) followed by treatment $T_{3.3.2}$ (mungbean residues incorporated with fertilizers for HYG) and $T_{3.3.1}$ (fertilizers for HYG) at BAU and OFRD farms, respectively. The yield performance of OFRD farm, Rangpur was similar to BAU farm, Mymensingh. It was observed from Table 1 that HYG based fertilizer performed generally better over

MYG based fertilizer alone or in combination with organic manure or crop residue. On the other hand, the performance of dhaincha green manure was better over mungbean residue in both the locations. Again, it was observed that when farmyard manure applied to the first crop of the pattern (maize), it had residual effect on the yield of T. aman rice.

Economics of fertilizer uses

The results showed in Tables 1 & 2 that most of the treatments for both the locations have marginal benefit cost ratio (MBCR) of more than 3.5 indicating that all those fertilizer treatments were economically viable (CIMMYT, 1984). The highest maize equivalent yield of 21.45 t ha^{-1} with the gross return of Tk 1,50,150 ha^{-1} at BAU farm and 19.54 t ha^{-1} with the gross return of Tk. 1,36,780 ha^{-1} at OFRD farm were recorded in $T_{3.3.3}$ (incorporation of mungbean residues along with recommended fertilizers dose for HYG based on IPNS). At BAU farm, the highest MBCR of 5.07 was found in $T_{3.3.1}$ (removal of mungbean residues along with recommended fertilizers for HYG) while at OFRD farm, the treatment $T_{2.3.1}$ (mungbean residues removal along with recommended fertilizers for MYG) recorded the highest MBCR of 5.17. There was an inverse relationship between the higher dose of fertilizer application and marginal benefit cost ratio (MBCR) at both the locations. If gross margin or MBCR is considered, incorporation of mungbean residue along with recommended fertilizer applied for MYG or HYG based on IPNS was found to be the most economically viable treatment. Similar observations were made by Islam *et al.* (2006), Rahman (2001) and Islam *et al.* (1999) on different field trials that the BCR was highest in NPKS (MYG) than NPKS (HYG) or NPKS (MYG) + CD treatments. The gross margin was found to be increased with increasing rates of fertilizer application and organic manuring. But the MBCR was found to be decreased with the increasing rate of fertilizer application. This might be due to the higher variable cost for the increased fertilizer application.

Table 1. Economic analysis of Maize-Mungbean/Dhaincha-T. aman cropping pattern at BAU farm, Mymensingh (average of three years)

Treatment	Maize equivalent yield (t ha^{-1})	Gross return (Tk ha^{-1})	TVC (Tk ha^{-1})	Gross margin (Tk ha^{-1})	Marginal gross margin (Tk ha^{-1})	MBCR
T_1	6.1	42,910	-	42,910	-	-
$T_{2.1}$	15.4	1,07,450	12,151	95,299	52,389	4.31
$T_{2.2.1}$	16.4	1,14,940	14,110	1,00,830	57,920	4.10
$T_{2.2.2}$	16.2	1,13,330	14,017	99,313	56,403	4.02
$T_{2.3.1}$	17.0	1,19,210	13,235	1,05,975	63,065	4.77
$T_{2.3.2}$	17.7	1,23,760	14,086	1,09,674	66,764	4.74
$T_{2.3.3}$	17.6	1,22,990	13,879	1,09,111	66,201	4.77
$T_{3.1}$	19.1	1,33,490	16,222	1,27,268	74,358	4.58
$T_{3.2.1}$	19.9	1,39,020	18,780	1,20,240	77,330	4.12
$T_{3.2.2}$	20.0	1,39,160	18,426	1,20,734	77,824	4.22
$T_{3.3.1}$	21.1	1,45,770	16,939	1,28,831	85,921	5.07
$T_{3.3.2}$	21.3	1,49,030	17,576	1,31,454	88,544	5.04
$T_{3.3.3}$	21.5	1,50,150	18,631	1,31,519	88,609	4.76
T_4	16.2	1,13,260	13,754	99,506	56,596	4.11
T_5	20.0	1,39,860	17,750	1,22,110	79,200	4.46

Economic evaluation of different fertilizers, manure and mungbean residue incorporation was also done through partial budgeting and dominance analysis followed by marginal analysis of cost undominated treatments (Perrin, 1979). In Table 3**,** gross margin from different treatments have been rearranged among the treatments from the highest to the lowest in order to identify the cost dominated treatments. It was observed from the Table 3 that treatments $T_{3.3.3}$, $T_{3.3.2}$, $T_{3.3.1}$, $T_{3.1}$, $T_{2.3.2}$, $T_{2.3.3}$, $T_{2.3.1}$, $T_{2.1,}$ T_1 at BAU farm and $T_{3.3.3}$, $T_{3.3.1}$, $T_{2.3.2}$, $T_{2.3.3}$, $T_{2.3.1,}$ $T_{2.1}$, T_1 at OFRD farm, respectively, were cost undominated. The treatments T_5, $T_{3.2.2}$, $T_{3.2.1}$, $T_{2.2.1}$, $T_{2.2.2}$, T_4 at BAU farm and $T_{3.3.2}$, T_5, $T_{3.2.2}$, $T_{3.2.1}$, $T_{3.1}$, T_4, $T_{2.2.1}$, $T_{2.2.2}$ at OFRD farm, Rangpur were dominated by cost**.** The cost dominated treatments were abandoned in marginal analysis as suggested by Elias and Karim (1984). Marginal analysis of the cost undominated treatments are shown in Tables 4 and 5, which reflects how the benefit from investment increases as the amount of investment increased. The highest marginal rate of return (MRR) were obtained through mungbean residue removal plot before T. aman rice plus inorganic fertilizers, which were 985% at BAU and 792% at OFRD farms, though the yield was lower than that of some other treatments. It signified that by spending additional Tk 100, Tk. 985 or 792 hectare^{-1} could be achieved by mungbean residue removal before T. aman rice transplantation in $T_{2.3.1}$ treatments. Though $T_{2.3.1}$ showed the highest marginal rate of return but displayed the lower yield and gross margin than $T_{3.3.3}$, $T_{3.3.2}$, $T_{3.3.1}$, $T_{3.1}$, $T_{2.3.2}$, $T_{2.3.3}$ at BAU farm and $T_{3.3.3}$, $T_{3.3.1}$, $T_{2.3.2}$, $T_{2.3.3}$ at OFRD farm, respectively. The yield and gross margin were the highest in $T_{3.3.3}$ at both farms followed by $T_{3.3.2}$ at BAU farm and $T_{3.3.1}$ at OFRD farm.

Table 2. Economic analysis of Maize-Mungbean/Dhaincha-T.aman cropping pattern at OFRD farm, Rangpur (average of three years)

Treatment	Maize equivalent yield (t ha^{-1})	Gross return (Tk ha^{-1})	TVC (Tk ha^{-1})	Gross margin (Tk ha^{-1})	Marginal gross margin (Tk ha^{-1})	MBCR
T_1	5.4	37,660	-	37,660	-	-
$T_{2.1}$	14.7	1,02,620	11,261	91,359	53,699	4.77
$T_{2.2.1}$	15.3	1,06,960	14,097	92,863	55,203	3.92
$T_{2.2.2}$	15.0	1,05,000	13,631	91,369	53,709	3.94
$T_{2.3.1}$	16.6	1,15,990	12,689	1,03,301	65,641	5.17
$T_{2.3.2}$	17.1	1,19,490	14,112	1,05,378	67,718	4.80
$T_{2.3.3}$	16.9	1,18,510	13,723	1,04,787	67,127	4.89
$T_{3.1}$	17.0	1,19,280	15,481	1,03,799	66,139	4.27
$T_{3.2.1}$	17.5	1,22,710	18,072	1,04,638	66,978	3.71
$T_{3.2.2}$	17.6	1,23,270	16,603	1,06,667	69,007	4.16
$T_{3.3.1}$	19.2	1,34,120	15,757	1,18,363	80,703	5.12
$T_{3.3.2}$	19.5	1,36,290	18,122	1,18,168	80,508	4.44
$T_{3.3.3}$	19.5	1,36,780	17,959	1,18,821	81,161	4.52
T_4	15.7	1,10,180	12,997	97,183	59,523	4.58
T_5	17.9	1,25,370	16,448	1,08,922	71,262	4.33

Table 3. Dominance analysis of various treatments applied in Maize-Mungbean/Dhaincha-T. aman rice cropping pattern

BAU farm, Mymensingh				OFRD farm, Rangpur			
Treatments	Gross margin (Tk ha^{-1})	Variable cost (Tk ha^{-1})	Inference	Treatments	Gross margin (Tk ha^{-1})	Variable cost (Tk ha^{-1})	Infer-ence
$T_{3.3.3}$	1,31,519	18,631	CUD	$T_{3.3.3}$	1,18,821	17,959	CUD
$T_{3.3.2}$	1,31,454	17,576	CUD	$T_{3.3.1}$	1,18,363	15,757	CUD
$T_{3.3.1}$	1,28,831	16,939	CUD	$T_{3.3.2}$	1,18,168	18,122	CD
$T_{3.1}$	1,27,268	16.222	CUD	T_5	1,08,922	16,448	CD
T_5	1,22,110	17,750	CD	$T_{3.2.2}$	1,06,667	16,603	CD
$T_{3.2.2}$	1,20,734	18,426	CD	$T_{2.3.2}$	1,05,378	14,112	CUD
$T_{3.2.1}$	1,20,240	18,780	CD	$T_{2.3.3}$	1,04,787	13,723	CUD
$T_{2.3.2}$	1,09,674	14,086	CUD	$T_{3.2.1}$	1,04,638	18,072	CD
$T_{2.3.3}$	1,09,111	13,879	CUD	$T_{3.1}$	1,03,799	15,481	CD
$T_{2.3.1}$	1,05,975	13,235	CUD	$T_{2.3.1}$	1,03,301	12,669	CUD
$T_{2.2.1}$	1,00,830	14,110	CD	T_4	97,183	12,997	CD
T_4	99,506	13,754	CD	$T_{2.2.1}$	92,863	14,097	CD
$T_{2.2.2}$	99,313	14,017	CD	$T_{2.2.2}$	91,369	13,631	CD
$T_{2.1}$	95,299	12,151	CUD	$T_{2.1}$	91,359	11,261	CUD
T_1	42,910	0	CUD	T_1	37,660	0	CUD

CUD: Cost undominated and CD: Cost dominated

Table 4. Marginal analysis of cost undominated treatments applied in Maize-Mungbean/Dhaincha-T. Aman rice cropping pattern at BAU farm, Mymensingh

Cost undominated treatments	Gross margin (Tk ha^{-1})	Variable cost (Tk ha^{-1})	Marginal gross margin (Tk ha^{-1})	Marginal variable cost (Tk ha^{-1})	Marginal rate of return (%)
$T_{3.3.3}$	1,31,519	18,631	65	1,055	0.06
$T_{3.3.2}$	1,31,454	17,576	2,623	637	4.12
$T_{3.3.1}$	1,28,831	16,939	1,563	717	2.18
$T_{3.1}$	1,27,268	16,222	17,594	2,136	8.24
$T_{2.3.2}$	1,09,674	14,086	563	207	2.72
$T_{2.3.3}$	1,09,111	13,879	3,136	644	4.87
$T_{2.3.1}$	1,05,975	13,235	10,676	1,084	9.85
$T_{2.1}$	95,299	12,151	52,389	12,151	4.31
T_1	42,910	-	42,920	-	-

Table 5. Marginal analysis of cost undominated treatments applied in Maize-Fallow-T.Aman rice cropping pattern at OFRD farm, Rangpur

Cost undominated treatments	Gross margin (Tk ha^{-1})	Variable cost (Tk ha^{-1})	Marginal gross margin (Tk ha^{-1})	Marginal variable cost (Tk ha^{-1})	Marginal rate of return (%)
$T_{3.3.3}$	1,18,821	17,959	458	2,202	0.21
$T_{3.3.1}$	1,18,363	15,757	12,985	1,645	7.89
$T_{2.3.2}$	1,05,378	14,112	591	389	1.52
$T_{2.3.3}$	1,04,787	13,723	1,486	954	1.56
$T_{2.3.1}$	1,03,301	12,769	11,942	1,508	7.92
$T_{2.1}$	91,359	11,261	53,699	11,261	4.77
T_1	37,660	-	37,669	-	-

Conclusion

Considering the highest marginal rate of return (MRR), the poor farmers may have options to choose the treatments $T_{2.3.1}$ (mungbean residues removed along with recommended fertilizer dose for MYG) to get additional benefit of Tk. 985 at BAU farm or Tk. 792 at OFRD farm by investing each extra one hundred taka per hactare over T_1. But the rich farmers who can invest more money for fertilizers use and interested for the higher gross margin, can adopt $T_{3.3.3}$ or $T_{3.3.2}$ to increase their gross margin profitably and sustaining soil fertility. However, soil fertility (unseen benefit) is taken into account with this economic benefit, the legume based treatments may be advocated for the farmers where (70-75) % N fertilizers may be applied to the following crop.

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