Productivity and Profitability of Mustard Mungbean Sequential Intercropping with Paired Rows Transplanted Sugarcane

M. J. Alam[1*], M. M. Rahman[2], M. A. Razzak[1], H. P. Roy[1] and M. A. T. Sohel[1]
[1] Agronomy and Farming Systems Division, BSRI, Ishurdi, Pabna, Bangladesh
[2] Professor, Department of Agronomy, Bangladesh Agricultural University, Mymensingh

ABSTRACT

An experiment was conducted at the Bangladesh Sugarcrop Research Institute (BSRI) farm, Ishurdi for consecutive two years starting from 2008-2009 to 2009-2010 to find out suitable mungbean variety for mustard-mungbean sequential intercropping with paired rows transplanted sugarcane. Five mungbean varieties *Viz.* BARI Mung 2, BARI Mung 6, BINA Mung 5, BINA Mung 7 and BU Mung 4 were included as second intercrop where mustard variety tori 7 was used as the first intercrop. The cane variety Isd 38 was used in this experiment. Onion - mungbean treatment was used as standard check. Results revealed that sequential intercropping practices did not affect sugarcane yield and juice quality. All the sequential intercropping treatments achieved higher benefit cost ratio (BCR) than the sole cane crop. Among the tested treatment combinations, Paired row cane (PRC) + mustard - BINA Mung 5 performed better in respect of yield and yield contributing characters. Mungbean based sequential intercropping with paired rows transplanted sugarcane could be considered as a technology for sustaining sugarcane production and maintaining soil fertility.

Key words: Productivity, Paired rows cane, Intercropping, Mustard, Mungbean

INTRODUCTION

Sugarcane (*Saccharum officinarum* L.) is one of the major sugarcrop in Bangladesh. In Bangladesh, on an average 4.5 million metric tons of sugarcane is produced annually from 0.12 million hectares of land (BBS, 2011), There are 30 Agro-ecological zones (AEZs) in Bangladesh but sugarcane production is mainly confined to only 12 AEZs. Sugarcane is mainly grown in high and medium high land under rainfed conditions mostly in the north-west and south-west regions of the country. The soil and climate of Bangladesh is very much congenial for sugarcane production but the average sugarcane yield is around 44 t ha^{-1} (BBS, 2011) while the world average is 70.76 t ha^{-1} (FAOSTAT, 2012). Bangladesh being a highly populated country with a limited land area, farmers of small land holding size are not able to grow long duration crops like sugarcane. Because of this, sugarcane is being replaced by different profitable short duration crops and fetches less benefit. In Bangladesh sugarcane setts are planted conventionally in trench made at 75-90 cm distances. In many cases, plant population establishment is hampered in this system and consequently gave poor yield. To

* Corresponding Author: M.J. Alam, Principal Scientific Officer
e-mail: alammjbsri@yahoo.com

overcome this situation and ensure plant establishment the system of settling planting at specified distances in the trenches has been developed.

Transplanting of cane ensures optimum plant establishment which leads to get higher yield. The initial growth of the cane is slow and thus inter row spaces is not covered by sugarcane leaf canopy for the first 120-150 days. The vacant space can be used for intercrop cultivation. In early stage of growth, some short duration winter crops *viz.* vegetables, pulses, oil seeds and spices can be grown as intercrop in the vacant spaces between two rows of sugarcane. The intercropping offers an opportunity of increasing land utilization. The traditional intercropping with single row sugarcane is less remunerative as the growth and yield of both the component crops are not satisfactory. Under this situation, paired rows system of cane cultivation has recently been developed that unveils the potential of practicing intercropping with sugarcane with high profit. Mustard occupies the highest area as intercrop with sugarcane due to low input requirement at the start. But inappropriate growing method showed an adverse effect on the emergence, tillering, millable cane and yield of cane (Bose and Ashraf, 1972; Kanwar, 1975; Rathi and Tripathi, 1975 and Imam *et al.*, 1982).

A minimum reduction of 2-3% in cane yield has been reported by Kanwar (1975) while the maximum reduction of 64.40% was observed by Anon, (1965) it might be due to the profuse branching habit of mustard and greater competition for moisture and nutrients with cane at young stage. Although mustard intercropping in single row system showed an adverse effect on tiller, millable cane and yield of sugarcane, the degree of adverse effect has been shown to be less under paired rows system of cane and mustard intercropping (Shaheen *et al.*, 1989). The decreases in millable cane and cane yield were 7.08 and 4.91% in single row system while it were 0.94 and 0.73% under paired rows system, respectively due to mustard intercropping. Imam *et al.* (1982) stated that sugarcane + mustard could be an alternative choice if investment is limited. Rathi and Singh (1979) reported that juice quality parameters of sugarcane (brix, purity and sucrose percentages) were not affected by onion intercropping. Increased net profits due to intercropping of onion have been reported by Behal and Narwal (1977).

Growing of mungbean as second intercrop fixes atmospheric nitrogen and enriches soil organic matter contributing to improvement of soil fertility and productivity for sustainable sugarcane production. Intercropping/mixed cropping makes the better use of sunlight and water. It shows some beneficial effects on pest and diseases (Abdullah *et al.*, 2006). In many cases it gives higher total production, monetary returns and greater resource use efficiently and increases the land productivity by almost 60 percent. Intercropping also increases nutritional quality of diet for the farm family (Khan *et al.*, 2005), allows better control of weeds, increases land equivalent ratio (Imran *et al.*, 2011). In an intercrop community, the individual plant of one crop exposed to both intra and inter-specific competition although causing a reduction in individual yield but total productivity per unit area increases (Gani and Paul, 2005). Therefore, the present study was undertaken to find out suitable summer mungbean variety/varieties as second intercrop in mustard-mungbean sequential intercropping systems on growth, yield and quality with paired rows transplanted sugarcane.

MATERIALS AND METHODS

Experiment was conducted at the Bangladesh Sugarcrop Research Institute (BSRI) farm, Ishurdi, pabna during 2008-2009 and 2009-2010 cropping seasons. Five mungbean varieties *Viz.* BARI Mung 2, BARI Mung 6, BINA Mung 5, BINA Mung 7 and BU Mung 4 were included as second intercrop where mustard variety tori 7 was used as the first intercrop. The experiment was set up in randomized complete block (RCB) design with three replications. The unit plot size was 8m × 8m. The treatments were as follows:

T_1 Paired rows cane (PRC) only
T_2 PRC + onion - BINA Mung 5 (standard)
T_3 PRC + mustard - BARI Mung 2
T_4 PRC + mustard - BARI Mung 6
T_5 PRC + mustard - BINA Mung 5
T_6 PRC + mustard - BINA Mung 7
T_7 PRC + mustard - BU Mung 4

Forty five days old sugarcane settlings of Isd 38 were transplanted on 25 November 2008 in 2008-09 and 14 November 2009 in 2009-10 on well prepared tranches at 60 cm apart paired rows maintaining 45 cm interplant spacing. The intercrops were grown within vacant wide space of 140 cm between two paired rows of cane. The Onion bulb was planted in 6 rows (20 cm apart) with 15 cm space between two bulbs. Mustard and mungbean seeds were sown in 3 rows (30 cm apart) continuously. Seed rates of onion were 400 kg and 750 kg ha^{-1} for intercrop and sole crop respectively. Seed rates of mustard were 3.0 kg and 5.0 kg ha^{-1} for intercrop and sole crop, respectively. The seed rate of mungbean was 10 kg ha^{-1} for intercrop and 15 kg ha^{-1} for sole crop. First intercrops (onion and mustard) were sown on 25 November 2008 and 14 November 2009 for 2008-09 and 2009-10 cropping seasons, respectively. The second intercrop mungbean varieties BARI Mung 2, BARI Mung 6, BINA Mung 5, BINA Mung 7 and BU Mung 4 were planted on 15 March 2008 and 14 March 2010 in 2008-09 and 2009-10 cropping seasons, respectively.

The tranches were made by paired rows trenchers at 140 cm distance. Before trenching, the land was prepared thoroughly by disc ploughing and harrowing followed by leveling. Sole crop of all first intercrops were grown in one side of the field and the second intercrop was also grown by sowing then at the same day of their sowing in the main field. For sugarcane and intercrops, fertilizers were applied following the recommended rates (BARC, 2005). N, P, K, S and Zn were applied in sugarcane @ 150, 50, 90, 34 and 3.5 kg ha^{-1}, respectively while N, P, K, S, Zn and B were applied @ 75, 30, 75, 30, 3 and 0.6 kg ha^{-1} for onion and @ 50, 11, 20, 10, 0.3 and 0.6 kg ha^{-1} for mustard. Only N, P and K were applied in mungbean @ 15, 18 and 14 kg ha^{-1}, respectively. Sole crops received 100% of the recommended doses of fertilizers while 60 % of the recommended rate was applied in intercrops. N, P, K, S, Zn and B were applied in the form of urea, triple super phosphate (TSP), muriate of potash (PoM), gypsum, zinc sulphate ($ZnSO_4$) and boric

acid, respectively. Pest management and necessary intercultural operations like weeding, mulching, gap filling, irrigation, earthing up, tying etc. were done according to the recommendation. Data on number of tiller, millable cane, plant height, diameter of cane, number of internodes cane^{-1}, unit stalk weight, cane dry matter m^{-2} and cane yield (t ha^{-1}) were recorded. The plant height, weight of 1000 grain, grain yield, straw yield and days to maturity were recorded for onion, mustard and mungbean. The plant height and bulb yield were recorded for onion. Brix (%), pol (%) cane, purity (%), recoverable sucrose (%) and sugar yield (t ha^{-1}) were also recorded. pH, organic matter content, total nitrogen, available phosphorus, exchangeable potassium, available sulphur and available zinc content of post-harvest soil were measured. Cane equivalent yield of intercrops and the adjusted cane yield were also calculated. Total production cost, gross income, net return, benefit cost ratio and land equivalent ratio were calculated for economic analysis.

RESULTS AND DISCUSSION

Growth parameters of sugarcane

Cane height, cane diameter and number of internode cane^{-1} did not differ significantly by different summer mungbean varieties in mustard - mungbeann sequential intercropping under paired rows system of planting in 2008-09 and 2009-10 cropping seasons. The total cane biomass yield significantly differed with all the treatment combinations for both the seasons. The highest biomass yield of sugarcane (3,587 g m^{-2}) was found with T_5 (PRC + tori 7 - BINA Mung 5) and the lowest biomass yield of sugarcane (2,771 g m^{-2}) was recorded with T_1 (PRC only) treatments in 2008-09 season. In 2009-10, the highest cane biomass yield (2,970 g m^{-2}) was found with T_5 (PRC + tori 7 - BINA Mung 5) and the lowest (2,630 g m^{-2}) was observed with T_1 (PRC only) treatment (Table 1).

Table 1. Effect of summer mungbean varieties in mustard - mungbean sequential intercropping on growth parameters of sugarcane in 2008-09 and 2009-10 cropping seasons

Treatments	Cane height (m)		Cane diameter (cm)		No. of internodes cane^{-1}		Dry matter yield (g m^{-2})	
	2008-09	2009-10	2008-09	2009-10	2008-09	2009-10	2008-09	2009-10
T_1	2.83	2.79	1.92	2.10	24	20	2,771 g	2,630 d
T_2	3.07	2.84	2.17	2.15	25	23	3,107 f	2,935 b
T_3	2.98	2.90	2.25	2.26	27	22	3,275 c	2,742 c
T_4	2.98	2.86	2.00	2.11	27	21	3,247 d	2,940 ab
T_5	3.46	3.10	2.35	2.09	28	22	3,587 a	2,970 a
T_6	3.23	2.89	2.17	2.17	26	21	3,191 e	2,770 c
T_7	3.20	2.91	2.25	2.12	27	22	3,330 b	2,742 c
CV (%)	4.21	8.72	3.30	7.43	7.47	7.90	0.28	0.70
LSD (0.05)	NS	NS	NS	NS	NS	NS	**	**

In a column, figures with similar letters do not differ significantly at 5% level

Yield and yield attributes of sugarcane

Tiller population, number of millable cane, unit cane weight and cane yield were not significantly different among the different intercrops combination. The highest number of tiller 263 × 10^3 ha^{-1} and 218 × 10^3 ha^{-1} were obtained from T_2 (PRC + Onion - BINA Mung 5) treatment in both the years. The highest number of millable cane of 98 × 10^3 ha^{-1} and 100 × 10^3 ha^{-1} were obtained from T_3 (PRC + tori7 - BINA Mung 2) and T_4 treatment in 2008-09 and 2009-10. The highest unit cane weight of 1.18 kg and 0.93 kg were found with T_5 (PRC + tori7- BINA Mung 5) in 2008-2009 and 2009-10 seasons. The highest cane yield of 111.20 t ha^{-1} and 89.23 t ha^{-1} were obtained from T_5 (PRC + tori7 - BINA Mung 5) treatment in 2008-09 and 2009-10 season respectively (Table 2).

Table 2. Effect of summer mungbean varieties in mustard - mungbean sequential intercropping on yield and yield attributes of sugarcane in 2008-09 and 2009-10 cropping seasons

Treatments	Tiller (×10^3 ha^{-1})		Millable cane (×10^3 ha^{-1})		Unit cane weight (kg)		Cane yield (t ha^{-1})	
	2008-09	2009-10	2008-09	2009-10	2008-09	2009-10	2008-09	2009-10
T_1	210	203	85	93	0.97	0.86	82.71	80.10
T_2	229	218	94	99	1.00	0.89	94.44	88.33
T_3	224	209	98	94	1.03	0.90	100.70	84.37
T_4	228	212	97	100	1.02	0.88	99.24	88.40
T_5	226	214	94	96	1.18	0.93	104.20	89.23
T_6	222	207	89	97	1.09	0.88	97.43	85.84
T_7	227	201	89	95	1.15	0.89	102.30	84.44
CV (%)	6.39	3.42	7.07	9.19	15.78	7.38	11.95	5.71
LSD (0.05)	NS	NS	NS	NS	NS	NS	NS	NS

In a column, figures with similar letters do not differ significantly at 5% level

Growth attributes of intercrops

Plant height, biomass yield, straw yield, 1000-grain weight and crop duration of first intercrops differed significantly among the different treatment combinations for both the years except 1000-grain weight in 2008-09. The highest plant height of 77.00 cm and 85.00 cm were found with the treatment T_5 (PRC + tori 7 - BINA Mung 5) while the lowest plant height of 47.00 cm and 52.00 cm were recorded with T_2 (PRC + onion - BINA Mung 5) tereatment in both the years. The highest biomass yield of 1.90 t ha^{-1} with T_6 (PRC + tori 7 - BINA Mung 7) in 2008-09 season and 2.07 t ha^{-1} were observed with the treatment T_7 (PRC + tori 7 - BU Mung 4) in 2009-10 season. The lowest biomass yield of 0.71 t ha^{-1} and 0.78 t ha^{-1} were produced by T_2 (PRC + onion - BINA Mung 5) treatment in both the years. The highest straw yield of 2.39 t ha^{-1} with T_6 (PRC + tori 7 - BINA Mung 7) treatment in 2008-09 and 2.59 t ha^{-1} were observed with the treatment T_7 (PRC + tori 7 - BU Mung 4) in 2009-10 season. The lowest straw yield of 0.89 t ha^{-1} and 0.98 t ha^{-1} were produced by T_2 (PRC + onion - BINA Mung 5) in both the years. The highest 1000-grain weight of 1.65 g were recorded in treatment T_6 (PRC + tori 7 - BINA Mung 7) and the lowest 1000- grain weight of 1.49 g were observed in T_3 (PRC + tori 7 - BARI Mung 2)

treatment in 2009-10 season. The crop duration was lowest of 97 days and 111 days with treatment T_2 (PRC + onion - BINA Mung 5) and the highest duration of 79 days and 80 days were found with T_3 (PRC + tori 7 - BARI Mung 2) to T_7 (PRC + tori 7 - BU Mung 4) treatment in both the years (Table 3).

Table 3. Effect of summer mungbean varieties in mustard - mungbean sequential intercropping on growth attributes of first intercrops in 2008-09 and 2009-10 cropping seasons

Treatments	Plant height (cm)		Biomass yield (t ha^{-1})		Straw yield (t ha^{-1})		1000-grain wt. (g)		Crop duration (days)	
	08-09	09-10	08-09	09-10	08-09	09-10	08-09	09-10	08-09	09-10
T_1	-	-	-	-	-	-	-	-	-	-
T_2	47.00 d	52.00 d	0.71 c	0.78 d	0.89 c	0.98 c	-	-	97 a	111 a
T_3	76.00 a	77.00 b	1.86 ab	2.00 c	2.32 b	2.51 b	1.50	1.49 b	79 b	80 b
T_4	74.00 b	70.00 c	1.90 a	2.06 a	2.38 a	2.57 ab	1.60	1.50 b	79 b	80 b
T_5	77.00 a	85.00 a	1.88 ab	2.02 c	2.35 ab	2.52 ab	1.55	1.53 b	79 b	80 b
T_6	73.00 b	78.00 b	1.90 a	2.03 bc	2.39 a	2.54 ab	1.61	1.65 a	79 b	80 b
T_7	70.00 c	75.00 b	1.85 b	2.07 a	2.31 b	2.59 a	1.53	1.50 b	79 b	80 b
CV (%)	1.51	3.26	1.89	1.08	1.48	2.29	5.39	3.55	2.79	2.22
LSD (0.05)	**	**	**	**	**	**	NS	**	**	**

In a column, figures with similar letters do not differ significantly at 5% level

Biomass yield of second intercrops was affected significantly due to different summer mungbean varieties in mustard - mungbean sequential intercropping with paired row transplanted sugarcane system but crop duration was not affected significantly. The crop duration was 78 days in 2008-09 and 81 days in 2009-10 from sowing to harvesting.

Intercrop yield and adjusted cane yield

The yield of the first intercrops (onion and tori 7) under paired rows system was found satisfactory. The yields of mungbean as second intercrop were significantly different among the different treatment combinations. Among the treatment combination the highest yield was obtained of 0.65 t ha^{-1} and 0.69 t ha^{-1} with T_5 (PRC + tori 7 - BINA Mung 5) treatemnt in both the years while the lowest yield was recorded of 0.51 t ha^{-1} and 0.59 t ha^{-1} with T_7 (PRC + tori 7 - BU Mung 4) treatment in both the year. The highest adjusted cane yield of 247.28 t ha^{-1} and 170.60 t ha^{-1} were obtained with T_2 (PRC + onion - BINA Mung 5) treatment in both the years while the lowest yield of 82.71 t ha^{-1} and 80.10 t ha^{-1} were found with T_1 treatment (sole cane only) in both the years (Table5).

Table 5. Effect of summer mungbean varieties in mustard - mungbean sequential intercropping on intercrops, cane equivalent yield and total adjusted cane yield in 2008-09 and 2009-10 cropping seasons

Treatments	Intercrop yield (t ha^{-1})				Cane equivalent yield of intercrop (t ha^{-1})		Adjusted cane yield (t ha^{-1})	
	First intercrop		Second intercrop					
	2008-09	2009-10	2008-09	2009-10	2008-09	2009-10	2008-09	2009-10
T_1	-	-	-	-	82.71	80.10	82.71 c	80.10 c
T_2	7.5	9.58	0.58 ab	0.68 ab	152.84	82.27	247.28 a	170.60 a
T_3	0.50	0.50	0.58 ab	0.60 c	27.84	23.15	128.54 b	107.52 b
T_4	0.49	0.48	0.53 b	0.65 abc	26.19	23.94	125.43 b	112.34 b
T_5	0.50	0.49	0.65 a	0.69 a	29.83	25.05	141.03 b	114.28 b
T_6	0.47	0.59	0.58 ab	0.61 bc	27.16	25.05	124.59 b	110.89 b
T_7	0.47	0.48	0.51 b	0.59 c	25.17	22.55	127.47 b	106.99 b
CV (%)	-	-	11.06	9.11	-	-	8.41	4.27
LSD (0.05)	-	-	**	**	-	-	**	**

In a column, figures with similar letters do not differ significantly at 5% level

Price of crops (2008-09): Sugarcane : 1760 Tk.t^{-1}, Onion : 32 Tk.kg^{-1}, Mustard : 40 Tk.kg^{-1}, Mungbean : 50 Tk.kg^{-1}

Price of crops (2009-10): Sugarcane : 2160 Tk.t^{-1}, Onion : 15 Tk.kg^{-1}, Mustard : 40 Tk.kg^{-1}, Mungbean : 50 Tk.kg^{-1}

Cane juice quality and sugar yield

Sugarcane juice quality parameters like brix (%), pol (%) cane, purity (%), recoverable sucrose (%) and sugar yield (t ha^{-1}) did not differ significantly by different summer mungbean varieties in mustard - mungbean sequential intercropping combination in 2008-09 and 2009-10 (Table 6). The brix (%) ranged from 20.50 to 22.00 and 16.80 to 17.53 in 2008-09 and 2009-10 seasons, respectively. In case of pol (%) cane ranged from 14.40 to 15.78 and 11.46 to 12.34 in 2008-09 and 2009-10 seasons, respectively. The purity (%) ranged from 88.66 to 92.43 and 86.25 to 88.99 in 2008-09 and 2009-10 seasons, respectively. The recoverable sucrose (%) ranged from 11.90 to 13.28 and 8.96 to 9.84 in 2008-09 and 2009-10 seasons. Sugar yield (t ha^{-1}) ranged from 10.19 to 14.79 and 7.47 to 8.69 in 2008-09 and 2009-10 seasons, respectively.

Table 6. Effect of different summer mungbean varieties in mustard - mungbean sequential intercropping on cane juice and sugar yield (t ha^{-1}) in 2008-09 and 2009-10 cropping seasons

Treatments	Brix (%)		Pol (%) cane		Purity (%)		Recoverable sucrose (%)		Sugar yield (t ha^{-1})	
	2008-09	2009-10	2008-09	2009-10	2008-09	2009-10	2008-09	2009-10	2008-09	2009-10
T_1	21.30	17.13	14.84	11.84	88.66	87.45	12.34	9.34	10.19	7.47
T_2	21.27	17.53	14.98	12.34	89.72	88.99	12.48	9.84	11.78	8.69
T_3	21.73	17.43	15.17	12.15	88.92	88.20	12.67	9.65	12.72	8.13
T_4	20.50	16.80	14.40	11.46	89.40	86.25	11.90	8.96	11.82	7.94
T_5	21.77	17.53	15.78	12.07	92.43	87.10	13.28	9.57	14.79	8.49
T_6	21.13	17.33	15.10	12.02	90.98	87.74	12.60	9.52	12.21	8.16
T_7	22.00	17.40	14.90	12.13	88.94	88.15	12.40	9.63	12.69	8.14
CV (%)	4.52	6.21	5.97	7.94	2.16	2.19	7.16	10.03	11.27	9.68
LSD (0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

In a column, figures with similar letters do not differ significantly at 5% level

Economic analyses

Cost of cultivation

The cost of cultivation was estimated for different sequential intercropping treatment. It was found that the maximum cost of cultivaion was required in T_2 (PRC + onion - BINA Mung 5) treatment which were 1,62,000 Tk.ha^{-1} and 1,45,000 Tk.ha^{-1} in 2008-09 and 2009-10, seasons, respectively. The sole cane required 80,000 Tk.ha^{-1} in both the years (Table 7). T_2 treatment required 1,62,000 Tk.ha^{-1} and 1,45,000 Tk.ha^{-1} in 2008-09 and 2009-10 seasons while other treatments required 1,06,000 Tk.ha^{-1} in 2008-09 and 2009-10 seasons.

Gross income and net return

The highest gross return of Tk. 4,35,214 ha^{-1} and Tk. 3,68,493 ha^{-1} were obtained from T_2 (PRC + onion - BINA Mung 5) treatment in 2008-09 and 2009-10, respectively. The lowest gross return of Tk. 1,45,570 ha^{-1} and Tk. 1,73,016 ha^{-1} was obtained from T_1 (sole cane only) plot in 2008-09 and 2009-10, respectively. The highest gross margin of Tk. 2,73,214.40 and Tk. 2,23,492 were obtained with T_2 (PRC + onion - BINA Mung 5) in 2008-09 and 2009-10 seasons, respectively. The lowest gross margin of Tk. 65,569 and Tk. 93,016 were found with T_1 (sole cane only) in 2008-09 and 2009-10 seasons (Table7).

Benefit cost ratio (BCR) and land equivalent ratio (LER)

The benefit cost ratio (BCR) was maximum in T_2 (PRC + onion - BINA Mung 5) treatment which were 2.69 in 2008-09 and of 2.54 in 2009-10. The next highest BCR was found with 2.34 and 2.33 with T_5 (PRC + tori 7 - BINA Mung 5) treatment in both the years. The minimum benefit cost ration were 1.82 in 2008-09 and 2.16 in 2009-10 under

the treatment T_1 (sole cane). Data on the LER value of different sugarcane + intercrop combination showed that the treatment T_5 (PRC + tori 7 - BINA Mung 5) had the highest LER of 2.40 in 2008-09 and 2.47 with T_2 (PRC + onion - BINA Mung 5) in 2009-10 while the lowest LER of 2.24 was in 2008-09 and 2.47 was in 2009-10 with T_5 (PRC + tori 7 - BINA Mung 5) and T_2 (PRC + onion - BINA Mung 5), respectively (Table7).

Table 7. Effect of different summer mungbean varieties in mustard - mungbean sequential intercropping on cost of production, benefit cost ratio (BCR) and land equivalent ratio (LER) in 2008-09 and 2009-10 cropping seasons

Treatments	Total production cost (Tk. ha^{-1})		Gross return (Tk. ha^{-1})		Gross margin (Tk. ha^{-1})		BCR		LER	
	2008-09	2009-10	2008-09	2009-10	2008-09	2009-10	2008-09	2009-10	2008-09	2009-10
T_1	80000	80000	145570	173016	65569	93016	1.82	2.16	1.00	1.00
T_2	162000	145000	435214	368493	273214	223492	2.69	2.54	2.40	2.47
T_3	106000	106000	226232	232239	120232	126239	2.13	2.19	2.22	2.17
T_4	106000	106000	220762	242644	114762	136644	2.08	2.29	2.23	2.17
T_5	106000	106000	248212	246837	142212	140836	2.34	2.33	2.20	2.24
T_6	106000	106000	219277	239514	113276	133514	2.07	2.26	2.02	2.21
T_7	106000	106000	224348	231090	118348	125090	2.12	2.18	2.13	2.11

Price of crops (2008-09) Sugarcane : 1760 Tk.t^{-1}, Onion : 32 Tk.kg^{-1}, Mustard : 40 Tk.kg^{-1}, Mungbean : 50 Tk.kg^{-1}
Price of crops (2009-10) Sugarcane : 2160 Tk.t^{-1}, Onion : 15 Tk.kg^{-1}, Mustard : 40 Tk.kg^{-1}, Mungbean : 50 Tk.kg^{-1}

Soil characteristics

Effects of different summer mungbean varieties in mustard - mungbean sequential intercropping in paired row transplanted sugarcane on post harvest soil pH, organic matter (%) and total N content (%) were not significant while that on available P (mg kg^{-1}), exchangeable K (cmol kg^{-1}), available S (mg kg^{-1}) and available Zn (mg kg^{-1}) were significant in both the years. Available P was the highest with T_4 (24.60 mg kg^{-1}) in 2008-09 and in T_3 (29.60 mg kg^{-1}) in 2009-10 while the lowest was in treatment T_1 (16.60 and 28.70 mg kg^{-1}) in both the years. Exchangeable K was the highest with treatment T_5 (0.16 cmol kg^{-1}) in 2008-09 and in T_6 (0.27 cmol kg^{-1}) in 2009-10 while the lowest was in treatment T_1 (0.11 and 0.20 cmol kg^{-1}) in both the years. Available S was the highest with treatment T_4 (26.70 mg kg^{-1}) in 2008-09 and in T_3 (25.70 mg kg^{-1}) in 2009-10 while the lowest was in treatment T_1 (16.40 and 15.30 mg kg^{-1}) in both the years. Available Zn was the highest with treatment T_4 (0.69 mg kg^{-1}and 0.66 mg kg^{-1}) while the lowest was in treatment T_1 (0.53 and 0.50 mg kg^{-1}) in both the years (Table 8 and 9). Before experimentation the pH value, organic matter content, total nitrogen, available status of calcium, magnesium, potassium, phosphorus, sulphur, boron, iron and zinc in the soil were 7.62, 1%, 0.05%, 11.51cmol kg^{-1}, 0.83 cmol kg^{-1}, 0.15 cmol kg^{-1},12.0 mg kg^{-1}, 20 mg kg^{-1}, 0.20 mg kg^{-1}, 3.40 mg kg^{-1} and 0.56 mg kg^{-1} soil, respectively.

Table 8. Effect of different summer mungbean varieties in mustard - mungbean sequential intercropping on post harvest soil pH, organic matter (%), total N content (%) and available P (mg kg^{-1}) content in 2008-09 and 2009-10 cropping seasons

Treatments	pH		Organic matter (%)		Total N content (%)		Available P (mg kg^{-1})	
	2008-09	2009-10	2008-09	2009-10	2008-09	2009-10	2008-09	2009-10
Post harvest soil								
T_1	7.6	7.6	0.99	1.00	0.04	0.05	16.60	28.70
T_2	7.7	7.6	1.09	1.07	0.05	0.05	22.00	23.30
T_3	7.5	7.7	1.08	1.06	0.05	0.05	16.70	21.90
T_4	7.6	7.6	1.02	1.04	0.05	0.05	24.60	29.40
T_5	7.6	7.7	1.05	1.02	0.05	0.05	21.80	22.40
T_6	7.6	7.6	1.07	1.05	0.05	0.05	19.60	29.60
T_7	7.6	7.7	1.09	1.05	0.05	0.05	18.90	21.90
CV (%)	2.33	2.19	5.58	7.57	24.05	24.42	7.98	7.12
LSD (0.05)	NS	NS	NS	NS	NS	NS	**	**

In a column, figures with similar letters do not differ significantly at 5% level

Table 9. Effect of different summer mungbean varieties in mustard - mungbean sequential intercropping on post harvest exchangeable K (cmol kg^{-1}), available S (mg kg^{-1}) and available Zn (mg kg^{-1}) content of soil in 2008-09 and 2009-10 cropping seasons

Treatments	Exchangeable K (cmol kg^{-1})		Available S (mg kg^{-1})		Available Zn (mg kg^{-1})	
	2008-09	2009-10	2008-09	2009-10	2008-09	2009-10
Post harvest soil						
T_1	0.11	0.20	16.40	15.30	0.53	0.50
T_2	0.13	0.26	18.30	24.30	0.64	0.61
T_3	0.15	0.22	19.30	25.70	0.67	0.63
T_4	0.12	0.21	26.70	20.50	0.69	0.66
T_5	0.16	0.26	20.50	18.30	0.68	0.65
T_6	0.14	0.27	23.50	25.50	0.64	0.60
T_7	0.13	0.24	25.00	18.30	0.63	0.65
$S\bar{x}$	0.01	0.01	0.81	0.64	0.01	0.01
CV (%)	10.41	5.86	8.88	7.27	2.28	2.82
LSD (0.05)	**	**	**	**	**	**

In a column, figures with similar letters do not differ significantly at 5% level

From the above results and discussions, BINA Mung 5 produced the highest yield and economic return among the tested five mungbean varieties as second intercrop in mustard-mungbean sequential intercropping with paired rows transplanted sugarcane.

REFERENCES

Abdullah, M.; Alam, M.A.; Rahman, M.A. and Siddiquee, M.N.A. 2006. Evaluation of tobacco intercropping as botanical pesticides in controlling borer pests in sugarcane. *Bangladesh J. Sugarcane*, **28**: 9-13.

Anonymous. 1965. Mixed cropping trial. Annual Report 1965. Sugarcane Res. Station, Shahjahanpur, UP., India. pp. 132-133.

BARC (Bangladesh Agricultural Research Council). 2005. Fertilizer Recommendation Guide. Bangladesh agri. Res. Coun., New Airport Road, Farm gate, Dhaka-1215. pp. 97-136.

BBS, 2011. Statistical Year Book of Agricultural Statistics of Bangladesh. Planning Division, Ministry of Planning. Government of the Peoples' Republic of Bangladesh. p. 122.

Behal, K.L. and Narwal, S.S. 1977. To study the feasibility of intercropping of rabi crops in autumn planted sugarcane. *Indian Sugar*, **27**: 23-26.

Bose, P.K. and Ashraf, M.H. 1972. Intercropping is autumn planted sugarcane in North Bihar and economics involved in it. *Indian Sugar*, **24**: 1.

FAOSTAT. 2012. Food and Agricultural Organization of the United Nations: Economic and Social Department: The Statistical Division. p. 567.

Gani, M.O. and Paul, S.K. 2005. Sustainability of sugarcane cultivation through paired row planting system with wide spacing and double intercropping. *Bangladesh J. Sugarcane*. 24-27: 26-32.

Imam, S.A.; Ali, A. and Razzaque, M.A. 1982. Performance of intercropping with sugarcane under several crop combinations. *Bangladesh J. Sugarcane*. **4**: 32-41.

Imran, M.; Ali, A.; Waseem, M.; Tahir, M.; Mohsin, A.U.; Shehzad, M.; Ghaffari, A. and Rehamn, H. 2011. Bio-economic assessment of sunflower - mungbean intercropping system at different planting geometry. Inter. *Res. J. Agril. Sci. and Soil Sci.*, 1(4) : 126-136.

Kanwar, R.S. 1975. Scope of intercropping in sugarcane in north India. Sugar News. 7(2): 5-8.

Khan, N.U.; Rahman, M.H.; Kabiraj, R.C.; Islam, M.A; and Paul, G.C. 2005. Performance of potato and maize as first intercrop, dhaincha (green manure) as second intercrop with paired row sugarcane in old himalayan piedmont plain. *Bangladesh J. Sugarcane*, **24-27**: 78-81.

Rathi, K.S. and Tripathi, H.M. 1975. Intercropping with autumn planted sugarcane. III cultivation of mustard with sugarcane in scientific way. *Co-operative Sugar*, **7**(1): 1-3.

Shaheen. M.; Hossain, A.H.M.D.; Gaffer, M.A. and Sadeque, M.A. 1989. Row arrangement for mustard intercropping with sugarcane. *Bangladesh J. Sugarcane*, **11**: 41-46.