Productivity of Tropical Sugarbeet as Intercrop with Sugarcane in Old Himalayan Piedmont Plain Soil

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ABSTRACT

A field experiment was conducted during 2014-2015 and 2015-2016 cropping seasons at Regional Sugarcrop Research Station, Thakurgaon to study the productivity of tropical sugarbeet as intercrop with sugarcane in Old Himalayan Piedmont Plain Soil. The treatments were T_1 : Single row cane (SRC) only, T_2 : Paired row cane (PRC) only, T_3 : SRC + 1 line sugarbeet, T_4 : SRC + 2 lines sugarbeet, T_5 : PRC + 1 line sugarbeet, T_6 : PRC + 2 lines sugarbeet, T_7 : PRC + 3 lines sugarbeet and T_8 : Sole sugarbeet. The sugarcane variety was Isd 39. From the pooled data the highest number of tillers (201.66 103 ha^{-1}), the highest number of millable cane (88.16 103 ha^{-1}), the highest stalk height (3.71 m) and the highest stalk diameter (2.15cm) were obtained in T_1 treatment. Significantly the highest brix (21.40%) and the highest cane yield (97.63 t ha^{-1}) were also obtained in T_1. The highest sugarbeet yield (90.70 t ha^{-1}) was obtained in T_8 (sole sugarbeet) treatment and the highest equivalent cane yield of intercrop (68.51 t ha^{-1}) was found in T_6 (PRC + 2 lines sugarbeet). The highest benefit cost ratio (BCR) of 3.39 was found in T_3 treatment and the lowest of 2.25 was found in T_8 treatment. Therefore, growing single row cane with one line sugarbeet followed by paired row cane with two lines sugarbeet might be profitable and remunerative package technologies for sugarcane farming in Old Himalayan Piedmont Plain Soil in Northern Region of Bangladesh.

Key words: Sugarcane, intercropping, sugarbeet, yield

INTRODUCTION

Sugarcane (*Saccharum officinarum* L.) is one of the most important food-cum-cash-cum-industrial crop in Bangladesh. It is the principal cash crop especially in north-western and south-western low rainfall belt of Bangladesh. Sugarcane is the raw material of sugar industry and the main source of white sugar and jaggary (locally called goor). Sugarcane is a long duration crop takes about 12-14 months from planting to harvesting which decreases economic return to the farmers compared to other crops from the same duration. To get higher economic return from sugarcane field, appropriate intercropping practices with short duration crops might be the alternative way to increase total yield, interim and higher monetary return. It helps diversification of crop production as per need of farmers (Singh *et al.,* 1986). Sugarcane is usually planted at wider row spacing, and takes about 3-5 months for canopy development. Because of wider row spacing and slow canopy development, it

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allows to grow short duration winter crops in the early stage as intercrops in the vacant spaces between two cane rows. Sugarcane growers can take this advantage with cultivation of various short duration crops like potato, onion bulb, onion seed, garlic, pulses, vegetables etc. as first intercrop and some summer crops like red/stem amaranth, mungbean, sesame, green manuring crops etc. as second intercrop to get interim return. Since small sugarcane growers can not wait for such a long time to get financial return from sole crop of sugarcane. As sugarcane crop is cultivated in high and medium high land and there is a higher demand for cereals and vegetables, it would better to cultivate various crops with sugarcane as intercrops. Economic benefits of first and second intercrop production with sugarcane in paired row planting system have been reported elsewhere (Alam *et al.*, 2014 and Islam *et al.*, 2009). Sugarbeet (*Beta vulgaris* L.) belong to the family Chenopodiaceae, is considered as the second important sugarcrop all over the world after sugarcane. It is grown in about 57 countries. Sugarbeet is mainly grown in Europe and to a lesser extent in Asia and North America (Kumar and Pathak, 2013) and generally considered as a crop of temperate region is spreading to subtropical countries where it can be grown successfully during winter season. It has a growth period nearly half of that of sugarcane but productivity per unit area is higher and it requires less water than sugarcane. Many environmental and agronomic factors influence sugarbeet yield and quality. For successful production of sugarbeet under subtropical environmental condition there is need to evaluate the performance of sugarbeet as intercropping with sugarcane. It contributes about 21.8% of world sugar (Anonymous, 2013). It is a biennial halophytic as well as Na-salts scavenger C_3 plant containing up to 20% sugar on fresh weight basis. With increasing trend of global population, land holdings are shrinking; therefore, farmers need to maximize their income from a limited farm area using scarce resources, and they want to protect themselves against a possible crop failure (Aziz *et al.*, 2015). In several countries, maximize net returns and better resource utilization (Rehman *et al.*, 2014a). Under intercropping system, interception of solar radiations improves and utilization of nutrients and water is more effective; thus, risk of crop failure is minimized (Layek *et al.*, 2015). Increasing sugarcane crises urge that sugarcane-sugarbeet intercropping system to be strengthened to provide raw material and prolong crushing season of sugar mills (Rehman *et al.*, 2014b). Crop productivity can be enhanced and soil fertility status can be sustained with improved plant nutrient management through intercropping. Sugarcane based intercropping is highly advantageous due to high amount of crop residues such as trash, roots, stubbles that improve soil productivity along with heavy fertilizer doses applied to the crop. Further benefit of having crop diversity in the system is becoming able to provide several products in the market addressing the price or competition issue of a single crop (Shukla *et al.*, 2017). Intercropping of sugarcane with other crops improves the soil chemical and biological properties and also enhances the microbial activity and diazotrophic (N-fixers) population in the soil (Solanki *et al.*, 2017). Several factors, viz. plant density, sowing time, compatible crops, nutrient management as well as farmers' and the region's socioeconomic conditions, can affect the profitability of intercropping (Aziz *et al.*, 2015). Agronomic interventions offer the opportunities of intercrops in sugarcane based system to improve the crop productivity, profitability and sustainability (Shukla *et al.*, 2017). Therefore, the present study was undertaken to examine the productivity of tropical sugarbeet as intercrop with sugarcane in Old Himalayan Piedmont Plain Soil.

MATERIALS AND METHODS

The experiment was conducted at experimental field of Regional Sugarcrop Research Station, Thakurgaon, Bangladesh during 2014-2015 and 2015-2016 cropping seasons under irrigated condition. The site represents the Old Himalayan Piedmont Plain Soils (Agro Ecological Zone 1) with medium high land of typical sandy loam soil having pH 5.5. Sugarbeet as intercrop was grown with single and paired row sugarcane. The sugarcane variety was Isd 39. The experiment was laid out in a randomized complete block design with three replications where the unit plot size was 8m × 6m. The treatments were T_1 : Single row cane (SRC) only, T_2 : Paired row cane (PRC) only, T_3 : SRC + 1 line sugarbeet, T_4 : SRC + 2 lines sugarbeet, T_5 : PRC + 1 line sugarbeet, T_6 : PRC + 2 lines sugarbeet, T_7 : PRC + 3 lines sugarbeet and T_8 : Sole sugarbeet. Previously raised two budded soil bed sugarcane settlings were transplanted in each plot during on 15th November, 2014 and 17th November, 2015, respectively. Plant to plant distance was 30 cm in 60 cm apart paired rows and the distance between two paired rows was 140 cm. For sugarcane Urea, TSP, MoP, Gypsum and $ZnSo_4$ were applied @ 358, 275, 240, 188 and 7 kg ha^{-1}, respectively. Full quantity of TSP, Gypsum, $ZnSo_4$ and 1/3rd of MoP were applied in trench and mixed with soil prior to transplanting of settlings and 1/3rd of urea was applied at 21 days after transplanting (DAT). The second dose of Urea (1/3rd) and MoP (1/3rd) were applied as first top dressing at 90 DAT and final top dressing was done with the rest amount of Urea and MoP at 150 DAT. Fertilizers were applied for sugarbeet as intercrop separately. For sugarbeet, mustard oil cake (MOC), Urea, TSP, MoP, Gypsum ,Zinc sulphate and Boric acid were applied @ 450 kg, 120 kg, 105 kg, 150 kg, 18 kg, 3.5 kg, and 1.2 kg ha^{-1} in the vacant spaces between two paired rows of cane. Total MOC was applied at the time of final land preparation. All TSP, Gypsum, Zinc sulphate, Boric acid, and 1/3rd of Urea and 1/3rd of MoP were applied in the line before ridge preparation. Rest amount of Urea and MoP were applied in two installments at 30 and 60 days after sowing. Sugarbeet seeds were sown maintaining seed to seed distance 20 cm in 3-4 cm depth and distance between two ridges was 50cm. Management practices, like thinning for once at 4-5 leaf stage, hoeing, weeding, irrigation and other intercultural operations were done timely. Pheromone trap (*Spodoptera pheromone*) was placed in the field to trap male insect. Nitro 505 EC (0.1 %) was sprayed twice at 7 days interval starting from 60 days after sowing (DAS). To control hairy caterpillar, soon after infestation, the larvae were destructed by hand. Ten plants were randomly harvested from each plot at 150 DAS to determine yield and yield attributes. Beet yield (t ha^{-1}) and beet brix% were recorded at the time of harvest where brix% was measured with the help of hand refractometer. For sugarcane, to control termite, Regent 3 GR (chlorpyrifos) was applied @ 33 kg ha^{-1} during planting and Furadan 5G (carbofuran) was applied @ 40 kg ha^{-1} in two times in the month of March and May 2015 and 2016 respectively. Intercultural operations like irrigation, gap filling, weeding, mulching, earthing-up, tying and cross tying were done in time. Cultural operations for

sugarbeet were also done as and when required. Data on yield and various yield contributing parameters of sugarbeet were collected at harvest i.e. after five months of seed sowing. Tiller population of sugarcane was recorded at 150 DAT. Stalk height, stalk diameter, millable cane and cane yield were recorded at harvest. The data were analyzed following standard statistical procedures (Gomez and Gomez, 1984) by the Microsoft excel where applicable. The analyses of variance for different parameters were performed and mean differences were compared by Duncan's Multiple Range Test (DMRT) using a computer operated program named MSTAT-C (Russel, 1986).

Equivalent cane yield of intercrops

Yield of intercrop was converted into equivalent cane yield (ECY) on the basis of prevailing market price and calculated by the following formula (Lal and Ray, 1976, Verma and Modgal, 1983 and Bandyopadhyay, 1984).

$$\text{Equivalent cane yield of intercrops (ECY)} = \frac{\text{Yis x Ps}}{\text{PS}}$$

where,

Yis = Yield of sugarbeet intercrop (t ha^{-1})
Ps = Selling price of sugarbeet
PS = Selling price of sugarcane

Adjusted cane yield

Adjusted cane yield (ACY) was calculated by adding equivalent cane yield of intercrops with the yield of sugarcane.

Adjusted cane yield (ACY) = ECY + SY

where,

ECY = Equivalent cane yield of intercrop
SY = Sugarcane yield

Benefit cost ratio

Benefit cost ratio (BCR) was calculated by the following formula (CIMMYT, 1988)

$$\text{BCR} = \frac{\text{Gross return (Tk.)}}{\text{Total production cost (Tk.)}}$$

RESULTS AND DISCUSSION

Tiller production

Tiller is an important factor of sugarcane production. Sugarbeet intercropping with single row and paired row sugarcane affected significantly the tiller production of sugarcane. The highest number of tillers of 201.66 10^3 ha^{-1} was obtained in T_1 : Single row cane (SRC) only treatment and the lowest of 155.20 10^3 ha^{-1} found in T_4 : SRC + 2 lines sugarbeet treatment (Table 1). The results are in agreement with the findings of Islam *et. al.,* (2016) when sugarbeet was intercropped with sugarcane.

Millable cane production

Millable cane production was affected significantly by sugarbeet intercropping with sugarcane. The highest number of millable cane of 88.16 10^3 ha^{-1} was produced in T_1 treatment and the lowest of 70.20 10^3 ha^{-1} was in T_4 treatment (Table 1). Present findings are in agreement with the findings of Alam *et. al.*,(2009) when tomato and mungbean were intercropped with sugarcane.

Stalk height

Significant effect was observed in stalk height of sugarcane with sugarbeet intercropping (Fig. 1). The highest stalk height (3.71 m) was obtained in T_1 treatment and the lowest stalk height (3.45 m) was obtained in T_7 treatment.

Stalk diameter

A significant variation was found on stalk diameter of sugarcane. The highest stalk diameter (2.15 cm) was recorded in T_1 treatment and the lowest diameter of 2.04 cm recorded in T_7 treatment (Fig. 1).

Brix (%)

Brix readings have been shown in Table 1. Significantly the highest brix reading of cane (21.40%) was obtained in T_1 treatment and the lowest (19.66%) was recorded in T_4 treatment. The present results agreed to the earlier report of Kashem *et. al.*(2009). No significant effect was observed on sugarbeet brix (%) and it ranged from 16.65 -17.60 % (Table 1).

Yield of sugarcane

It was seen that significantly the highest cane yield of 97.63 t ha^{-1} was obtained in T_1 followed by 92.23 t ha^{-1} in T_2 and the lowest cane yield of 68.28 t ha^{-1} was obtained in T_4 (Table 2). The results are in agreements with Islam *et. al.* (2016).

Yield of intercrop (sugarbeet)

Significant effect on sugarbeet yield was observed when it was grown with sugarcane under different treatment combinations. The highest sugarbeet yield of 90.70 t ha^{-1} was obtained in T_8 treatment followed by 61.43 t ha^{-1} in T_6 and the lowest yield of 48.46 t ha^{-1} was obtained in T_3 treatment (Tabel 2).

Equivalent cane yield of intercrop

The highest equivalent cane yield of intercrop (68.51 t ha^{-1}) was found in T_6 treatment and the lowest equivalent cane yield of 42.85 t ha^{-1} found in T_3 (Table 2). The results are in agreement with Alam *et. al.*(2014) and Islam *et al.* (2016).

Total adjusted cane yield

Total adjusted cane yields have been shown in table 2. The highest total adjusted cane yield of 149.81 t ha^{-1} was obtained in T_6 followed by 141.11 t ha^{-1} in T_3 and the lowest of 92.23 t ha^{-1} in T_2 treatment.

Economics of intercropping

The economic analysis of the experiment under different treatments is shown in Table 3. Among the different treatments the highest total production cost of 1,35,400 Tk. ha^{-1} was in T_7 (PRC + 3 lines sugarbeet) treatment and the lowest of 1,06,500 Tk.ha^{-1} in T_1 (SRC only). The highest gross return of 4,02,989 Tk. ha^{-1} was achieved in T_6 (PRC+2 lines sugarbeet) treatment and the lowest of 2,48,098 Tk. ha^{-1} in T_2 (PRC only) treatment. The highest gross margin of 2,71,589 Tk. ha^{-1} was obtained in T_6 (PRC + 2 lines sugarbeet) treatment and the lowest gross margin of 1,21,198 Tk. ha^{-1} in T_2 (PRC cane only) treatment. The highest benefit cost ratio (BCR) of 3.39 was found in T_3 (SRC + 1 line sugarbeet) treatment followed by 3.04 in T_6 (PRC + 2 lines sugarbeet) treatment and the lowest of 2.25 was found in T_8 (sole sugarbeet) treatment. The cost and return are in agreement with the economic analysis of Islam *et. al.*(2016) when sugarcane was intercropped by some sugarbeet varieties.

The overall results showed that growing single row cane with one line sugarbeet and paired row cane with two lines sugarbeet would be profitable, and it could be remunerative package technologies for the sugarcane farmers in Old Himalayan Piedmont Plain Soil especially in Northern region of Bangladesh.

Table 1. Effect of sugarbeet intercropping with sugarcane on tiller and millable cane production of sugarcane and brix (%) of sugarcane and sugarbeet (pooled data)

Treatments	Tillers ($\square 10^3 ha^{-1}$)	Millable cane ($\square 10^3 ha^{-1}$)	Brix (%)	
			Sugarcane	Sugarbeet
T_1: Single row cane (SRC) only	201.66 a	88.16 a	21.40 a	-
T_2: Paired row cane (PRC) only	176.32 ab	82.63 b	21.10 a	-
T_3: SRC + 1 line sugarbeet	167.55 b	78.82 cd	20.33 ab	17.00
T_4: SRC + 2 lines sugarbeet	155.20 b	70.20 c	19.66 b	16.66
T_5: PRC + 1 line sugarbeet	174.71 ab	82.22 bc	20.83 a	17.60
T_6: PRC + 2 lines sugarbeet	173.32 b	81.64 bc	20.66 a	17.16
T_7: PRC +3 lines sugarbeet	161.38 b	77.25 d	19.82 b	16.65
T_8: Sole sugarbeet	-	-	-	16.83
LSD (0.05)	24.80	3.75	0.97	NS
CV (%)	9.98	5.61	2.68	1.04

Price of crops: Sugarcane: 2690 Tk t^{-1} and sugarbeet : 3000 Tk t^{-1} (Assume).

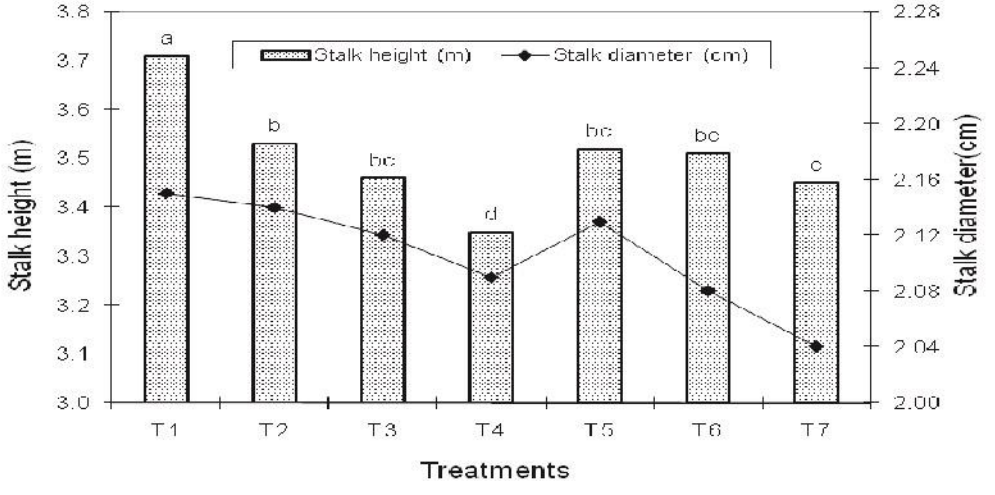

Figure 1. Effects of sugarbeet intercropping with sugarcane on stalk height and stalk diameter of sugarcane

Table 2. Cane yield, sugarbeet yield, equivalent cane yield of intercrop and total adjusted cane yield as affected by sugarbeet intercropping with sugarcane (pooled data)

Treatments	Cane yield (t ha^{-1})	Sugarbeet yield (t ha^{-1})	Equivalent cane yield of intercrop (t ha^{-1})	Total adjusted cane yield (t ha^{-1})
T_1: Single row cane (SRC) only	97.63 a	-	-	97.63
T_2: Paired row cane (PRC) only	92.23 ab	-	-	92.23
T_3: SRC+ 1 line sugarbeet	87.07 ab	48.46d	54.04	141.11
T_4: SRC+ 2 lines sugarbeet	68.28 c	52.34 c	58.37	126.65
T_5: PRC+ 1 line sugarbeet	87.25 ab	38.43 e	42.85	130.10
T_6: PRC+ 2 lines sugarbeet	81.30 b	61.43 b	68.51	149.81
T_7: PRC+ 3 lines sugarbeet	73.44 bc	55.30 bc	61.67	135.11
T_8: Sole sugarbeet	-	90.70 a	-	101.15
LSD (0.05)	10.59	7.32	-	-
CV (%)	6.97	4.88	-	-

Price of crops: Sugarcane: 2690 Tk t^{-1} and sugarbeet : 3000 Tk t^{-1} (Assume).

Table 3. Total production cost, gross return, gross margin and benefit cost ratio of sugarbeet intercropping with sugarcane (pooled data)

Treatments	Total production cost (Tk. ha^{-1})	Gross return (Tk. ha^{-1})	Gross margin (Tk. ha^{-1})	Benefit cost ratio (BCR)
T_1: Single row cane (SRC) only	1,06,500	2,62,625	1,56,125	2.47
T_2: Paired row cane (PRC) only	1,26,900	2,48,098	1,21,198	1.96
T_3: SRC + 1 line sugarbeet	1,12,000	3,64,065	2,52,065	3.25
T_4: SRC + 2 lines sugarbeet	1,17,500	3,49,573	2,32,073	2.97
T_5: PRC + 1 line sugarbeet	1,32,400	3,49,993	2,17,593	2.64
T_6: PRC + 2 lines sugarbeet	1,40,900	4,48,508	3,07,608	3.18
T_7: PRC + 3 lines sugarbeet	1,45,400	2,99,554	1,54,154	2.06
T_8: Sole sugarbeet	1,21,000	2,72,100	1,51,100	1.25

Price of crops: Sugarcane: 2,690 TK t^{-1} and Sugarbeet: 3,000 Tk t^{-1} (Assume).

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