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Productivity and Profitability of Onion Seed Crop-Mungbean Sequential Intercropping with Sugarcane

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ABSTRACT

An experiment was conducted at the Bangladesh Sugarcane Research Institute (BSRI) farm, Ishurdi, Pabna for consecutive two years from 2008-2009 to 2009-2010 to find out the growth, yield, quality and economics of onion seed crop in onion seed crop-mungbean sequential intercropping with paired rows transplanted sugarcane. Onion seed crop was grown in 40 cm, 30 cm, 24 cm and 20 cm row spacing, respectively in between two paired rows of cane. In this trial, onion bulb - mungbean and potato-mungbean treatments were used as standard check. Results revealed that sequential intercropping practices did not have any adverse effect on cane yield and juice quality. All the sequential intercropping treatments showed higher benefit cost ratio (BCR) than the sole cane crop. Among the treatment combinations, paired rows cane (PRC) + 20 cm row spacing (6 rows) of onion seed crop- mungbean performed better in respect of yield, yield contributing characters and economics. Onion seed crop-mungbean sequential intercropping with paired rows transplanted sugarcane could be considered as a technology for sustainable sugarcane farming maintaining soil health.

Key words: Productivity, sugarcane, paired rows cane, intercropping, onion seed crop

INTRODUCTION

Sugarcane (*Saccharum officinarum* L.) is one of the major food-cum-industrial cash crops in Bangladesh and cultivated in more than 90 countries of the tropical and sub-tropical regions of the world (FAO, 2011). Sugarcane occupies an area of 23.82 million hectares with a total production of 1685.44 million metric tons (FAO, 2012). In Bangladesh, on an average 4.5 million metric tons of sugarcane is produced annually from 0.12 million hectares of land (FAOSTAT, 2012). Sugarcane is mainly grown in high and medium high land under rainfed conditions in the north-west and south-west regions of the country. The world average yield of sugarcane is 70.76 tha^{-1} while in Bangladesh it is about 44 tha^{-1} (BBS, 2010). Sugarcane cultivation fetches less benefit compared with other short duration fruit and vegetable crops like papaya, banana, tomato, carrot, cabbage and cauliflower. Because of this, sugarcane is being replaced by different

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profitable short duration crops. Conventionally sugarcane setts are planted in trench made at 90-100 cm distances. In many cases, plant population establishment is hampered in this system. To overcome this situation and ensure plant establishment the system of settling planting at specified distances in the trenches has been developed. The transplanting of cane ensures optimum plant establishment. The initial crop growth of the crop 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 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. In paired rows system of sugarcane planting, two rows of cane are planted at 60 cm apart rows in a trench leaving 120-140 cm vacant space between two paired rows of cane (Alam *et al.*, 2008). The paired rows planting patterns are very easy to adopt and no modifications are necessary in the existing implements (Umrani, 1981). More than one intercrops in sequence can be easily cultivated with paired rows system to make sugarcane cultivation more profitable (Alam *et al.*, 2007). Successful intercropping of various crops with sugarcane has been reported by many researchers (Alam *et al.*, 2007 and Alam *et al.*, 2008). It has been reported that potato, onion, garlic and cabbage could be cultivated profitably as first intercrops with sugarcane (Matin *et al.*, 2001). Besides, after harvesting of first intercrop, the possibility of growing some short duration crops such as leafy vegetables, mungbean and dhaincha successfully as second intercrop with sugarcane has been explored. Many reports suggest that mungbean can be used as second intercrop (Hossain *et al.*, 1995). The possibility of growing a second intercrop under single row system of cane plantation is restricted due to canopy development of cane after the harvest of first intercrop. On the other hand, sequential intercropping in paired rows sugarcane is feasible (De and Singh, 1979).

Among all the intercrops, potato, onion, mustard, lentil, cabbage, cauliflower, carrot etc., are grown with sugarcane. Mustard ranks the first covering about 40-50% of the total intercropped area in Bangladesh (Hossain, 1984). In another study, potato yield was increased by 80-100% in paired rows system compared to the single row system. The adverse effects of mustard intercrop on tiller, millabe cane and cane yield under paired rows system increased by 80% compared to the single row intercrop (Ahmed *et al.*, 2007). The yield of onion as intercrop could be increased under paired rows system of cane plantation by accommodating higher intercrop population compared to the single row system. It has been reported that the yield of onion under paired rows systems is 4.4 tha^{-1} while it was 2.25 tha^{-1} under single row system (Imam *et al.*, 1990 and Miah *et al.*, 1994). The intercropping onion with paired rows cane showed the highest potential for increasing the net returns per unit area (562 US$ ha^{-1}) under intercropped systems (Imam *et al.*, 1990). Compared to other crops, onion exerted least detrimental effect on the emergence, tiller, millable cane and yield of sugarcane (Hossain, 1984). Higher yield of cane due to intercropping with onion has also been reported by (Anon., 1979 and Parashar *et al.*, 1979). Singh and Rai (1996) reported that cane yield was increased by

2.28% when onion was intercropped. Rathi and Singh (1979) and Parashar *et al.* (1979) reported that juice quality parameters of sugarcane (brix, purity and sucrose percentages) were not affected by onion intercropping. Due to shallow rooting depth, onion extract nutrient from an area on the ridges where the sugarcane shoot roots are not reached at that stage. This minimizes competition for nutrients and water. Moreover, a lower rate of pest incidence has been reported in intercropped cane with onion (Verma *et al.*, 1981). Increased net profits due to intercropping of onion have been reported by Behal and Narwal (1977) and Verma *et al.* (1981). Khan *et al.* (1985) have successfully grown summer mung with 13 tha^{-1} fresh biomass weight after harvesting potato and incorporated the biomass of mungbean into the soil to improve soil fertility and productivity. Intercropping 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 growth, yield, quality and economics of onion seed crop in onion seed crop-mungbean sequential intercropping with paired rows transplanted sugarcane.

MATERIALS AND METHODS

The experiment was conducted at the Bangladesh Sugarcane Research Institute (BSRI) farm, Ishurdi, pabna during 2008-2009 and 2009-2010 cropping seasons. The site represents High Ganges River Flood Plain under Agro-Ecological Zone 11 with medium high land of typical sandy loam soil. The experiment was set up in randomized complete block design with three replications. The unit plot size was 8m × 8m. The treatments are as follows:

T_1 - Paired rows cane (PRC) only
T_2 - PRC + onion (bulb) - BINA Mung 5 (standard)
T_3 - PRC + potato - BINA Mung 5
T_4 - PRC + 40 cm row spacing of onion seed crop - BINA Mung 5
T_5 - PRC + 30 cm row spacing of onion seed crop - BINA Mung 5
T_6 - PRC + 24 cm row spacing of onion seed crop - BINA Mung 5
T_7 - PRC + 20 cm row spacing of onion seed crop - BINA Mung 5

Forty five days old sugarcane settlings of variety Isd 38 were transplanted on 20 November 2008 in 2008-2009 and 08 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. Onion bulb was planted at 40, 30, 24 and 20 cm apart rows to accommodate 3, 4, 5 and 6 lines of onion seed crop in the space between two paired rows. The seed rates of onion seed (for seed) were 500 kg and 1000 kg ha^{-1} for paired rows intercrop and sole crop. The first intercrops (onion, potato and onion seed) were sown on 27 November 2008 and 20 November 2009 for 2008-2009 and 2009-2010 cropping seasons, respectively. The second intercrop variety BINA Mung 5 was sown in 3 lines in between two paired rows of

sugarcane on 18 March 2009 and 10 March 2010 in 2008-09 and 2009-10 cropping seasons, respectively. Sole crop of all first and second intercrops were sown in one side of the main field on the same days as of intercrops. 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. 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 (MoP), Gypsum, Zinc sulphate ($ZnSO_4$) and Boric acid, respectively. Pest management and necessary intercultural operations like weeding (3 times), mulching (3 times), gap filling (1 time), irrigation (4 times), earthing up (2 times), tying (1 time) etc. were done according to the recommendation. Data on number of tiller, number of millable cane, plant height, diameter of cane, number of internodes $stalk^{-1}$, unit stalk weight, cane dry matter m^{-2} and cane yield were recorded. The plant height, weight of 1000 grain/seeds, grain/seeds yield, straw yield and days to maturity were recorded for intercrops. The plant height and bulb yield were recorded for onion. Brix (%), pol (%) cane, purity (%), recoverable sucrose (%) and sugar yield were also recorded. pH value, 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 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 row spacing of onion seed crop in onion seed crop - mungbeann sequential intercropping under paired rows system of planting in 2008-09 and 2009-10 cropping seasons. The total biomass of sugarcane significantly differed due to these treatment combinations in both the seasons. The highest cane biomass yield of 3080 g m^{-2} was observed with T_2 (PRC + onion - BINA Mung 5) and the lowest cane biomass yield of 2410 g m^{-2} was found with T_1 (Paired rows cane only) treatments in 2008-09 season. In 2009-10, the highest cane biomass yield (3100 g m^{-2}) was recorded with T_7 (PRC + 20 cm row spacing of onion seed crop - BINA Mung 5) and the lowest (2510 g m^{-2}) was found with T_1 (Paired rows cane only) treatment (Table 1).

Table 1. Effect of row spacing on productivity of onion seed crop in onion - mungbean sequential intercropping on growth parameters of sugarcane in 2008-2009 and 2009-2010

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	2.58	2.12	2.15	2.02	23	22	2410 c	2510 e
T_2	2.75	2.61	2.30	2.26	26	28	3080 a	3060 a
T_3	2.72	2.25	2.28	2.20	25	24	3050 a	2975 d
T_4	2.63	2.58	2.25	2.11	25	26	2440 bc	3022 bc
T_5	2.67	2.48	1.97	2.12	23	25	2500 b	3000 cd
T_6	2.60	2.56	2.17	2.13	25	26	2450 bc	3050 b
T_7	2.67	2.60	2.10	2.16	24	27	2490 bc	3100 a
$S\bar{x}$	0.11	0.08	0.05	0.06	0.69	0.95	18.00	7.32
CV (%)	9.71	8.55	5.91	6.62	6.28	9.31	1.72	0.61
Level of significance	NS	NS	NS	NS	NS	NS	**	**

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

T_1 - Paired rows cane (PRC) only,
T_2 - PRC + onion (bulb) - BINA Mung 5 (standard),
T_3 - PRC + potato - BINA Mung 5,
T_4 - PRC + 40 cm row spacing of onion seed crop - BINA Mung 5,
T_5 - PRC + 30 cm row spacing of onion seed crop - BINA Mung 5,
T_6 - PRC + 24 cm row spacing of onion seed crop - BINA Mung 5 and
T_7 - PRC + 20 cm row spacing of onion seed crop - BINA Mung 5

Yield and yield attributes of sugarcane

Tiller population, number of millable cane, unit cane weight and cane yield were not significantly differed among the different intercrops combinaton. The highest number of tiller 222 × 10^3 ha^{-1} and 225 × 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 99 × 10^3 ha^{-1} and 108 × 10^3 ha^{-1} were obtained from T_2 (PRC + Onion - BINA Mung 5) and T_7 treatment in 2008-09 and 2009-10 season, respectively. The highest unit cane weight of 0.94 kg was found with T_6 (PRC + 24 cm row spacing of onion seed crop - BINA Mung 5) in 2008-2009 and that of 0.90 kg were obtained from T_1 and T_3 in 2009-10 seasons. The highest cane yield of 91.54 tha^{-1} and 93.12 tha^{-1} were obtained from T_2 (PRC + Onion - BINA Mung 5) treatment in 2008-09 and 2009-10 season, respectively (Table 2).

Table 2. Effect of row spacing on productivity of onion seed crop in onion - mungbean sequential intercropping on yield and yield attributes of sugarcane in 2008-2009 and 2009-2010

Treatments	Tiller ($\times 10^3$ ha^{-1})		Millable cane ($\times 10^3$ ha^{-1})		Unit cane weight (kg)		Cane yield (tha^{-1})	
	2008-09	2009-10	2008-09	2009-10	2008-09	2009-10	2008-09	2009-10
T_1	210	212	96	90	0.86	0.90	82.88	81.24
T_2	222	225	99	106	0.92	0.88	91.54	93.12
T_3	218	215	97	98	0.93	0.90	90.31	87.81
T_4	220	224	98	103	0.85	0.87	83.28	89.25
T_5	217	223	96	100	0.90	0.89	86.82	88.54
T_6	200	219	89	105	0.94	0.85	83.69	89.63
T_7	205	223	91	108	0.92	0.83	84.08	90.10
$S\bar{x}$	5.53	2.91	3.32	3.13	0.04	0.01	1.32	2.40
CV (%)	6.40	3.25	8.60	7.60	11.98	4.48	3.81	6.72
Level of significance	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 and crop duration of first intercrops differed significantly among the different treatment combinations except 1000-grain weight. The highest plant height of 86.50 cm and 89.10 cm were found with the treatment T_7 (PRC + 20 cm row spacing of onion seed crop - BINA Mung 5) while the lowest plant height of 42.33 cm and 48.00 cm were recorded with T_2 (PRC + onion - BINA Mung 5) tereatment in both the years. The highest biomass yield of 0.96 tha^{-1} and 1.08 tha^{-1} were observed with the treatment T_7 (PRC + 20 cm row spacing of onion seed crop - BINA Mung 5) while the lowest biomass yield of 0.41 tha^{-1} and 0.53 tha^{-1} were produced by T_2 (PRC + onion - BINA Mung 5) in both the years. The highest straw yield of 1.20 tha^{-1} and 1.35 tha^{-1} were observed with the treatment T_7 (PRC + 20 cm row spacing of onion seed crop - BINA Mung 5) while the lowest straw yield of 0.51 tha^{-1} and 0.66 tha^{-1} were produced by T_3 (PRC + potato - BINA Mung 5) in both the years. The highest 1000-grain weight of 3.3 g and 3.33 g were recorded in treatment T_4 (PRC + 40 cm row spacing of onion seed crop - BINA Mung 5) and the lowest 1000-grain weight of 3.27 g and 3.3 g were observed in T_7 (PRC + 20 cm row spacing of onion seed crop - BINA Mung 5) treatment in both the years. The crop duration was lowest of 94 days and 100 days with treatment T_2 (PRC + onion - BINA Mung 5) and the highest duration of 140 days and 141 days were found with T_4 (PRC + 40 cm row spacing of onion seed crop - BINA Mung 5),T_5 (PRC + 30 cm row spacing of onion seed crop - BINA Mung 5),T_6 (PRC + 24 cm row spacing of onion seed crop - BINA Mung 5) and T_7 (PRC + 20 cm row spacing of onion seed crop - BINA Mung 5) treatment in both the years (Table 3).

Table 3. Effect of row spacing on productivity of onion seed crop in onion - mungbean sequential intercropping on growth and yield attributes of first intercrops in 2008-09 and 2009-10

Treatments	Plant height (cm)		Biomass yield (tha^{-1})		Straw yield (tha^{-1})		1000-grain wt. (g)		Crop duration (days)	
	2008-09	2009-10	2008-09	2009-10	2008-09	2009-10	2008-09	2009-10	2008-09	2009-10
T_1	-	-	-	-	-	-	-	-	-	-
T_2	42.33 c	48.00 e	0.41 d	0.53 d	0.83 c	0.95 c	-	-	94 b	100 b
T_3	48.00 c	49.67 e	0.66 c	0.75 c	0.51 d	0.66 d	-	-	96 b	101 b
T_4	85.00 b	88.15 b	0.88 b	0.92 b	1.10 ab	1.15 ab	3.30	3.33	140 a	141 a
T_5	84.66 b	86.50 c	0.80 b	0.90 b	1.00 ab	1.12 ab	3.28	3.31	140 a	141 a
T_6	84.25 b	85.00 d	0.88 b	0.92 b	1.10 ab	1.15 ab	3.29	3.31	140 a	141 a
T_7	86.50 a	89.10 a	0.96 a	1.08 a	1.20 a	1.35 a	3.27	3.30	140 a	141 a
$S\bar{x}$	0.30	0.09	0.04	0.01	0.03	0.01	0.17	0.01	0.88	0.86
CV (%)	1.15	0.34	2.47	0.77	7.43	3.08	19.02	0.75	1.97	1.89
Level of significance	**	**	**	**	**	**	NS	NS	**	**

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

Biomass yield of second intercrops was not affected significantly due to onion seed crop in onion - mungbean sequential intercropping with paired rows transplanted sugarcane system but crop duration was not affected significantly. The crop duration was 70 days in 2008-09 and 72 days in 2009-10 from sowing to harvesting.

Intercrop yield and adjusted cane yield

The overall yield performance of the first intercrops (Onion, Potato, Onion seed) under paired rows system was found satisfactory. The yield of mungbean as second intercrops was significantly influenced by the different treatment combinations. Seed yield of mungbean was satisfactory in both the years. Among the treatment combination the highest green biomass yield was obtained of 6.7 tha^{-1} in 2008-09 and 7.50 tha^{-1} in 2009-10 with same treatment while the lowest yield was recorded of 6.20 tha^{-1} in 2008-09 and 7.10 tha^{-1} with the same treatment T_1(Paired rows cane only). Adjusted cane yield is an important parameter for determining the total yield potentials of the intercropped plot (cane + intercrop) over the sole cane plot. In the present experiment, the highest adjusted cane yield of 290.91 tha^{-1} and 281.07 tha^{-1} were obtained from the T_6 treatment (PRC+6 lines onion seed-BINA Mung 5) in 2008-09 and 2009-10 while the lowest of 82.66 tha^{-1} and 81.24 tha^{-1} were from the T_1 treatment (sole cane), respectively (Table 4).

Table 4. Effect of row spacing on productivity of onion seed crop in onion - mungbean sequential intercropping on intercrops, cane equivalent yield of intercrops and total adjusted cane yield in 2008-2009 and 2009-2010

Treatments	Intercrop yield (tha^{-1})				Cane equivalent yield of intercrop (tha^{-1})		Adjusted cane yield (tha^{-1})	
	First intercrop		Second intercrop					
	2008-09	2009-10	2008-09	2009-10	2008-09	2009-10	2008-09	2009-10
T_1	-	-	-	-	82.88	81.24	82.88 f	81.24 f
T_2	7.30	8.00	0.48	0.64	146.37	70.36	237.91 c	163.48 c
T_3	7.63	8.03	0.43	0.61	55.57	51.30	145.88 e	139.11 e
T_4	0.21	0.23	-	-	145.30	129.75	128.58 d	219.00 d
T_5	0.23	0.25	-	-	159.00	140.92	245.82 c	229.46 c
T_6	0.26	0.32	-	-	179.49	179.67	263.18 b	269.30 b
T_7	0.30	0.34	-	-	206.83	190.97	290.91 a	281.07 a
$S\bar{x}$	-	-	-	-	-	-	1.32	2.40
CV (%)	-	-	-	-	-	-	1.56	2.93
Level of significance	-	-	-	-	-	-	**	**

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

Price of crops (2008-09) Sugarcane: 1760 Tk. t^{-1}, Potato: 10 Tk. kg^{-1}, Onion (bulb): 32 Tk. kg^{-1}, Onion seed : 1200 Tk.kg^{-1}, Mungbean : 50 Tk. kg^{-1} and Mungbean (GM) : 600 Tk. t^{-1}

Price of crops (2009-10) Sugarcane 2160 Tk. t^{-1}, Potato: 10 Tk. kg^{-1}, Onion (bulb): 15 Tk. kg^{-1}, Onion seed : 1200 Tk. kg^{-1}, Mungbean : 50 Tk. kg^{-1} and Mungbean (GM) : 600 Tk. t^{-1}

Cane juice quality and sugar yield

Sugarcane juice quality parameters like brix (%), pol (%) cane, purity (%), recoverable sucrose (%) and sugar yield (t ha^{-1}) were not significantly in 2008-09 and 2009-10 (Table 5). The brix (%) ranged from 21.50 to 23.03 and 16.33 to 18.30 in 2008-09 and 2009-2010 seasons. In case of pol (%) cane ranged from 15.34 to 16.07 and 11.10 to 12.88 in 2008-09 and 2009-10 seasons. The purity (%) ranged from 88.62 to 91.68 and 85.89 to 88.95 in 2008-09 and 2009-10 seasons. The recoverable sucrose (%) ranged from 12.55 to 13.57 and 9.10 to 10.38 in 2008-09 and 2009-10 seasons. Sugar yield (tha^{-1}) ranged from 9.90 to 11.91 and 7.39 to 8.92 in 2008-09 and 2009-10 seasons.

Table 5. Effect of row spacing on productivity of onion seed crop in onion - mungbean sequential intercropping on juice quality and sugar yield (tha^{-1}) in 2008-09 and 2009-10

Treatments	Brix (%)		Pol (%) cane		Purity (%)		Recoverable sucrose (%)		Sugar yield (tha^{-1})	
	2008-09	2009-10	2008-09	2009-10	2008-09	2009-10	2008-09	2009-10	2008-09	2009-10
T_1	21.60	18.30	15.37	12.88	90.71	88.90	12.87	10.38	9.90	7.39
T_2	22.10	17.22	15.75	11.96	91.50	88.95	12.55	9.10	11.49	8.47
T_3	21.80	16.33	15.69	11.10	91.68	85.89	13.19	8.59	11.91	7.55
T_4	23.03	17.80	16.01	12.50	88.62	88.85	13.51	9.99	11.25	8.92
T_5	21.50	17.07	15.34	11.81	90.90	87.49	12.84	9.31	11.14	8.24
T_6	22.50	16.37	16.07	11.46	91.03	86.69	13.57	8.96	10.82	7.80
T_7	22.30	18.23	15.84	12.62	90.53	87.60	13.34	10.12	11.20	8.12
$S\bar{x}$	0.42	0.57	0.20	0.49	0.78	0.78	0.20	0.49	0.23	0.40
CV (%)	4.59	8.03	3.04	9.93	2.11	2.22	3.61	12.53	4.94	11.77
Level of significance	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. The highest costs of cultivation 1,62,000 Tk.ha^{-1} was required for the treatment T_2 (PRC + onion bulb - BINA Mung 5) and T_3 (PRC + potato - BINA Mung 5) in 2008-09 and 1,61,000 Tk.ha^{-1} in T_7 during 2009-10 seasons. The lowest cost of 80,000 Tk.ha^{-1} was required sole cane in both the seasons (Table 6). Other treatments required 1,47,000 Tk.ha^{-1} and 1,55,000 Tk.ha^{-1} in T_4 treatment; 1,49,000 Tk.ha^{-1} and 1,57,000 Tk.ha^{-1} in T_5 treatment; 1,51,000 Tk.ha^{-1} and 1,59,000 Tk.ha^{-1} in T_6 and 1,53,000 Tk.ha^{-1} in 2008-09 and 2009-10 seasons, respectively.

Gross income and net return

Under intercrop condition, the highest gross income of Tk. 5,12,001 ha^{-1} and Tk. 6,07,116 ha^{-1} was obtained from the T_7 treatment in 2008-09 and 2009-10 while the lowest gross income was from the T_1 treatment in 2008-09 (Tk. 1,45,869 ha^{-1}) and 2009-10 (Tk. 1,75,478 ha^{-1}) seasons, respectively. Similar result has also been obtained in case of net return in 2008-09 and 2009-10 (Table 6).

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

The highest BCR of 3.35 and 3.77 were found from T_7 (PRC + 24 cm row spacing of onion seed crop - BINA Mung 5) treatment in 2008-09 and 2009-10, respectively. The lowest BCR of 1.58 and 2.07 were observed from T_3 (PRC + potato - BINA Mung 5) treatment 2008-09 and 2009-10, respectively. The highest LER of 2.31 in 2008-09 and 2.59 in 2009-10 from T_6 (PRC + 24 cm row spacing of onion seed crop - BINA Mung 5) treatment while the lowest LER of 1.95 in 2008-09 from T_4 (PRC + 40 cm row spacing of onion seed crop - BINA Mung 5) and 2.27 in 2009-10 was obtained from T_3 (PRC + potato - BINA Mung 5) treatments (Table 6).

Table 6. Effect of row spacing on productivity of onion seed crop in onion - mungbean sequential intercropping on cost of production, benefit cost ratio (BCR) and land equivalent ratio (LER) in 2008-09 and 2009-10

Treatments	Total production cost (Tk. ha^{-1})		Gross income (Tk. ha^{-1})		Net return (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	145869	175478	65868	95478	1.82	2.19	1.00	1.00
T_2	162000	145000	418721	353116	256721	208116	2.58	2.44	2.29	2.38
T_3	162000	145000	256746	300470	94745	155469	1.58	2.07	2.20	2.27
T_4	147000	155000	402293	473040	255292	318040	2.74	3.05	1.95	2.34
T_5	149000	157000	432643	495626	283643	338626	2.90	3.16	2.12	2.39
T_6	151000	159000	463194	581681	312194	422680	3.07	3.66	2.31	2.59
T_7	153000	161000	512001	607116	359000	446116	3.35	3.77	2.30	2.49

Soil characteristics

Effects of row spacing on productivity of onion seed crop in onion-mungbean sequential intercropping in paired row transplanted sugarcane on post harvest soil pH, total N content (%), and available Zn (mg kg^{-1}) were not significant while that on organic matter (%), available P (mg kg^{-1}), exchangeable K (cmol kg^{-1}) and available S (mg kg^{-1}) were significant in both the years. The highest organic matter was obtained in T_2 (1.07 % & 1.06 %) while the lowest was in treatment T_1 (1.00 and 0.97 %) in both the years. Available P was the highest with T_6 (17.80 mg kg^{-1} & 19.00 mg kg^{-1}) while the lowest was in treatment T_3 (13.20 and 14.20 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_2 & T_7 (0.18 cmol kg^{-1}) in 2009-10 while the lowest was in treatment T_1 (0.10 and 0.12 cmol kg^{-1}) in both the years. Available S was the highest with treatment T_2 (26.40 mg kg^{-1}) in 2008-09 and in T_4 (25.20 mg kg^{-1}) in 2009-10 while the lowest was in treatment T_1 (18.50 and 21.20 mg kg^{-1}) in both the years (Table 7 and 8).

Table 7. Effect of row spacing on productivity of onion seed crop in onion - mungbean sequential intercropping on soil pH, organic matter (%), total N content (%) and available P (mg kg^{-1}) content of post harvest soil in 2008-09 and 2009-10

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
T_1	7.6	7.6	1.00	0.97	0.04	0.04	16.00	15.70
T_2	7.6	7.7	1.07	1.06	0.05	0.06	16.70	18.25
T_3	7.5	7.6	1.02	1.02	0.06	0.05	13.20	14.20
T_4	7.6	7.7	1.05	1.05	0.05	0.06	16.50	18.40
T_5	7.5	7.7	1.06	1.05	0.06	0.06	16.50	16.00
T_6	7.5	7.6	1.00	1.05	0.05	0.05	17.80	19.00
T_7	7.5	7.7	1.02	1.04	0.06	0.05	16.40	15.80
$S\bar{x}$	0.05	0.05	0.01	0.01	0.01	0.01	0.45	0.47
CV (%)	1.55	1.64	0.87	1.80	11.72	19.37	6.93	7.07
Level of significance	NS	NS	NS	NS	NS	NS	**	**

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

Table 8. Effect of row spacing on productivity of onion seed crop in onion - mungbean sequential intercropping on exchangeable K (cmol kg^{-1}), available S (mg kg^{-1}) and available Zn (mg kg^{-1}) content of post harvest 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
T_1	0.10	0.12	18.50	21.20	0.54	0.60
T_2	0.15	0.18	26.40	24.00	0.65	0.66
T_3	0.12	0.15	23.30	24.50	0.57	0.65
T_4	0.14	0.13	19.50	25.20	0.57	0.64
T_5	0.16	0.17	20.00	22.00	0.66	0.62
T_6	0.13	0.16	19.50	23.50	0.64	0.66
T_7	0.14	0.18	25.50	23.20	0.61	0.65
$S\bar{x}$	0.14	0.01	0.25	0.49	0.01	0.01
CV (%)	48.94	15.56	2.98	5.31	2.74	2.36
Levelof significance	**	**	**	**	NS	NS

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

From the experiment it can be concluded that intercropping of onion seed crop with sugarcane does not have any adverse effect on growth, yield and juice quality of sugarcane. Onion seed crop intercropping was economically more profitable than sole cane and the highest economic benefit was obtained from the onion seed crop-

mungbean sequential intercropping using six rows onion seed crop maintaining 20 cm row spacing in between two paired rows of transplanted sugarcane. Therefore, this intercropping sequence can be practiced for sustaining sugarcane farming and maintaining soil health.

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