SUSTAINABLE CROP PRODUCTION RETAINING SOIL FERTILITY AND ENVIRONMENT THROUGH AGRO-FORESTRY SYSTEM

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Accepted for publication: September 25, 2007

ABSTRACT

Sheikh M. H. R., Ali M. O., Khan M.S., Hannan A. and Rahman M. T. 2007. *Sustainable Crop Production Retaining Soil Fertility and Environment through Agro-Forestry System.* **Int. J. Sustain. Crop Prod. 2(6):1-5**

A field experiment on sustainable crop production retaining soil fertility and environment through agro-forestry system was carried out in High Ganges Floodplain Soils (AEZ-11) of Ishurdi in the farmer's existing Mehagoni orchard of village Velupara during the period of 2005-2006 to determine the spatial soil variability and crop productivity as affected by tree pruning/training management. The experimental tree species was Mehagoni and crops were Black gram, Wheat and Broadcast Aus. There were five treatments viz. T_1 = tree with crop and training & mulching at 4 month interval, T_2 = tree with crop and training & mulching at 6 month interval, T_3 = tree with crop and training & mulching at 1 year interval, T_4= tree with crop but Non training, T_5= tree without crop and Non training. Statistically significant results were obtained and T_2 (i.e. tree with crop and training & mulching at 6 months interval) showed the best performance. Highest grain yield and straw weight of B-Aus, Blackgram and Wheat were obtained from T_2. Highest tree height and breadth were also obtained from T_2. Statistically significant results were obtained from increase of tree height but statistically identical results were obtained from T_1, T_3, T_4 and T_5 in case of tree breadth. The economic analysis showed that highest gross margin (Tk. 29,928/ha/yr) was obtained from T_2 against the variable cost (Tk. 30,723/ha/yr). The highest marginal rate of return 1,321% was obtained from T_3 along with gross margin of Tk. 18,437/ha/yr. Soil fertility status was improved due to addition of biomass through mulching of tree leaves and biomass of Blackgram in the pattern.

Key words: Crop production, Soil fertility and environment, agro-forestry system

INTRODUCTION

Fertile 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. Mono crop based fertilizer recommendations are providing 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. (Rahman, 1994)

The nutrients added to the soil in form of fertilizers are not being removed or utilized by the crops in one season. Some amounts are left over in the field. So, proper fertilizer management is very important considering the residual effect of the nutrients. Moreover, inclusion of 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 (N) fixing and addition of organic matter to soil. On the other hand for healthy environment of a country at least 25% of the total land should be covered with forest area (CGLAR, 1988). Some researcher (Balasubramanian. and Sekayanae, 1991; Bheemalah *et al.* 1992) reported that trees improved soil fertility with little or no reduction in crop yields. Our present work is to develop an agro forestry module.

For this reason, a fertilizer management experiment in a Mehagoni (*Sweitenia macrophylla*) orchard was designed to be carried out at farmers' field of village Velupara, Ishurdi, Pabna on long term basis on the cropping pattern. Blackgram - Wheat – B.Aus. The main objectives of this experiment were (i) to evaluate the growth and development of tree species as affected by training management, (ii) to develop module of agroforestry for crop field, (iii) to determine the spatial soil variability and crop productivity as affected by tree pruning/training management and (iv) to investigate long term dynamics of soil organic matter, nutrients and crop yields at the tree-crop interface.

MATERIALS & METHODS

The experiment was conducted under existing Mehagoni orchard at farmers' field of village Velupara, Ishurdi, Pabna during 2005-2006. The plot size was 3m x 3m, one tree at the centre. The land was well ploughed following laddering. Fertilizers were applied as per recommendation (Anonymous, 2000). The crops were Blackgram (BARI Mash-2), Wheat (Shatabdi) and Broadcast Aus (a local popular variety named Kalaburi) were sown on August 05, 2005, November 15, 2005 and April 15, 2006, respectively. Weeding, spraying and irrigation were done whenever necessary. Trainings were done according to the treatments. The experiment was

carried out following Randomized Complete Block Design with six replications. The treatments were i) T_1 = tree with crop and training & mulching at 4 months interval, ii) T_2 = tree with crop and training & mulching at 6 months interval, iii) T_3 = tree with crop and training & mulching at one year interval, iv) T_4= tree with crop but Non training, v) T_5= tree without crop and Non training. The crops Blackgram, Wheat and Broadcast Aus were harvested on October 14, 2005, March 14, 2006 and July 15, 2006, respectively. The data of the crops were recorded against different yield contributing parameters, grain yield and straw weight for Blackgram, Wheat and Broadcast Aus respectively. The data for tree height and breadth were also recorded. The recorded date were analysed statistically following Duncan's Multiple Rang Test according to Gomez and Gomez, (1984). Analytical data of the experimental soil are presented below in Table 1.

Table 1. Analytical data of the experimental soils

Location	pH	OM %	Ca	Mg	K	Total N %	P	S	B	Cu	Fe	Mn	Zn
			meq/100g				μg/ml						
Farmer's orchard	7.6	1.25	13	1.8	0.17	0.06	12	15	0.2	1.5	48	11	1.7
Critical Level	-	-	2.0	0.8	0.2	-	14	14	0.2	1.0	10	5.0	2.0

RESULTS AND DISCUSSION

Blackgram (BARI Mash 2)

There was no significant difference in grain yield and other yield contributing parameters of Blackgram between T_1 and T_2 (Table 2). But higher straw weight was obtained from T_2. Yields from the T_4 (Tree with crop but Non training) were significantly lower than that of T_1, T_2 & T_3. The biomass was ploughed down after the harvest of grain.

Table 2: Performance of different growth and yield parameters of Blackgram under Agro-forestry System at Ishurdi, Pabna during the period of 2005-2006

Treatments	Plant population /m^2	Plant height (cm)	No. of pod/plant	No. of seed/ pod	1000 grain weight (g)	Grain yield (t/ha)	Straw weight (t/ah)
T_1	18.00a	29.75a	18.00a	5.25a	40.00a	0.68a	0.88b
T_2	18.50a	32.00a	18.00a	5.25a	40.75a	0.70a	0.98a
T_3	12.00b	31.50a	13.00b	5.25a	35.00b	0.45c	0.80c
T_4	8.50c	30.75a	8.75c	3.50b	32.25c	0.14d	0.69d
T_5	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CV (%)	10.06	4.69	6.56	12.12	4.13	1.81	3.96

* 20 kg Nitrogen/ha was applied in all treatments except T_5 (Native treatment).

Wheat (Shatabdi)

Statistically identical grain yields and other yield contributing parameters were obtained by the T_1 and T_2 (Table 3). The combined effect of T_2 produced grain 3.08 t/ha as compared to 2.98 t/ha in the T_1. The same trend was also observed for the straw weight. Both grain and straw yield were found to be higher in all the treatments than those obtained from T_4 (i.e. Tree with crop and non training). This findings is supported by Haque and Hossain, 1992. This might be due to inclusion of green biomass of Blackgram between the two cereal crops and training and mulching effect of the trees which helped to sustain the soil productive.

Table 3: Performance of different growth and yield parameters of Wheat under Agro-Forestry System at Ishurdi, Pabna during the period of 2005-2006

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	33.00ab	173.0a	96.35a	9.28b	46.08a	41.65a	2.98a	3.90b
T_2	35.00a	175.3a	97.72a	10.00a	45.40a	41.97a	3.08a	4.24a
T_3	30.50b	164.5b	84.25b	8.74b	44.94a	40.86a	2.46b	2.58c
T_4	24.75c	147.3c	79.50c	7.45c	37.28b	37.45b	1.74c	1.93d
T_5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CV (%)	5.14	2.27	2.59	4.11	4.42	1.83	4.68	1.34

Broadcast Aus (Kala buri)

In the year, 2005-2006, statistically significant grain yields and straw weight were obtained but T_2 showed the highest performance. Incase of plant population/m^2, number of tillers/m^2, plant height, length of panicle, Number of seed/panicle and 1000 grain weight T_2 showed the highest performance though in most cases T_1 and T_2 showed statistically identical results (Table 4). This result was accordance with Samsuzzaman *et al.* (1996).

Table 4: Performance of different growth and yield parameters of B. Aus under Agro-forestry System at Ishurdi, Pabna during the period of 2005-2006

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	20.00a	139.8a	74.05a	21.66b	57.50b	24.13a	2.14b	2.61ab
T_2	21.00a	144.0a	74.50a	22.27a	63.00a	24.85a	2.34a	2.79a
T_3	15.50b	123.8b	71.73b	20.94c	53.00b	21.93b	2.06b	2.44b
T_4	12.25c	104.3c	61.65c	18.05d	44.25c	17.33c	1.88 c	2.12c
T_5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CV (%)	7.65	2.87	1.10	1.24	5.50	5.00	4.02	6.78

Trees (Mehagoni)

Statistically significant results were obtained in case of tree height and breadth. Highest height (513.5cm) and breadth (25.8cm) were obtained from T_2 (Table 5). These results were similar with the findings of Haque (1994) and Hossain and Bari (1996).

Table 5: Performance of increasing height and breadth of experimental trees Mehagoni (*Sweitenia macrophylla*) under Agro-forestry System at Ishurdi, Pabna during the period of 2005-2006

Treatments	Initial tree height (average) (cm)	Mean height after one year (cm)	Difference of height (cm)	Initial tree breadth (average) (cm)	Mean breadth after one year (cm)	Difference of breadth (cm)
T_1	426.0	466.0c	40.0	15.4	21.8b	6.4
T_2	436.0	513.5a	77.5	15.0	25.8a	10.8
T_3	432.8	477.5b	44.7	15.5	22.9b	7.4
T_4	429.8	454.2d	24.4	15.4	21.9b	6.5
T_5	426.7	447.8d	21.1	15.5	21.8b	6.3
CV (%)	-	0.46	-	-	3.13	-

Soil fertility status after cropping cycle

Perceptible changes in soil chemical properties occurred through the use of chemical fertilizer and incorporation of blackgram biomass and mulching with tree leaves (Table 6). The pH of the soil reached near neutrality ranging from 7.2 to 7.3 after one year. The organic matter, P, N, S and Zn content was increasing due to biomass addition. Similar results were found by Balasubramanian and Sekayanae (1991) and Bheemalah *et al. (*1992). The balance between K application and K uptake was negative while the changes in the soil test values showed lower values than that of initial values.

Table 6. Soil fertility status of the experimental field after cropping cycles

Soil status	Treatment	Soil texture	pH	OM %	Total N %	P µg/ml	K meq/ 100 ml	S µg/ml	Zn µg/ml
Initial	All	Sandy loam	7.6	1.25	0.06	12	0.17	15	1.7
Final	T_1	Sandy loam	7.2	1.30	0.067	15	0.15	16	2.0
	T_2	Sandy loam	7.2	1.32	0.068	16	0.15	17	2.0
	T_3	Sandy loam	7.2	1.28	0.067	15	0.14	15	2.0
	T_4	Sandy loam	7.3	1.24	0.065	14	0.12	15	1.8
	T_5	Sandy loam	7.3	1.22	0.065	14	0.12	13	1.7

Economic Analysis

The economic analysis (Table 7 & 8) showed that highest gross margin (Tk. 29,928/ha/yr) was obtained from T_2 against the variable cost (Tk. 30,723/ha/yr). The purpose of marginal analysis is to reveal how the net benefits from investment increases as the amount of investment increases. The highest marginal rate of return 1,321% was obtained from T_3 along with gross margin of Tk. 18,437/ha/yr.

Table 7. Gross return, variable cost and gross margin of B.Aus-Blackgram-Wheat cropping pattern in agro forestry system

Treatment	Gross return (Tk./ha/yr.)	Nutrient cost (Tk./ha/yr.)	Gross margin (Tk./ha/yr.)	Remarks
T_1	57911	31773	26138	*CD
T_2	60651	30723	29928	*CUD
T_3	48110	29673	18437	CUD
T_4	33193	28623	4570	CUD
*T_5	-	-	-	-

*T_5 = Tree without crop and Non training, *CD = Cost dominated, *CUD = Cost undominated

1 kg N = Tk. 13
1 kg P = Tk. 95
1 kg K = Tk. 28
1 kg Wheat straw = Tk. 0.50
1 kg Blackgram biomass = Tk. 0.20
1 kg T. Aman straw = Tk. 0.50
1 kg Wheat grain seed = Tk. 22
1 kg Blackgram grain seed = Tk. 40
1 kg B.Aus grain seed = Tk. 12
1 kg Wheat grain non seed = Tk. 10
1 kg Blackgram grain non seed = Tk. 20
1 kg B.Aus grain non seed = Tk. 7
Rate of land preparation with power tiller = Tk. 2250/ha
Labour wages Tk. = 70/day

Table 8. Marginal analysis of cost undominated treatments of B.Aus-Blackgram-Wheat cropping pattern in agro forestry system.

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	29928	11491	30723	1050	1034
T_3	18437	13867	29673	1050	1321
T_4	4570	-	28623	-	-

CONCLUSION

Addition of green biomass of Blackgram, mulching with tree leaves and fertilizers of different treatments improved soil nutritional status in comparison to control (T_5). The average soil fertility status were mostly unchanged, somewhere it was increased. So, through this practice the soil nutritional status may be retained and the farmer can grow crop successfully and profitably in the Mehagoni orchard.

Acknowledgment: The research work was supported by technology developing, research and developmental project funded by Ministry of Science and information & communication technology, Bangladesh during the period 2005-06.

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