# SUSTAINABLE CROP PRODUCTION RETAINING SOIL FERTILITY AND ENVIRONMENT THROUGH MUSTARD-MUNGBEAN-T.AMANCROPPING PATTERN

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*Accepted for publication on 11 July 2009*

**ABSTRACT**

Sheikh, M. H. R., Khan, M. S., Hannan, A., A. Huda and M. T. Rahman 2009. *Sustainable crop production retaining soil fertility and environment through mustard-Mungbean-T.Amancropping pattern*. J.Soil.Nature. 3 (2):10-14.

A field experiment on sustainable crop production retaining soil fertility and environment through Mustard-Mungbean-T.aman cropping pattern was conducted during the period of 2008-09 in High Ganges River Floodplain Soils (AFZ-11) of Ishurdi to find out sustainable fertilizer doses for Mustard-Mungbean-T.aman cropping pattern, to monitor soil health, to estimate uptake of different nutrients and make a balance sheet for each nutrient. There were three levels each of N (80, 120 and 160 kg/ha), P (18, 36 and 54 kg/ha) and K (35, 70 and 105 kg/ha) in the treatment combinations. The combined effect of 120- 36-70-40-3-1 kg/ha of NPKSZnB ($T_2$) produced highest grain yield of mustard. While the residual effect of ($T_2$), application of 25 kg N and 10 kg P per hectare for Mungbean and 120-36-70-10 kg/ha of NPKS ($T_2$) for T.aman gave the highest yield of both grain and straw weight of Mungbean and T.aman. Soil fertility status was improved due to addition of biomass from mungbean in the pattern and residual effect of chemical fertilizers from different treatments. The soil pH, organic matter, total N, P, S, Zn and B content of soil was increased. But more K is to be added to soil to improve the K content of the soil. Highest marginal rate of return (1560 %) was obtained also from $T_2$ along with the gross margin Tk.1,56,736/ha/yr.

***Keywords: Crop production, Soil fertility, Environment and Cropping pattern***

## INTRODUCTION

Sustainable crop production means at necessary levels to meet the increasing needs and aspiration of expanding population without degrading soil fertility and environment. The double challenge of increasing food production to cover human needs and preserving the natural resources on which, agricultural production depends has led to the concept of sustainable agriculture. According to the Consultative Group on International Agricultural Research (CGIAR, 1988) a sustainable agriculture is one that, over the long term, enhances environment quality and the resource base on which agriculture depends; provides for basic human food and fibre needs is economically viable and enhances the quality of life for farmer and society as a whole. Bangladesh is a very densely populated and food deficit agricultural country.

Production of Mustard, Mungbean and T. aman has long lagged behind domestic demand in Bangladesh, where these are the preferred crops for human consumption. Indeed, this crop are grown so extensively-both as a sole crop and as pattern base crop. There is a large number of cropping patterns in Bangladesh. The patterns are mainly rice based and vary on agro-ecological condition and availability of irrigation facility. Mustard-Mungbean-T.aman is one of the important cropping patterns in High Ganges River Floodplain Soil (AFZ-11) of Bangladesh. Soil fertility is a major determinant for the success and failure of a crop production system. Long term soil fertility monitoring under a specific cropping system would be of great help in determining a better soil fertility management programme for sustaining productivity at high level. On the other hand, the management practices in a crop of cropping pattern greatly influence the other crop of the same pattern. Puddling of rice soil creates a plough pan and results in poor soil structure. This in turn, causes water logging, poor root growth and poor availability of nutrients for the next upland crop like mustard. So, this suggests that in cropping system, sustainability of soil fertility may decline in the long run. In an intensive fertilizer use programme, due consideration must be paid to the residual and cumulative effects of the plant nutrients applied to the preceding crops. Yield should not be limited by a nutrient deficiency or imbalance. Soil nutrient levels should be built to an optimum level and maintained. Soil is the most natural resource of a country. But it is being exhausted with the increase of cropping intensity, introducing high yielding varieties along with modern technologies. As a result, soil resources are going to be depleted with many essential elements day by day (Hasan *et. al*., 2003). Mono crop based fertilizer recommendations are proving to be costly to the poor farmers. On the other hand rich farmers are using high dose of chemical fertilizer especially urea for some crops which creates imbalances in soil nutrients (Kabir *et al*., 2002) and also creates imbalances in environment (Haque et *al*., 1991). The nutrients added to the soil in the form of fertilizers are not being removed or utilized by the crops in one season. Some amounts are left over in the field which may be harmful for next crop as well as environment. So, proper fertilizer management is very important considering the residual effect of the nutrients (Saha *et al*., 2003). Moreover, inclusion of a pulse crops in the cropping pattern would reduce the requirement of chemical fertilizers in the next crop maintaining a good health of soils through biological nitrogen fixing and addition of organic matter to soil Some researchers (Balasubramanian and Sekayanae, 1991; Bheemalah *et al.*, 1992) reported that biomass of legumes and arable crops improved soil fertility with little or no reduction in crop yields. .For this reason, a study was designed to find out sustainable fertilizer doses for Mustard-

Mungbean-T.aman cropping pattern, to monitor soil health after cropping cycle, to estimate uptake of different nutrients and make a balance sheet for each nutrient and develop a cropping pattern module and production package for the farmers.

## MATERIALS AND METHODS

The experiment was conducted in High Ganges River Floodplain Soils (AEZ-11) of Regional Agricultural Research Station (RARS), Ishurdi, Pabna during the period of 2008-09. The experimental crops were Mustard (*Brassica campestris*) variety BARI Sarisha-9, Mungbean (*Vigna radiate* L.) variety BARI Mung-5 and T. aman rice (*Oryza sativa* L.) variety BRRI-32. The plot size was 6m x 5m. The land was well ploughed following laddering. Fertilizers were applied as per treatments. The crops T. aman, Mustard and Mungbean were Transplanted/sown on July 02, 2008, November 07, 2008 and March 04, 2009, respectively, Weeding, spraying and irrigation were done whenever necessary. The experiment was carried out following Randomized Complete Block Design with eight treatments accordingly (Anonymous, 2005) and four replications. The treatment combinations for Mustard and T. Aman were as follows:

| Treatment | Treatment for mustard | | | | | | Treatment for T. aman | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | N | P | K | S | Zn | B | N | P | K | S |
| | kg/ha | | | | | | kg/ha | | | |
| $T_1$ | 80 | 36 | 70 | 40 | 3 | 1 | 80 | 36 | 70 | 10 |
| $T_2$ | 120 | 36 | 70 | 40 | 3 | 1 | 120 | 36 | 70 | 10 |
| $T_3$ | 160 | 36 | 70 | 40 | 3 | 1 | 160 | 36 | 70 | 10 |
| $T_4$ | 120 | 18 | 70 | 40 | 3 | 1 | 120 | 18 | 70 | 10 |
| $T_5$ | 120 | 54 | 70 | 40 | 3 | 1 | 120 | 54 | 70 | 10 |
| $T_6$ | 120 | 36 | 35 | 40 | 3 | 1 | 120 | 36 | 35 | 10 |
| $T_7$ | 120 | 36 | 105 | 40 | 3 | 1 | 120 | 36 | 105 | 10 |
| $T_8$ | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

In case of Mustard all PKSZnB, cowdung and half of Nitrogen (N) were applied at the time of final land preparation and remaining half N was applied before flowering, on the other hand for T.aman all PKS were applied at the time of final land preparation and N was applied in two equal installments i.e.15-20 days and 40-45 days after transplanting. Only 25 kg N and 10 kg of P / ha was applied in all treatments except the control treatment in case of Mungbean. The crops T. aman, Mustard and Mungbean were harvested on November 01, 2008, February 11, 2009 and May 26, 2009, respectively. The data of the crops were recorded against different yield contributing parameters, grain yield and straw weight for T.aman, Mustard and Mungbean respectively. The recorded data were analysed statistically following Duncan's Multiple Rang Test according to Gomez and Gomez (1984). A description of nutrient status of initial soil prior to fertilization is presented in Table 1.

Table 1. Analytical data of the experimental soils (Presowing)

| Location | pH | OM (%) | Ca | Mg | K | Total N | P | S | B | Cu | Fe | Mn | Zn |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | meq/100g | | | (%) | g/ml | | | | | | |
| RARS, Ishurdi | 7.4 | 1.32 | 14 | 2.6 | 0. 16 | 0.050 | 11 | 13 | 0.17 | 1.6 | 58 | 8 | 1.7 |
| Critical level | - | - | 2.0 | 0.8 | 0.2 | - | 14 | 14 | 0.2 | 1.0 | 10 | 5.0 | 2.0 |

## RESULTS AND DISCUSSION

Yield and different yield contributing parameters of Mustard, Mungbean and T. aman as influenced by different treatments are presented in Table 2, 3 and 4.

### *Mustard*

Yield increase of mustard grain and straw due to different treatment combinations over native nutrient treatment have been shown in Table 2. With the increasing rate of nitrogen application up to 120 kg N/ha, there was significant effect in increasing seed yield. Beyond this, higher application rate had some reduced effect. The seed yield was also increased progressively and significantly with the increased rate of P application. The calcareous soil being deficient in available phosphorus showed positive effect in increasing seed yield due to higher rate of P application. Application of 70 kg K/ha was enough to produce significant seed yield. Higher K addition had beneficial effect. The available K in the soil was below the critical level. So a maintenance dose of potassium was sufficient for higher yield. The combined effect of $N_{120}P_{36}K_{70}S_{40}Zn_3B_1$ kg/ha ($T_{2)}$ produced the highest seed yield (1.50 t /ha) and straw wt. (4.61 t/ha).

Table 2. Mean performance of different parameters of Mustard under Mustard-Mungbean-T.aman cropping pattern at RARS, Ishurdi during the period of 2008-09

| Treatments | Plant population /$m^2$ | Plant height (cm) | Number of branches /plant | Number of pod/plant | Number of seed/ pod | 1000 grain weight (g) | Grain yield (t/ha) | Straw weight (t/ah) |
|---|---|---|---|---|---|---|---|---|
| $T_1$ | 84.50c | 108.5b | 3.83bc | 56.33b | 24.85b | 3.075b | 1.24e | 4.13b |
| $T_2$ | 91.50a | 115.3a | 4.75a | 65.90a | 27.85a | 3.25a | 1.50a | 4.61a |
| $T_3$ | 86.50b | 108.8b | 4.15b | 54.75bc | 24.98b | 3.10b | 1.35cd | 3.92bcd |
| $T_4$ | 83.25cd | 107.5b | 3.95bc | 53.65c | 23.13c | 3.08b | 1.29de | 3.75d |
| $T_5$ | 87.50b | 103.5c | 4.25b | 53.70c | 23.10c | 3.05b | 1.47ab | 4.08bc |
| $T_6$ | 81.50d | 102.5c | 3.68c | 50.71d | 21.30d | 2.97bc | 1.38c | 3.88cd |
| $T_7$ | 79.50e | 98.5d | 3.15d | 48.35e | 20.80d | 2.98bc | 1.40bc | 4.00bc |
| $T_8$ | 74.75f | 95.5e | 2.70e | 41.50f | 18.02 | 2.86c | 0.64f | 1.65e |

In a column, similar letter(s) do not differ significantly at 5 % level of probability, $T_1$ = 80-36-70-40-3-1 kg NPKSZn B/ha, $T_2$ = 120-36-70-40-3-1 kg NPKSZn B/ha, $T_3$ = 160-36-70-40-3-1 kg NPKSZn B/ha, $T_4$ = 120-18-70-40-3-1 kg NPKSZn B/ha, $T_5$ = 120-54-70-40-3-1 kg NPKSZn B/ha, $T_6$= 120-36-35-40-3-1 kg NPKSZn B/ha, $T_7$ = 120-36-105-40-3-1 kg NPKSZn B/ha and $T_8$ = Control (Native fertility).

## MUNGBEAN

Significant differences were observed in different parameters, The highest grain yield (1.52 t /ha) and biomass weight (8.28 t /ha) of mungbean due to fertilizer treatments was found against the treatment $T_2$ (Table 3). Only 25 kg N and 10 kg P/ha was applied in all treatments except the control (Native fertility) treatment.

Table 3. Mean performance of different parameters of Mungbean under Mustard-Mungbean-T.aman cropping pattern at RARS, Ishurdi during the period of 2008-09

| Treatments | Plant population /$m^2$ | Plant height (cm) | Number of pod/plant | Number of seed/ pod | 1000 grain weight (g) | Grain yield (t/ha) | Straw weight (t/ah) |
|---|---|---|---|---|---|---|---|
| $T_1$ | 43.50b | 29.00bc | 9.95b | 8.73b | 38.63b | 1.43b | 7.50b |
| $T_2$ | 46.50a | 34.25a | 12.02a | 10.70a | 41.08a | 1.52a | 8.28a |
| $T_3$ | 42.50bc | 31.25ab | 9.08b | 8.58bc | 37.95c | 1.35c | 7.45b |
| $T_4$ | 40.75c | 31.50ab | 9.23bc | 7.80d | 37.50cd | 1.32d | 7.42b |
| $T_5$ | 44.25b | 31.75ab | 10.47b | 8.03cd | 37.08de | 1.42b | 7.53b |
| $T_6$ | 41.00c | 29.50bc | 7.85c | 7.43de | 36.74e | 1.28e | 5.60c |
| $T_7$ | 38.75d | 26.00cd | 9.05bc | 7.03e | 35.38f | 1.40b | 6.98b |
| $T_8$ | 32.50e | 22.75d | 8.01c | 5.40f | 34.54g | 1.27e | 5.80c |

In a column, similar letter(s) do not differ significantly at 5 % level of probability 25 kg N and 10 kg of P / ha was applied in all treatments except the control treatment. T. Aman Incorporation of green biomass of mungbean and residual effect of previous applied fertilizer influenced the grain yield and straw wt of T.aman significantly. The highest yield of grain and straw wt was found 5.30 and 6.55 t/ha, respectively (Table 4) against the treatment $T_2$ (120-36-70-10 kg NPKS/ha).

Table 4. Mean performance of different parameters of T.aman under Mustard-Mungbean-T.aman cropping pattern at RARS, Ishurdi during the period of 2008-09

| Treatments | Plant population /$m^2$ | No. of tillers/$m^2$ | Plant height (cm) | length of panicle (cm) | No. of seed/ panicle | 1000 grain weight (g) | Grain yield (t/ha) | Straw weight (t/ah) |
|---|---|---|---|---|---|---|---|---|
| $T_1$ | 28.00ab | 219.0b | 99.50b | 24.25b | 102.8c | 20.25bc | 5.15b | 5.57bc |
| $T_2$ | 29.00a | 226.3a | 102.00a | 25.75a | 109.3a | 22.00a | 5.30a | 6.55a |
| $T_3$ | 26.25bc | 217.5b | 98.50bc | 22.00c | 105.3b | 19.25cd | 5.10b | 5.49bc |
| $T_4$ | 24.75c | 213.5c | 97.00c | 20.75c | 102.8c | 19.00cd | 4.64cd | 5.27cd |
| $T_5$ | 27.75ab | 223.5a | 99.50b | 24.75ab | 106.0b | 21.00ab | 5.16b | 5.72b |
| $T_6$ | 25.00c | 216.8b | 94.50d | 19.25d | 103.0c | 19.75d | 4.65cd | 5.24cd |
| $T_7$ | 22.50d | 208.3d | 93.25d | 18.25d | 102.3c | 18.50de | 4.12e | 5.10d |
| $T_8$ | 19.00e | 181.8e | 90.75e | 16.25e | 98.75d | 17.25e | 3.10f | 4.43e |

In a column, similar letter(s) do not differ significantly at 5 % level of probability, $T_1$ = 80-36-70-10 kg NPKS /ha, $T_2$ = 120-36-70-10 kg NPKS /ha, $T_3$ = 160-36-70-10 kg NPKS /ha, $T_4$ = 120-18-70-10 kg NPKS /ha, $T_5$ = 120-54-70-10 kg NPKS /ha, $T_6$= 120-36-35-10 kg NPKS /ha, $T_7$ = 120-36-105-10 kg NPKS /ha, $T_8$ = Control (Native fertility).

Yield increase of mustard grain and straw due to different treatment combinations over native nutrient treatment have been shown in Table 2. With the increasing rate of nitrogen application up to 120 kg N/ha, there was significant effect in increasing seed yield. Beyond this, higher application rate had some reduced effect. This result is at per that of Bhuiyan *et al*. (1991) and Farid *et al.* (1994). The seed yield also increased progressively and significantly with the increased rate of P application. The calcareous soil being deficient in available phosphorus showed positive effect in increasing seed yield due to higher rate of P application. This finding is supported by Bodruzzaman *et al*. (2003). Application of 70 kg K/ha was enough to produce significant seed yield. Higher K addition had beneficial effect. The available K in the soil was below the critical level. So a maintenance dose of potassium was sufficient for higher yield. The combined effect of $N_{120}P_{36}K_{70}S_{40}Zn_3B_1$

kg/ha ($T_2$) produced the highest seed yield and straw wt. (1.50 and 4.61 t/ha), respectively. Significant differences were observed in different parameters of Mungbean, Highest grain yield (1.52 t /ha) and biomass weight (8.28 t/ha) of Mungbean due to fertilizer treatments was obtained against the treatment $T_2$ (Table 3). These results are supported by that of Saha *et al*. (2000) and Khan et *al*. (2006).

Incorporation of green biomass of Mungbean and residual effect of previous applied fertilizer influenced the grain yield and straw wt of T.aman significantly. The highest yield of grain and straw wt of T.aman was found 5.30 and 6.55 t/ha, respectively (Table 4) against treatment $T_2$ (120-36-70-10 kg NPKS/ha). Addition of green biomass improved soil fertility which increased the yield of the subsequent cereal crop. The findings are supported by Bhuiyan (1995), Sheikh *et al.* (2007a) and Sheikh *et al.* (2007b).

***Soil fertility status (post sowing)***

The status of soil pH, organic matter, total N, available P, and S in initial soil as well as in soil after completion of cropping cycle of Mustard-Mungbean-T.aman cropping pattern have been shown in Table 5. Initially the pH of the soil was 7.4. But after cropping cycle, the pH reached near neutrality ranging from 7.1 to 7.4. The highest amount of organic matter was found in $T_2$ treatment where high amount of biomass was added. The soil fertility was improved i.e OM, total N, P, S, Zn and B content of soil was increased. But more K is to be added to soil to improve the K content of the soil.

Table 5. Soil test values after cropping cycle

| Soil status | Treatment | Soil texture | PH | OM % | Total N % | P µg/ml | K meq/100 ml | S µg/ml | Zn µg/ml | B µg/ml |
|---|---|---|---|---|---|---|---|---|---|---|
| Initial | All | Sandy loam | 7.4. | 1.32 | 0.050 | 11 | 0.17 | 13 | 1.7 | 0.17 |
| Final | $T_1$ | Sandy loam | 7.2 | 1.38 | 0.059 | 14 | 0.16 | 15 | 2.2 | 0.23 |
| | $T_2$ | Sandy loam | 7.1 | 1.40 | 0.064 | 16 | 0.17 | 16 | 2.2 | 0.24 |
| | $T_3$ | Sandy loam | 7.27. | 1.37 | 0.063 | 15 | 0.16 | 16 | 2.2 | 0.23 |
| | $T_4$ | Sandy loam | 27.3 | 1.36 | 0.063 | 14 | 0.16 | 16 | 2.0 | 0.23 |
| | $T_5$ | Sandy loam | | 1.37 | 0.063 | 13 | 0.16 | 14 | 2.1 | 0.23 |
| | $T_6$ | Sandy loam | 7.3 | 1.36 | 0.062 | 13 | 0.15 | 14 | 2.0 | 0.20 |
| | $T_7$ | Sandy loam | 7.3 | 1.36 | 0.062 | 12 | 0.17 | 13 | 2.0 | 0.19 |
| | $T_8$ | Sandy loam | 7.4 | 1.30 | 0.054 | 10 | 0.12 | 12 | 1.5 | 0.18 |

***Economic Analysis***

The economic analysis (Table 6 and 7) showed that highest gross margin (Tk.1,56,736/ha/yr) was obtained from $N_{120}P_{36}K_{70}S_{40}Zn_3B_1$ kg/ha ($T_2$) against variable cost (Tk.71759/ha/yr). The purpose of marginal analysis is to reveal how the net benefit from investment increases as the amount of investment increases. Highest marginal rate of return (1560.00 %) was obtained from the $T_2$ along with the gross margin Tk.1,56,736/ha/yr.

Table 6. Gross return, variable cost and gross margin of Mustard-Mungbean-T.Aman at Ishurdi after cropping cycle

| Treatment | Gross return (Tk./ha/yr.) | Variable cost (Tk./ha/yr.) | Gross margin (Tk./ha/yr.) | Remarks |
|---|---|---|---|---|
| $T_1$ | 209735 | 70629 | 139106 | CUD |
| $T_2$ | 228495 | 71759 | 156736 | CUD |
| $T_3$ | 209175 | 72890 | 136285 | CD |
| $T_4$ | 198055 | 65099 | 132956 | CUD |
| $T_5$ | 218725 | 76419 | 142306 | CD |
| $T_6$ | 198930 | 67559 | 131371 | CD |
| $T_7$ | 198390 | 75959 | 122431 | CD |
| $T_8$ | 143745 | 39870 | 103875 | CUD |

Legend

1 kg N = Tk.14.13
1 kg P= Tk 185
1 kg K = Tk. 60
1 Kg S=Tk.50
1 Kg Zn=Tk.417
1 Kg B=Tk..824
1 kg Mustard seed= Tk.60
1 kg Mungbean seed= Tk.70
1 kg T. Aman seed = Tk. 20

1 kg Mustard non seed = Tk.40
1 kg Mungbean non seed= Tk.50
1 kg T. aman non seed = Tk.15
1 kg Mustard straw = Tk.0.50
1 kg Mungbean biomass = Tk.0.50
1 Kg T.aman straw = Tk.1.00
CUD=Cost un dominated
CD =Cost dominated

Land preparation cost = Tk.400/Bigha/Crop. (Tk.3000/Hectare)
Labour wages = Tk.150/Day/Labour.

Table 7. Marginal analysis of cost undominated treatments of Mustard-Mungbean-T.Aman at Ishurdi after cropping cycle

| Treatment | Gross margin (Tk./ha/yr.) | Marginal increase in gross margin (Tk./ha/yr) | Variable cost (Tk./ha/yr.) | Marginal increase in variable cost (Tk./ha/yr) | MRR (%) |
|---|---|---|---|---|---|
| $T_2$ | 156736 | 17630 | 71759 | 1130 | 1560.00 |
| $T_1$ | 139106 | 6150 | 70629 | 5530 | 111.21 |
| $T_4$ | 132956 | 29081 | 65099 | 25229 | 115.27 |
| $T_8$ | 103875 | - | 39870 | - | - |

## CONCLUSION

Addition of green biomass of mungbean and fertilizers of different treatments improved soil nutrient status in comparison to the control (Native fertility) treatment. The average soil fertility status were mostly unchanged, somewhere it was increased. So, through this practice the soil nutritional status may be sustained and the farmer can grow year round crop successfully and profitably.

## ACKNOWLEDGMENT

The research work was supported by technology developing, research and developmental project funded by Ministry of Science and Information and Communication Technology, Bangladesh during the period of 2008-09.

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