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Performance of Green Manures as Second Intercrops on Sugarcane Productivity in Sugarcane-Potato Intercropping System

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ABSTRACT

A field experiment was conducted at farmer's plot in Chuadanga district under Ganges River Flood plain soils (AEZ 11) during 2001-2002 cropping season to evaluate the performance of different green manuring (GM) crops as second intercrops on sugarcane productivity in sugarcane potato intercropping system. It was set up with four treatments. Green manure crop as second intercrop, irrespective of species increased cane yield and yield contributing parameters significantly over control (no GM) except brix and unit stalk weight. The treatment T_2 where sunhemp (*Crotalaria juncea*) was incorporated produced the highest cane yield (124.5 tha^{-1}). All the green manuring treatments produced higher net profit and BCR over control. Highest net profit (113479.25 Tk ha^{-1}) and BCR (2.60) also obtained from Sunhemp incorporation as GM.

Key words: Green manure, Sugarcane, Potato, Intercropping, Productivity.

INTRODUCTION

Intercropping is an economic approach of getting additional farm income and high agricultural production per unit area from same piece of land. Sugarcane is a long duration crop, grows very slowly at initial stage. So during this time, some short duration crop can be grown easily between sugarcane rows. Intercropping has been adopted in commercial scale (Rahman *et al.*, 1976). It is reported that 50-80 per cent of the rainfed crops is planted as intercrop with sugarcane (*Saccharum officinarum* L) in many developing countries. Only 15-20 per cent areas under sugarcane cultivation are intercroped in Bangladesh while in Mauritius, about 70-77 per cent cane areas are intercroped mainly with potato and tomato (Imam *et al.*, 1990). Many investigators reported that sugarcane yield increased when potato was grown with sugarcane as intercrop (Anon., 1992; Singh *et al.*, 1986, Imam *et al.*, 1990). Moreover, the highest net profit is earned by potato intercropping over pure stand sugarcane (Anon., 1982, Imam *et al.*, 1987). The combined return of cane and potato was always higher, when both the crops were planted together and received their full rates of fertilizer (Imam *et al.*, 1990). Organic matter (OM) and Nitrogen (N) levels in upland soils of Bangladesh are far bellow than requirement for crop growth and this are depleting day by day. Alam *et al.* (1997) reported that Bangladesh soils are deficient in nutrients and fail to give crop yields without any fertilizer. Sugarcane is a long duration crop and it is grown well in the soil having abundant organic matter and sufficient level of available plant nutrients (Islam *et al.*, 1995). So, to improve the soil health and for sustainable sugarcane production, addition of organic matter and plant nutrients are essential. But the availability of farmyard manure is limited due to diversion of the same for multiple uses (Mia *et al.*, 1993). So green manuring is a good option for maintaining soil health for sustainable sugarcane production. GM increases the soil NP concentrate, maintenance and renewal of organic matter and impresses the soil physical and chemical conditions (Jiao, 1983). Tamhane *et al.* (1970) gave similar opinion that GM crop provides a favourable environment for many physical, chemical and biological activities. Legumes benefit the succeeding crop through symbiotic nitrogen fixation and

mobilization lesser available forms of plant nutrients, Improvement of soil structure and decrease in leaching loss of nutrients (Sharma *et al.*, 1985). But due to high cropping intensity, it has a limited scope to cultivate GM crops separately. Parthasarathy (1972) reported that cultivation of GM as intercrop with sugarcane may be done. Many legume species have been studied as green manure in different countries. Legumes have unique ability to fix atmospheric N and to contribute large quantities of N to the following crop. Green manuring crop like *Crotalaria juncea* , *Sesbania rostrata*, *Sesbania aculeata* and *Indigofera tinctoria* have been reported as a potential green manuring crop to Bangladeshi farmers (Uddin *et al.*, 1996 and Alam *et al.*, 1997)

In Bangladesh potato is cultivated as first intercrop and GM as second intercrop in sugarcane field. Information on the effect of GM as second intercrop after harvest of first intercrop potato on sugarcane productivity is insufficient. Therefore, a study was undertaken to assess the effect of different green manures as second intercrop in sugarcane potato intercropping system on sugarcane productivity.

MATERIALS AND METHODS

The field experiment was conducted during 2001-2002 cropping season at farmer's field in Chuadanga district under high Ganges River Flood Plain soils of Bangladesh (AEZ-11) to study the effect of green manures as second intercrop in sugarcane potato intercropping system on sugarcane productivity. Soil samples were collected from the experiment plot before transplanting of sugarcane settling and later analysed for nutrient status. Soil pH was measered in soil: water suspension at 1: 2.5 by glass electrode, total N by Kjeldhal method (Jackson, 1973); organic carbon by wakly and Black wet oxidation method; available P ((NaHCo3 extractant) by standard ammonium molybdate method of Olsen; exchangeable K by flame photometer. Nutrient status of the initial soil is shown in the Table 1.

Table 1. Properties of initial soil of the experimental plots.

Location	Texture	pH	OM (%)	Total N (%)	Available P (ppm)	Exchangeable K (meq%)	Available S (ppm)
Chuadanga	Sandy loam	7.5	1.03	0.092	26.32	0.184	16.05

The experiment comprised with following treatments:
T_0 = Paired row cane (PRC) + Potato
T_1 = PRC+ Potato + Dhaincha (*Sesbania aculeata*)
T_2 = PRC+ Potato + Sunhemp (*Crotalaria juncea*)
T_3 = PRC+ Potato + Indigo (*Indigofera tinctoria*)

The experiment was laid down in RCB design with four replications. Individual plot size was 48 sq. m. (8 m x 6 m). After the final land preparation, 45 day old soil bed settlings of variety Isd 30 were transplanted in late December, 2001 in paired row system. The paired row was made by alternating cane between row spacing of 120 cm with 60 cm, such that the potato intercrop occupied the wider space between paired cane rows. The cutting of potato (var. Cardinal) tubers 1-2 sprouted bud was planted between the vacant spaces of two rows of sugarcane in mid November, 2001. Potato tuber were planted in 3 rows following spacing row to row 30 cm and plant to plant 15 cm. Sugarcane and intercrop potato received fertilizer as shown bellow in table (Table 2).

Table2. Treatment wise GM crop and fertilizer rate for sugarcane and potato.

Treatment	Fertilizer rate for sugarcane (Kg/ ha)					Fertilizer rate for potato (Kg/ ha)			GM crop used
	N	P	K	S	Zn	N	P	K	
T_0	130	35	60	20	3	50	10	20	-
T_1	130	35	60	20	3	50	10	20	*Sesbania aculeata*
T_2	130	35	60	20	3	50	10	20	*Crotalaria juncea*
T_3	130	35	60	20	3	50	10	20	*Indigofera tinctoria*

In sugarcane, after land preparation full dose of P (as TSP), S (as Gypsum), Zn (as Zinc sulphate) and half of K (as MOP) were applied in the trenches as basal dose. One third of N (as Urea) was applied as top dressing after 20 d of transplanting. Rest of N and K were applied in two equal installments within 100 d and 150 d after cane plantation. For intercrop potato, half of the total N and full dose of P and K were applied as basal dose. Remaining N was applied after 40 d of potato plantation. Three different GM crops namely dhaincha (*Sesbania aculeata*), sunhemp (*Crotalaria juncea*) and indigo (*Indigofera tinctoria*) were cultivated as 2nd intercrop after harvesting of potato. Seeds of GM crops were sown in April, 2002 after 1st shower in the vacant space of 120 cm between paired rows of sugarcane and the biomass was incorporated in soil after 45-60 days. No fertilizer was applied for the GM crops. The recommended crop management practices were adopted for cane as well as potato. Sugarcane was harvested after one year. For sugarcane data on yield, yield attributing parameters and brix were recorded and analysed statistically using "Analysis of variance" technique where differences among treatments means are compared by means of DNMR test. For intercrop potato yield was recorded and for GM crop fresh and dry biomass yield was recorded. Laboratory analysis was done for N content in dry biomass of different GM crops. Data on different GM crops were presented in Table 3 and data with statistical notation for sugarcane and potato were presented in and Table 4. Cost of cultivation was calculated on the basis of land preparation, cost of seed, fertilizer, pesticide, labour and interest on current capital and are presented in Table 5.

RESULTS AND DISCUSSION

A. Effect of green manuring on sugarcane productivity.

It is seen from the Table 3 that the highest fresh and dry biomass was obtained from Sunhemp (9.40 and 3.00 t ha^{-1}, respectively), the second highest from Dhaincha (7.40 and 2.23 t ha^{-1}, respectively) and the lowest from Indigo (4.27 and 1.32 t ha^{-1}, respectively). Highest per cent of N in dry matter was found in Indigo (2.01%), the 2nd highest from Sunhemp (1.81 %) and the lowest from Dhaincha (1.42 %). Highest N contribution in soil was obtained from Sunhemp (54.30 Kg ha^{-1}), the 2nd highest from dhaincha (31.67 Kg ha^{-1}) and the lowest from Indigo (26.55 Kg ha^{-1}). This was at par with the findings of Paul *et al* (1999).

Data on different growth parameters, yield, brix of cane and yield of potato are presented in Table 4. It is seen from the table that green manuring has significant effect on numbur of tillers, millable canes, cane height, girth of cane, number of internodes per cane and yield of cane except unit stalk weight and brix. All the parameters except unit stalk weight and brix of sugarcane were significantly increased in green manure incorporated plots over control plots. Highest number of tillers (207.6 x 10^3 ha^{-1}) were obtained from T_2 treatment (PRC + potato-Sunhemp) and the lowest (178.0 x 10^3 ha^{-1}) from control plots where no green manure was

incorporated. Treatment T_1 (PRC + potato-dhaincha) and T_3 (PRC + potato-indigo) produced statistically similar number of tiller (196.9 x 10^3 ha^{-1} and 194.0 x 10^3 ha^{-1}, respectively). Which corroborates with the findings of Paul *et al.* (1999) who obtained higher number of tillers from sunhemp incorporated plots than that of dhaincha and indigo. All the treatments showed significant increase in number of millable canes over control. Highest number of millable canes was produced from T_2 treatment (145.9 x10^3 ha^{-1}) and the lowest from T_0 (127.3 x 10^3 ha^{-1}). Treatments T_1, T_2 and T_3 produced statistically similar number of millable canes. Which also supports the findings of Paul *et al.* (1999) who found higher millable canes from sunhemp incorporated plots. Height of cane showed significant increase in GM incorporated plots over control. Highest cane height was obtained from T_2 treatment (3.82 m) followed by T_1 (3.74 m) and the lowest from T_0 (3.22 m). All the green manuring treatments showed statistical similarity in height of cane. Girth of cane increased significantly due to green manuring over control. All the treatments of green manuring showed statistical similarity in girth though, the highest girth was obtained from T_1 (2.23 cm). On the other hand, the lowest girth (2.13 cm) was obtained from T_0 (control) treatment, but it was statistically similar with the treatment T_3 where indigo was incorporated as green manure. This at par with that of Paul *et al.* (1999) found statistically similar girth of sugarcane in different GM incorporated plots. Number of internodes per cane showed significant increase in GM incorporated plots over control. Highest internodes per cane was found from dhaincha (28.70) incorporation (T_2) followed by sunhemp (26.60) incorporation (T_1) and the lowest from control (23.55). All the treatments exhibited statistical similarity among them regarding number of internodes per cane. Regarding brix, no significant effect was found among the treatments. Which was in agreement with the findings of Imam *et al.* (1986). Islam *et al.* (1999) and Paul *et al.* (1999) who found no significant effect in brix of sugarcane due to different green manuring as intercrop in sugarcane. Unit stalk weight also responded insignificantly due to different green manuring. Yield of cane were increased significantly in the green manure incorporated plots over control. Highest cane yield was obtained from T_2 treatment (124.5 t ha^{-1}) followed by T_1 treatment (124.5 t ha^{-1}) and the lowest from control plots (109.6 t ha^{-1}). Different green manuring treatments showed statistical similarity in case of cane yield. These findings were at par with that of Paul *et al.* (1999) who found higher cane yield in sunhemp incorporated plots followed by dhaincha incorporated plots. Imam *et al.* (1986) obtained higher cane yield from cow pea incorporated plots. Islam *et al.* (1999) found statistically similar higher yield from dhaincha and sunhemp incorporation as intercrop in sugarcane.

The yield of 1st intercrop potato from T_0, T_1, T_2 and T_3 treatments were 7.5, 7.8, 8.0 and 8.2 t ha^{-1}, respectively (Table 4). Data showed that yield of potato was increased over control (no green manure) due to green manuring. The highest yield of potato was obtained from T_3 treatment (PRC+Potato+Indigo). Yield increase of potato in green manuring treatments might be due to additional nitrogen and organic matter release by the crops.

B. Economics of green manuring in sugarcane potato intercropping system.

The results presented in the Table 5 reveals that the combined yield of cane and potato in terms of cane yield showed that the highest production per unit area and time were obtained from T_2 treatment (163.61 t ha^{-1}) where sunhemp was intercroped as GM. Second (157.73 t ha^{-1}), third (156.38 t ha^{-1}) and lowest (146.27 t ha^{-1}) adjusted cane yield was obtained from T_1, T_3 and T_0 treatment, respectively. Highest net profit (113479.25 Tk ha^{-1}) and BCR (2.60) were obtained from T_2 treatment. Second and the third highest net profit (107664.25 and 105545.50 Tk ha^{-1},

respectively) and BCR (2.54 and 2.49, respectively) was found from T_1 and T_3 treatments and the lowest net profit (97451.75 Tk ha^{-1}) and BCR (2.45) was obtained from T_0 treatment.

It is seen from the Figure 1 that the highest benefit over control was found in sunhemp green manuring treatment (16027.50 Tk ha^{-1}) the 2nd highest from dhaincha (10212.50 Tk ha^{-1}) and the loest from indigo (8093.75 Tk ha^{-1}).

From the above discussion it is reveals that all the yield contributing parameters and yield of sugarcane increased progressively over control due to green manuring as second intercrop in sugarcane potato intercropping system. Sunhemp exhibited superior performance among the GM crop used, regarding yield contributing parameters and yield of sugarcane. The possible reason for such advantage may be due to higher addition of biomass and N contribution to soil by sunhemp. Green manuring with dhaincha and indigo also showed better performance over control (no green manuring) regarding growth parameters and yield. Brix and unit stalk weight of cane showed non significant effect due to different green manuring treatments.

Economics of green manuring showed that all the green amnuring treatments gave higher net profit and BCR over control. Highest net profit and BCR was obtained from sunhemp green manuring treatment followed by dhaincha.

In conclusion, green manuring as second intercrop may be suggested to improve both soil health and cane yield in sugarcane potato intercropping system. Sunhemp could be preferred as a companion green manuring crop with sugarcane. However, dhaincha and indigo may also be practiced as a profitable green manuring crop as second intercrops to be incorporated into soil in sugarcane-potato intercropping system.

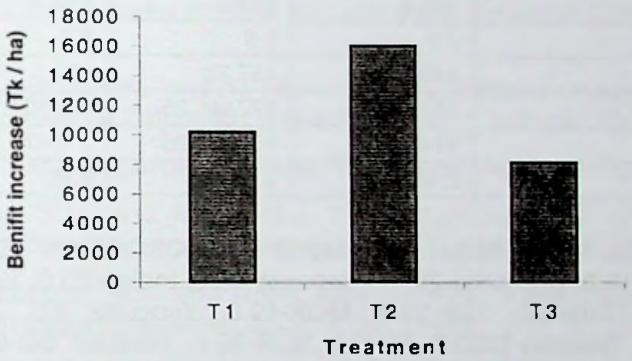

Fig 1. Benefit increase over control due to green manuring (Tk/ ha).

Table 3. Biomass, N content and N- contribution in soil by different green manuring crops.

GM crop	Fresh biomass (t ha^{-1})	Dry biomass (t ha^{-1})	N in DM (%)	N contribution in soil (Kg ha^{-1})
Sesbania aculeata	7.40	2.23	1.42	31.67
Crotalaria juncea	9.40	3.00	1.81	54.30
Indigofera tinctoria	4.27	1.32	2.01	26.55

Table 4. Performance of different green manures as 2nd intercrop in sugarcane potato Intercropping system.

Parameter	Treatment				LSD (P=0.05)
	T_0	T_1	T_2	T_3	
Tiller (x 10^3 ha^{-1})	178.0 c	196.9 b	207.6 a	194.0 b	8.72
Millabe canes(x 10^3 ha^{-1})	127.3 b	143.3 a	145.9 a	141.8 a	5.67
Height of cane (m)	3.22 c	3.74 ab	3.82 a	3.63 b	0.13
Girth of cane (cm)	2.13 b	2.23 a	2.20 a	2.18 ab	0.05
Number of internodes $cane^{-1}$	23.55 c	28.70 a	26.60 ab	25.15 bc	2.60
Unit stalk weight (Kg)	0.86	0.84	0.85	0.82	NS
Brix	17.29	17.42	16.66	16.72	NS
Yield of cane (t ha^{-1})	109.6 c	119.6 ab	124.5 a	116.3 b	5.93
Yield of Potato (t ha^{-1})	7.5	7.8	8.0	8.2	-

Figures with same letter(s) do not differ significantly at 5% level as per DNMR test.

Table 5. Economics of green manuring as 2nd intercrop in sugarcane-potato intercropping system.

Subject	Treatment			
	T_0	T_1	T_2	T_3
Production cost of cane (Tk ha^{-1})	46859.00	46859.00	46859.00	46859.00
Production cost of potato(Tk ha^{-1})	20243.00	20243.00	20243.00	20243.00
Cost for green manuring (Tk ha^{-1})	-	2680.00	3480.00	3280.00
Total cost (Tk ha^{-1})	67102.00	69782.00	70582.00	70382.00
Yield of cane (t ha^{-1})	109.6	119.6	124.4	116.3
yield of potato (t ha^{-1})	7.5	7.8	8.0	8.2
Adjusted yield (t ha^{-1})	146.27	157.73	163.61	156.38
Gross return (Tk ha^{-1})	164553.75	177446.25	184061.25	175927.50
Net profit (Tk ha^{-1})	97451.75	107664.25	113479.25	105545.50
Benefit cost ratio (BCR)	2.45	2.54	2.60	2.49

Market price of cane @ Tk. 1125.0 M ton^{-1} , Potato @ Tk. 5500.0 M ton^{-1}, Seed cost (Tk. Kg^{-1}): Sugarcane- 1.13, Potato-12.0, Dhaincha-20.0, Sunhemp-40.0, Indigo-30.0, Fertilizer cost (Tk. Kg^{-1}): Fertilizers: Tk. Kg^{-1} Urea-6.0, TSP-13.0, MOP-10.0, Zypsum- 4.0, Zinc Sulphate-60.0, Pesticide cost (Tk. Kg^{-1}): Bavistin-1250.0, Regent 3GR-95.0, Furadan 5G-85.0, Dithane M 45-500.0.

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