Reprint **ISSN 1991-3036 (Web Version)**

International Journal of Sustainable Crop Production (IJSCP)

(*Int. J. Sustain. Crop Prod.*)

Volume: 10 **Issue: 1** **February 2015**

Int. J. Sustain. Crop Prod. 10(1): 1-10 (February 2015)

PRODUCTIVITY OF LENTIL-MUNGBEAN SEQUENTIAL INTERCROPPING IN PAIRED ROW SUGARCANE

M.J. ALAM, M.M. RAHMAN, M.A.R. SARKAR, M.K. RAHMAN, A.K.M.R. ISLAM, M.A.T. SOHEL, M.J. UDDIN AND M.K. HABIB

An International Scientific Research Publisher

Green Global Foundation©

Web address: http://ggfjournals.com/e-journals archive
E-mails: editor@ggfjournals.com and editor.int.correspondence@ggfjournals.com

ISSN-1991-3036 (Online)
Int. J. Sustain. Crop Prod. 10(1):1-10(February 2015)

PRODUCTIVITY OF LENTIL-MUNGBEAN SEQUENTIAL INTERCROPPING IN PAIRED ROW SUGARCANE

M.J. ALAM[2*], M.M. RAHMAN[1], M.A.R. SARKAR[1], M.K. RAHMAN[3], A.K.M.R. ISLAM[4], M.A.T. SOHEL[4], M.J. UDDIN[5] AND M.K. HABIB[5]

[1]Professor, Department of Agronomy, Bangladesh Agriculture University, Mymensingh, Bangladesh; [2]PSO [3]CSO [4]SSO [5]SO Scientist of Bangladesh Sugarcane Research Institute, Ishurdi, Pabna, Bangladesh.

*Corresponding author & address: Dr. Md. Jahangir Alam, E-mail: alammjbsri@yahoo.com
Accepted for publication on 5 January 2015

ABSTRACT

Alam MJ, Rahman MM, Sarkar MAR, Rahman MK, Islam AKMR, Sohel MAT, Uddin MJ, Habib MK (2015) Productivity of lentil-mungbean sequential intercropping in paired row sugarcane. *Int. J. Sustain. Crop Prod.* 10(1), 1-10.

An experiment was conducted at the Bangladesh Sugarcane Research Institute (BSRI) farm, Ishurdi for consecutive two years starting from 2008-2009 to 2009-2010 to find out suitable lentil variety for lentil-mungbean sequential intercropping with paired row transplanted sugarcane. BARI Masur 4, BARI Masur 5, BARI Masur 6, BINA Masur 2 and BINA Masur 3 were used as lentil varieties. In this trial, 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 showed higher BCR than the sole cane crop. Among the treatment combinations, PRC + BARI Masur 5- Mungbean performed better in respect of yield and yield contributing characters. Mungbean based sequential intercropping with paired row transplanted sugarcane could be considered as a profitable combination for sustaining sugarcane farming and maintaining soil health.

Key words*: productivity, sugarcane, paired row cane (prc), intercropping, lentil*

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. It is mostly grown in the north-west and south-west regions of the country especially in the greater districts of Jessore, Kushtia, Pabna, Rajshahi, Bogra, Rangpur, Dinajpur and Faridpur and in some pockets of greater districts of Mymensingh, Dhaka, Noakhali, Sylhet, Comilla, Chittagong, Khulna and Barisal. The world average yield of sugarcane is 70.76 t ha^{-1} while that in Bangladesh is around 44 t ha^{-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 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 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 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 row system of cane cultivation has recently been developed that unveils the potential of practicing intercropping with sugarcane with high profit. In paired row 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 row 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 row system to make sugarcane cultivation more profitable (Alam *et al.* 2007). Successful intercropping of various crops with sugarcane has been reported by many researchers (Islam *et al.* 2009; Alam *et al.* 2007; 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 row 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 row system compared to the single

row system. The adverse effects of mustard intercrop on tiller, millabe cane and cane yield under paired row 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 row 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 row systems is 4.4 t ha^{-1} while it was 2.25 t ha^{-1} under single row system (Imam *et al.* 1990). The intercropping onion with paired row 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).

Gergawi and Salama (1994) observed a field trial of chickpea and lentil intercropped with autumn planted sugarcane and the highest land equivalent ratio was obtained when two rows of lentil was intercropped with sugarcane. On the other hand, the highest total income was recorded when one row of chickpea was intercropped with sugarcane.

Gill *et al.* (1994) observed that lentil intercropping has no significant effect on sugarcane or total sugar production. Sugarcane intercropped with lentil gave 10.92% higher net economic return than sugarcane sole.

Panwar *et al.* (1990) stated the comparative performance of intercropping lentil, gram, wheat and maize with sugarcane and sugarcane alone. They observed that number of tiller, millable cane and cane yield were increased considerable when lentil was intercropped with sugarcane compared to the sole cane. Among the different intercrops, the highest net return was obtained from sugarcane + lentil compared to other combinations.

Yadava (1987) observed soil fertility improvement through legumes intercropping with sugarcane. In India, a large quantity of N fertilizer (150 kg ha^{-1}) is required to produce cane yield. Legume is a companion intercropping system that improves soil fertility by fixing atmospheric N to benefit sugarcane grown in association or in succession.

Mixed cultivation of lentil/sugarcane has long been practiced in the sub-continent. Systematic trials of lentil along with other pulses and legume have been stated over a decade back. Intercropping of leguminous crops has been found to increase or decrease or have no effect on yield of cane (Hossain 1984).

A number of studies had been conducted on intercropping lentil with single row sugarcane planting system, a very little number of studies had been made on the lentil intercropping in paired row system. Under paired row system of sugarcane, the highest sugarcane yield (96 t ha^{-1}) was obtained when intercropped with lentil followed by kheshari, pea and soybean. The highest net return of Tk. 9,400 was obtained from lentil intercropping while the lowest of Tk. 100 only was from kheshari in paired row system. It is further observed that the level of intercrop yield (lentil) was increased in paired row system compared to the single row system (Hossain *et al.* 1995).

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 lentil variety for lentil-mungbean sequential intercropping on growth, yield and quality with paired row 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 season. The site represents High Ganges River Floodplain under Agro-Ecological Zone 11 with medium high land of typical sandy loam soil. BARI Masur 4, BARI Masur 5, BARI Masur 6, BINA Masur 2 and BINA Masur 3 were used as lentil (*Lens culinaris* L.) varieties. 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 row cane (PRC), T_2 - PRC + onion - BINA Mung 5 (standard, Control), T_3 - PRC + BARI Masur 4 - BINA Mung 5, T_4 - PRC + BARI Masur 5 - BINA Mung 5, T_5 - PRC + BARI Masur 6 - BINA Mung 5, T_6 - PRC + BINA Masur 2 - BINA Mung 5 and T_7 - PRC + BINA Masur 3 - BINA Mung 5.

Sowing/Planting

Forty five days old sugarcane settlings were transplanted on 24 November 2008 in 2008-09 and 16 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. In case of

paired row sugarcane, seed rate and spacing for onion and mungbean were similar to that of experiment 1. For lentil, seeds were sown 3 rows (30 cm apart) in PRC in line sowing. The seed rates of lentil were 15.0 and 20.0 kg ha^{-1} for paired row intercrop and sole crop. The first intercrops (onion and lentil varieties) were sown on 24 November 2008 and 16 November 2009 for 2008-09 and 2009-10 seasons, respectively. The second intercrop (BINA Mung 5) was planted on 08 March 2008 and 15 March 2010 in 2008-09 and 2009-10 cropping seasons, respectively. The trenches were made by paired row 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.

Fertilizer application

For sugarcane and other intercrops, fertilizers were applied following the recommended rates (BARC 2005), such as 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 @ 10, 12, 8, 3, 0.6 and 0.3 kg ha^{-1} for lentil. 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. For sugarcane, whole amount of TSP, gypsum, zinc sulphate and one third of MoP were placed in trenches and incorporated with soil prior to transplanting of settlings. Urea was applied in three equal splits as side dressing at 21, 90 and 150 days after transplanting (DAT). The rest MoP were applied in two equal splits at 90 and 150 DAT, respectively. In case of onion, one-half of urea and MoP and whole dose of TSP, gypsum, $ZnSO_4$ and boric acid were applied at final land preparation. The rest of urea and MoP were applied in two equal splits at 25 and 50 DAT. For lentil intercrops, all fertilizers were applied just before at the time of sowing. After harvesting of first intercrops (onion and lentil varieties), mungbean variety BINA Mung 5 was sown as second intercrop. Three lines of mungbean were sown at 30 cm apart rows between two paired rows of cane.

Pest management

Furadan 5G was applied at the rate of 40 kg ha^{-1} in three splits (8, 16 and 16 kg ha^{-1}) at transplanting, 90 DAT and 150 DAT, respectively to control early shoot borer (ESB) and top shoot borer (TSB). In addition to this, Regent 3G was applied in trenches at the rate of 33 kg ha^{-1} before cane transplanting to control termites. Apart from chemical control, mechanical control was also done as and when required. No disease infestation was found in the field. The crop field was infested by some weed species such as *Cyperus rotundus* L., *Cynodon dactylon* L., *Chenopodium album* L., *Nicotiana plumbaginfolia*, *Argemone mexicana* and *Hydrocotyle asiatica*. Among them, *Cyperus rotundus* L. and *Cynodon dactylon* L. were the most dominating weed species in both sugarcane and intercrop plots. Spading and hand weeding were done at 30 and 60 DAT, respectively to control the weeds.

Irrigation and other management practices

Irrigation (10 cm) was given to the furrow of the sugarcane field after two days of settling placement. Subsequent four irrigations were done following furrow irrigation method at 30, 60, 90 and 120 DAT when the soil moisture reached to 60% depletion of field capacity. Earthing up was done manually three times at 120, 150 and 180 DAT. This operation converted the furrows into ridges and ridges into furrows. Tying was done two times in July and September to keep the cane clump straight to avoid lodging. The dried leaves were removed from the plants and the green leaves on plants were tied together by taking all the canes in one bundle. Cross tying was done by binding two clumps of adjacent rows together.

Data recorded

Number of tiller, number of millable cane, plant height (of cane), 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 BARI Masur 4, BARI Masur 5, BARI Masur 6 and BINA Masur 2 and BINA Masur 3 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. The detailed procedure of data recording for sugarcane and intercrops are described below:

Sugarcane

Total number of tillers (shoot of cane) and millable cane (economic shoot or stalks) of sugarcane of each unit plot was recorded at 150 days after transplanting (DAT) and at harvest. For recording cane biomass, three hills were randomly selected $unit^{-1}$ plot and were cut at ground level at 240 DAT. The sample plants were separated

into leaves and stalks. The samples were dried in oven at 70^0 C (until attaining a constant weight) and the weight was expressed in g m^{-2}. The plant height was recorded from randomly selected five canes by measuring the length from ground level to collar band of cane. The individual stalk weight was obtained by dividing the total weight of cane stalk of a plot with the number of millable cane stalks the plot. The stalk girth was measured with slide calipers by taking reading on diameter of top, middle and bottom and from average of these readings. The total number of internodes of five cane stalks was counted and the average number of internodes $cane^{-1}$ was recorded.

Intercrops

Plant height was measured with meter scale for the base of the plant to the tip of the tallest leaf of the plant. Total plants of each plot were harvested and the biomass was recorded. The biomass yield was expressed as t ha^{-1}. Yield of first and second intercrops (onion bulb, lentil and mungbean) were measured by the top loading balance on whole plot basis. Then the yield was expressed in t ha^{-1}. The total period from days after emergence (DAE) to maturity of the crop was counted and expressed in days. Straw was sun dried and weighed. Then a sub-sample of 200 g was oven dried for each crop. The straw yield was expressed in t ha^{-1}. For grain crops, one thousand seeds were counted from seed lot of each plot (for grain crop) and weighed to obtain 1000 - grain weight.

Harvesting

The first intercrops were harvested during 3 to 7 March 2009 in 2008-2009 and 4 to 11 March 2010 in 2009-10 seasons when they reached its maturity. In 2008-09, BARI Masur 4, BARI Masur 5 and BARI Masur 6 were harvested on 04 March 2009 and BINA Masur 2 and BINA Masur 3 were harvested on 07 March while onion was harvested on 03 March 2009. In 2009-10, BARI Masur 4, BARI Masur 5 and BARI Masur 6 were harvested on 09 March and BINA Masur 2 and BINA Masur 3 were harvested on 11 March while onion was harvested on 04 March 2009 respectively. Second intercrop viz. mungbean variety BINA Mung 5 was harvested on 20 May 2009 and 02 June 2010 in 2008-2009 and 2009-10 season, respectively. Sugarcane was harvested on 24 December 2009 in 2008-2009 (398 days after transplanting) and on 17 December 2010 in 2009-2010 (399 days after transplanting).

Chemical analysis of cane juice

Brix (%), pol (%), purity (%) and recoverable sucrose (%) in sugarcane juice were recorded at harvest. Brix (%) refers to the total soluble solids while pol (%) refers to percentage of sucrose content in cane juice. Purity (%) refers to ratio of sucrose content (pol %) to the total soluble solids (brix %) in juice. Five cane stalks were selected from each plot at random and was crushed with a mini power crusher for juice extraction. The collected juice was poured in to a glass cylinder and the brix (%) was determined by brix hydrometer. The same juice was clarified with basic lead sub-acetate and after filtration it was poured in 200 mm polarimeter tube for determination of pol (%) of cane (Anon. 1970). Recoverable sucrose was determined by using the following formula:

$$\text{Recoverable sucrose (\%)} = \{\text{Pol} - (\frac{\text{Brix-Pol}}{2})\} \times \text{Juice factor (J.F.)}$$

Where, juice factor was 0.73.

Sugar yield was determined by multiplying with the recoverable sucrose (%) content with cane yield ha^{-1}.

$$\text{Sugar yield (t ha}^{-1}) = \frac{\text{Cane yield (t ha}^{-1}) \times \text{recoverable sucrose (\%)}}{100}.$$

The economics and statistical analyses on different treatments for sugarcane and intercrops were done following the standard procedures.

RESULTS AND DISCUSSION

Growth parameters of sugarcane

Cane height, cane diameter and number of internode $cane^{-1}$ did not differ significantly by different lentil varieties in lentil - mungbea sequential intercropping under paired row transplanted sugarcane in 2008-09 and 2009-10 cropping seasons. The total cane biomass yield of significantly differed due to these treatment combinations in both the seasons. The highest biomass yield of sugarcane were 3400 g m^{-2} found with T_6 (PRC only) treatments in 2008-09 season. While In 2009-10, the highest cane biomass yield of 3350 g m^{-2} was + BINA Musur 2 - BINA Mung 5) and the lowest cane biomass yield of 2865 g m^{-2} was found with T_1 (PRC observed with T_4 (PRC + BARI Musur 5 - BINA Mung 5) and the lowest 2500 g m^{-2} was recorded with T_1 (PRC only) treatment (Table 1).

Table 1. Effect of lentil - mungbean sequential intercropping with paired row transplanted sugarcane on growth parameters of sugarcane in 2008-09 and 2009-10

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	2.42	2.12	2.12	25	21	2865 e	2500 b
T_2	3.02	2.64	2.30	2.40	27	27	3350 ab	3200 a
T_3	2.97	2.52	2.28	2.21	26	24	3052 d	3150 a
T_4	2.62	2.79	2.15	2.44	26	28	3300 b	3350 a
T_5	2.35	2.73	2.10	2.38	27	23	3210 c	2700 a
T_6	3.23	2.68	2.37	2.15	29	25	3400 a	2660 a
T_7	3.03	2.57	2.35	2.24	28	24	3325 b	2910 a
$S\bar{x}$	0.06	0.11	0.08	0.06	0.84	1.21	15.69	267.74
CV (%)	5.99	9.97	9.05	5.80	7.63	11.99	1.20	23.58
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 row cane (PRC), T_2 - PRC + onion - BINA Mung 5 (standard, Control), T_3 - PRC + BARI Masur 4 - BINA Mung 5, T_4 - PRC + BARI Masur 5 - BINA Mung 5, T_5 - PRC + BARI Masur 6 - BINA Mung 5, T_6 - PRC + BINA Masur 2 - BINA Mung 5 and T_7 - PRC + BINA Masur 3 - BINA Mung 5

Yield and yield attributes of sugarcane

Number of millable cane, unit cane weight and cane yield did not differ significantly among the different, lentil - mungbean sequential intercropping treatments with paired row transplanted sugarcane. However, tiller population of sugarcane significantly differed among these treatment combinations. The highest number of tiller was 240 × 10^3 ha^{-1} in T_7 (PRC + BINA Musur 3 - BINA Mung 5) treatment and 220 × 10^3 ha^{-1} were obtained from T_2 (PRC + Onion - BINA Mung 5) treatment in 2008-09 and 2009-10 seasons, respectively. The highest number of millable cane of 103 × 10^3 ha^{-1} and 113 × 10^3 ha^{-1} were obtained from T_4 (PRC + BARI Musur 5 - BINA Mung 5) treatment in both the years. The highest unit cane weight of 1.09 kg was found with T_6 (PRC + BINA Musur 2 - BINA Mung 5) in 2008-2009 and that of 0.92 kg was obtained from T_3 (PRC + BARI Musur 4 - BINA Mung 5) in 2009-10 seasons. The highest cane yield of 100 t ha^{-1} in T_6 and 96.04 t ha^{-1} were obtained from T_4 (PRC + BARI Musur 5 - BINA Mung 5) treatment in 2008-09 and 2009-10 season, respectively (Table 2).

Table 2. Effect lentin - mungbean sequential intercropping on yield and yield attributes of sugarcane in 2008-09 and 2009-10

Treatments	No. of tiller (×10^3 ha^{-1})		No. of 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	228 a	207 ab	88	98	1.00	0.83	87.99	81.21
T_2	234 a	220 a	96	102	1.04	0.89	99.79	90.83
T_3	229 a	198 b	97	98	0.99	0.92	95.63	89.79
T_4	227 a	195 bc	103	113	0.95	0.85	97.36	96.04
T_5	232 a	199 b	94	96	1.00	0.91	94.03	87.15
T_6	201 b	202 ab	92	100	1.09	0.85	100.00	85.21
T_7	240 a	187 b	92	104	1.07	0.85	98.04	88.26
$S\bar{x}$	5.52	4.89	2.71	2.36	0.06	0.01	3.80	2.04
CV (%)	5.94	5.99	7.02	5.68	13.41	2.04	7.67	5.64
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 row cane (PRC), T_2 - PRC + onion - BINA Mung 5 (standard, Control), T_3 - PRC + BARI Masur 4 - BINA Mung 5, T_4 - PRC + BARI Masur 5 - BINA Mung 5, T_5 - PRC + BARI Masur 6 - BINA Mung 5, T_6 - PRC + BINA Masur 2 - BINA Mung 5 and T_7 - PRC + BINA Masur 3 - BINA Mung 5

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. The highest plant height of the first intercrop were 43.50 cm and 40.50 cm in the treatment T_2 (PRC + Onion - BINA Mung 5) in both the years. The lowest plant height of 29.33 cm and 28.50 cm were recorded with T_7 (PRC + BINA Musur 3 - BINA Mung 5) treatment in 2008-09 and 2009-10 seasons. In case of the biomass yield of 2.30 t ha^{-1} and 2.31 t ha^{-1} were observed with the

treatment T_5 (PRC + BARI Musur 6 - BINA Mung 5) in both the year. The lowest biomass yield of 0.80 t ha^{-1} and 0.79 t ha^{-1} were produced by T_2 (PRC + 0nion - BINA Mung 5) in 2008-09 and 2009-10, respectively (Table 3). Similar trend was observed in straw yield in both the years. The highest 1000-grain weight of 18.40 g and 19.00 g were recorded in treatment T_3 (PRC + BARI Musur 4 - BINA Mung 5) both the years while the lowest 1000-grain weight of 14.20 g and 14.30 g were observed in T_6 (PRC + BINA Musur 2 - BINA Mung 5) treatment in both the years. The lowest crop duration 99 days and 102 days were treatment T_2 (PRC + 0nion - BINA Mung 5) and the highest crop duration 104 days (2008-09) found in and 116 days (200910) were found in T_6 (PRC + BINA Musur 2 - BINA Mung 5) and T_7 (PRC + BINA Musur 3 - BINA Mung 5) treatment, respectively (Table 3).

Table 3. Effect of lentil - mungbean sequential intercropping with paired row transplanted sugarcane on growth yield attributes of first intercrops in 2008-09 and 2009-10

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	43.50 a	40.50 a	0.80 c	0.79 e	1.00 e	0.99 e	-	-	99 b	102 b
T_3	34.67 c	34.50 c	2.24 ab	2.20 b	2.80 b	2.75 b	18.40 a	19.00 a	101 ab	114 a
T_4	33.33 d	32.50 e	2.14 b	2.04 d	2.67 d	2.55 d	17.60 b	18.10 b	101 ab	114 a
T_5	35.67 b	37.00 b	2.30 a	2.31 a	2.87 a	2.89 a	16.00 c	17.50 c	101 ab	114 a
T_6	35.00 bc	33.50 d	2.16 b	2.12 b	2.70 c	2.65 c	14.20 d	14.30 e	104 a	116 a
T_7	29.33 e	28.50 f	2.18 ab	2.04 d	2.73 c	2.55 d	14.30 d	16.50 d	104 a	116 a
$S\bar{x}$	0.16	0.14	0.14	0.05	0.01	0.02	0.08	0.05	0.74	0.93
CV (%)	1.33	1.20	4.14	1.54	1.01	2.19	1.75	0.99	2.10	2.38
Level of significance	**	**	**	**	**	**	**	**	**	**

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

T_1 - Paired row cane (PRC), T_2 - PRC + onion - BINA Mung 5 (standard, Control), T_3 - PRC + BARI Masur 4 - BINA Mung 5, T_4 - PRC + BARI Masur 5 - BINA Mung 5, T_5 - PRC + BARI Masur 6 - BINA Mung 5, T_6 - PRC + BINA Masur 2 - BINA Mung 5 and T_7 - PRC + BINA Masur 3 - BINA Mung 5

Intercrop yield and adjusted cane yield

The yield of the first intercrops (onion and lentil) under paired row system was found satisfactory. The yield of mungbean as second intercrop was significantly differed among the different treatment combinations. Among the treatment combination the highest yield of 0.56 t ha^{-1} and 0.64 t ha^{-1} were obtained from T_2 (PRC + onion - BINA Mung 5) treatment in both the years while the lowest yield of 0.41 t ha^{-1} and 0.56 t ha^{-1} were found in T6 and T7 treatment. respectively for both the years (2008-09 and 2009-10). The highest adjusted cane yield of 217.15 t ha^{-1} and 172.66 t ha^{-1} were obtained of both the year while the lowest of 87.99 t ha^{-1} and 81.21 t ha^{-1} were found with T_1 treatment (sole cane) in both the years (Table 4).

Table 4. Effect of lentil - mungbean sequential intercropping on intercrops, cane equivalent yield of intercrops and total adjusted cane yield in 2008-09 and 2009-10

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	-	-	-	-	87.99	81.21	87.99 c	81.21 d
T_2	5.58	9.65	0.56 a	0.64 a	117.36	81.83	217.15 a	172.66 a
T_3	0.65	0.74	0.44 b	0.60 ab	34.66	34.44	130.29 b	124.23 c
T_4	0.76	0.87	0.42 b	0.67 a	37.84	39.68	135.20 b	135.72 b
T_5	0.72	0.83	0.46 b	0.60 ab	37.61	36.94	131.64 b	124.09 c
T_6	0.56	0.78	0.41 b	0.65 a	30.74	36.71	130.74 b	121.92 c
T_7	0.57	0.81	0.44 b	0.56 b	31.93	35.46	129.97 b	123.72 c
$S\bar{x}$	-	-	0.01	0.02	-	-	3.80	2.04
CV (%)	-	-	11.86	9.12	-	-	6.76	4.01
Level of significans	-	-	**	**	-	-	**	**

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

T_1 - Paired row cane (PRC), T_2 - PRC + onion - BINA Mung 5 (standard, Control), T_3 - PRC + BARI Masur 4 - BINA Mung 5, T_4 - PRC + BARI Masur 5 - BINA Mung 5, T_5 - PRC + BARI Masur 6 - BINA Mung 5, T_6 - PRC + BINA Masur 2 - BINA Mung 5 and T_7 - PRC + BINA Masur 3 - BINA Mung 5

Price of crops (2008-09) Sugarcane : 1760 Tk.t^{-1}, Onion : 32 Tk.kg^{-1}, Lentil : 60 Tk.kg^{-1}, Mungbean : 50 Tk.kg^{-1}
Price of crops (2009-10) Sugarcane : 2160 Tk.t^{-1}, Onion : 15 Tk.kg^{-1}, Lentil : 60 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 lentil - mungbean sequential intercropping combination in 2008-09 and 2009-10 (Table 5). The brix (%) ranged from 21.43 to 22.90 and 16.90 to 19.80 in 2008-09 and 2009-10 seasons. The pol (%) cane ranged from 15.23 to 16.12 and 11.71 to 14.01 in 2008-09 and 2009-10 seasons, respectively. The purity (%) ranged from 88.40 to 91.02 and 88.27 to 90.14 in 2008-09 and 2009-10 seasons. The recoverable sucrose (%) ranged from 12.73 to 13.62 and 9.21 to 11.49 in 2008-09 and 2009-10 seasons. Sugar yield (t ha^{-1}) ranged from 11.36 to 13.71 and 8.13 to 10.31 in 2008-09 and 2009-10 seasons, respectively.

Table 5. Effect of lentil - mungbean sequential intercropping on juice quality and sugar yield (t ha^{-1}) in 2008-09 and 2009-10

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	21.90	19.77	15.38	13.99	89.43	90.08	12.88	11.49	11.36	8.64
T_2	21.43	19.80	15.28	14.01	90.85	90.14	12.78	11.35	12.74	10.31
T_3	22.17	17.90	15.84	12.52	91.02	89.03	13.34	10.02	12.75	8.99
T_4	22.63	19.50	15.70	13.05	88.41	89.93	13.20	10.55	12.84	10.13
T_5	22.03	18.63	15.45	13.10	89.29	89.56	12.95	10.60	12.20	9.24
T_6	21.43	19.53	15.23	13.69	90.58	89.38	12.73	11.19	13.71	9.54
T_7	22.90	16.90	16.12	11.71	89.69	88.27	13.62	9.21	13.31	8.13
$S\bar{x}$	0.40	0.47	0.28	0.28	0.63	0.64	0.28	0.28	0.49	0.23
CV (%)	4.43	6.06	4.39	5.32	1.71	1.74	5.24	6.53	9.58	6.24
Level of significane	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

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

T_1 - Paired row cane (PRC), T_2 - PRC + onion - BINA Mung 5 (standard, Control), T_3 - PRC + BARI Masur 4 - BINA Mung 5, T_4 - PRC + BARI Masur 5 - BINA Mung 5, T_5 - PRC + BARI Masur 6 - BINA Mung 5, T_6 - PRC + BINA Masur 2 - BINA Mung 5 and T_7 - PRC + BINA Masur 3 - BINA Mung 5

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 6). 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 1,07,000 Tk. ha^{-1} and 1,16,000 Tk. ha^{-1}, respectively in 2008-09 and 2009-10.

Gross income and net return

Under intercrop condition, the highest gross income of Tk. 3,82,190 ha^{-1} and Tk. 3,72,943 ha^{-1} were obtained from the T_2 treatment in 2008-09 and 2009-10 while the lowest gross income were from the T_1 plot in 2008-09 (Tk. 1,54,862 ha^{-1}) and 2009-10 (Tk. 1,75,414 ha^{-1}). 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 benefit cost ratio **(**BCR) was maximum in T_2 (PRC + onion - BINA Mung 5) treatment which were 2.36 in 2008-09 and 2.57 in 2009-10. The lowest BCR were 1.94 in 2008-09 and 2.19 in 2009-10 in T_1 (sole cane only) treatment. Data on the LER value of different sugarcane + intercrop combination showed that the treatment T_2 (PRC + onion - BINA Mung 5) had the highest LER of 2.20 in 2008-09 and 2.51 in 2009-10 while the lowest LER of 1.95 was recorded in 2008-09 and 2.15 in 2009-10 with T_5 (PRC + BARI Musur 6 - BINA Mung 5) and T_6 (PRC + BINA Musur 2 - BINA Mung 5), respectively (Table 6).

Table 6. Effect of lentil - 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	154862	175414	74862	95413	1.94	2.19	1.00	1.00
T_2	162000	145000	382190	372943	220190	227942	2.36	2.57	2.20	2.51
T_3	107000	116000	229309	268346	122308	152346	2.14	2.31	1.95	2.15
T_4	107000	116000	237954	293146	130953	177146	2.22	2.53	2.12	2.36
T_5	107000	116000	231693	268044	124692	152044	2.17	2.31	2.10	2.18
T_6	107000	116000	230100	263354	123100	147353	2.15	2.27	1.95	2.25
T_7	107000	116000	228750	267242	121750	151241	2.14	2.30	2.01	2.18

T_1 - Paired row cane (PRC), T_2 - PRC + onion - BINA Mung 5 (standard, Control), T_3 - PRC + BARI Masur 4 - BINA Mung 5, T_4 - PRC + BARI Masur 5 - BINA Mung 5, T_5 - PRC + BARI Masur 6 - BINA Mung 5, T_6 - PRC + BINA Masur 2 - BINA Mung 5 and T_7 - PRC + BINA Masur 3 - BINA Mung 5

Price of crops (2008-09) Sugarcane : 1760 Tk.t^{-1}, Onion : 32 Tk.kg^{-1}, Lentil : 60 Tk.kg^{-1}, Mungbean : 50 Tk.kg^{-1}
Price of crops (2009-10) Sugarcane : 2160 Tk.t^{-1}, Onion : 15 Tk.kg^{-1}, Lentil : 60 Tk.kg^{-1}, Mungbean : 50 Tk.kg^{-1}

Soil characteristics

The post harvest soil pH, total N content (%), exchangeable K (cmol kg^{-1}) and available Zn (mg kg^{-1}) were not significantly affected by lentil - mungbean sequential intercropping in paired row transplanted sugarcane but the effect was significant on organic matter (%), available P (mg kg^{-1}) and S (mg kg^{-1}) in both the years. The highest organic matter was recorded in T_2 (1.19 %) in 2008-09 and T_4 (1.16 %) in 2009-10 while the lowest was in treatment T_1 (0.79 and 0.85 %) in both the years. Available P was the highest with T_4 (49.70 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 (21.00 and 22.00 mg kg^{-1}) in both the years. Available S was the highest with treatment T_3 (26.20 mg kg^{-1}and 26.00 mg kg^{-1}) in 2008-09 and in 2009-10 while the lowest was in treatment T_1 (16.70 and 19.70 mg kg^{-1}) in both the years (Table 7 and 8).

Table 7. Effect of lentil - mungbean sequential intercropping on harvest soil soil pH, organic matter (%), total N content (%) and available P (mg kg^{-1}) content 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
Post harvest soil								
T_1	7.6	7.7	0.99	1.00	0.04	0.05	21.00	22.00
T_2	7.6	7.6	1.09	1.04	0.05	0.06	27.00	27.50
T_3	7.6	7.6	1.05	1.02	0.06	0.05	25.40	29.60
T_4	7.7	7.6	1.03	1.05	0.07	0.05	49.70	23.80
T_5	7.6	7.7	1.02	1.03	0.06	0.06	32.80	27.40
T_6	7.6	7.6	1.07	1.01	0.06	0.05	25.60	28.70
T_7	7.6	7.6	1.02	1.04	0.05	0.06	35.60	23.60
$S\bar{x}$	0.04	0.04	0.04	0.06	0.01	0.01	0.33	0.21
CV (%)	1.31	1.11	8.80	11.78	11.12	8.28	2.56	2.02
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 row cane (PRC), T_2 - PRC + onion - BINA Mung 5 (standard, Control), T_3 - PRC + BARI Masur 4 - BINA Mung 5, T_4 - PRC + BARI Masur 5 - BINA Mung 5, T_5 - PRC + BARI Masur 6 - BINA Mung 5, T_6 - PRC + BINA Masur 2 - BINA Mung 5 and T_7 - PRC + BINA Masur 3 - BINA Mung 5

Table 8. Effect of lentil - mungbean sequential intercropping on harvest soil exchangeable K (cmol kg^{-1}), available S (mg kg^{-1})and available Zn (mg kg^{-1}) content in 2008-09 and 2009-10

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	0.19	16.70	19.70	0.64	0.60
T_2	0.13	0.21	18.00	20.50	0.63	0.61
T_3	0.14	0.21	26.20	26.00	0.67	0.65
T_4	0.12	0.23	21.70	25.20	0.65	0.66
T_5	0.12	0.20	25.10	21.90	0.68	0.60
T_6	0.12	0.23	18.70	21.90	0.65	0.67
T_7	0.13	0.23	20.50	25.50	0.68	0.66
$S\bar{x}$	0.01	0.01	0.27	0.22	0.01	0.01
CV (%)	15.95	11.18	3.08	2.39	3.94	5.03
Level of significance	NS	NS	**	**	NS	NS

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

T_1 - Paired row cane (PRC), T_2 - PRC + onion - BINA Mung 5 (standard, Control), T_3 - PRC + BARI Masur 4 - BINA Mung 5, T_4 - PRC + BARI Masur 5 - BINA Mung 5, T_5 - PRC + BARI Masur 6 - BINA Mung 5, T_6 - PRC + BINA Masur 2 - BINA Mung 5 and T_7 - PRC + BINA Masur 3 - BINA Mung 5

CONCLUSION

Although onion intercropping can give higher economic return, the input is costly for the marginal farmers of Bangladesh. Therefore, this commonly practiced method can be recommended for specific for the farmers who can provide higher input having higher benefit. On the other hand, among the tested lentil varieties BARI Masur 5 appeared as the best for intercropping with sugarcane for higher economic return. This variety has short field duration and therefore, permits growing mungbean earlier. Thus, lentil variety BARI Masur 5 could be selected for lentil – mungbean sequential intercropping in paired row sugarcane for sustainable sugarcane production and maintaining soil fertility.

REFERENCES

Abdullah M, Alam MA, Rahman MA, Siddiquee MNA (2006) Evaluation of tobacco intercropping as botanical pesticides in controlling borer pests in sugarcane. *Bangladesh J. Sugarcane*. 28, 9-13.

Ahmed T, Bashar MK, Biswas MM, Abdullah M, Kashem MN, Rahman MK (2007) Performance of sugarcane with double intercrops in Tista Meander Floodplain Soils. *Bangladesh J. Sugarcane*. 29, 56-59.

Alam MJ, Hossain MS, Islam AKMR, Rahman MK, Kabir ML (2007) Productivity of sugarcane with wheat-mungbean intercropping combination under paired row planting system. *Bangladesh J. Sugarcane.* 29, 79-84.

Alam MJ, Hossain MS, Islam AKMR, Rahman MK, Kabir ML (2008) Performance of jute varieties for seed production as first and mungbean as second intercrop under transplanted cane in paired row. *Bangladesh J. Sugarcane*. 30, 116-121.

Anonymous (1970) Laboratory Manual for Queensland Sugar Mills (5^{th} edition). Published by Watwon, Ferguson and Co. Brisbane. pp. 94-143.

Anonymous (1979) Annual report (Special issue) 1973-78. Sugarcane Res. Inst. pub. No. 5. pp. 23-88.

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

BBS (2010) Statistical Year Book of Agricultural Statistics of Bangladesh. Planning Division, Ministry of Planning. Government of the Peoples' Republic of Bangladesh. p. 122.

De R, Singh SP (1979) Management practices for intercropping system. *In: Proc.* Int. Workshop on intercropping. ICRISAT, Hyderabad, India 10-13 Jan. pp. 17-21.

FAO (2011) Food and Agricultural Organization of the United Nations: Economic and Social Department: The Statistical Division. p. 567.

FAO (2012) Production Year Book. Food and Agricultural Organization of the United Nations, Rome. 36, 178-179.

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

Gani MO, Paul SK (2005) Sustainability of sugarcane cultivation through paired row planting system with wide spacing and double intercropping. *Bangladesh J. Sugarcane*. 24-27: 26-32.

Gergawi ASS, Salama MA (1994) Intercropping of autumn planted sugarcane with chickpea and lentil in middle Egypt. *Assiut-J. Agril. Sci*. 25(5), 47-56.

Gill MB, Nazir MS, Saeed M, Afghan S (1994) Agro economic studies on lentil intercropping in autumn sugarcane planted on flat and in pits. *Pakistan Sugar J*. 8(4), 11-16.

Hossain AHMD (1984) Intercropping with reference to sugarcane cultivation in Bangladesh. M.Sc. (T.A.D.) Thesis. University of Reading, England. p. 121.

Hossain AHMD, Rahman MK, Kabir ML, Matin MA, Alam MJ (1995) Performance of soybean and some other crops as intercrops with paired row transplanted sugarcane. *Bangladesh J. Sugarcane.* 17, 119-122.

Imam SA, Hossain AHMD, Sikka LK, Midmore DJ (1990) Agronomic management of potato/sugarcane intercropping and its economic implications. Field Crops Research, 25, 111-122.

Imran M, Ali A, Waseem M, Tahir M, Mohsin AU, Shehzad M, Ghaffari A, 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.

Islam AKMR, Hossain MS, Alam MJ, Rahman MK, Haque MA, Kabir ML (2009) Yield of different winter crops with cane as first and mungbean as second intercrop in rainfed condition under paired row planting system. *Bangladesh J. Sugarcane*. 31, 38-44.

Khan NU, Rahman MH, Kabiraj RC, Islam MA, Paul GC (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.

Matin MA, Kabir ML, Alam MJ, Zaman AKMM (2001) Performance of winter vegetable and summer mung as intercrops with paired row transplanted sugarcane. *Bangladesh J. Sugarcane*. 23, 7-14.

Panwar BS, Singh BV, Shanna RC (1990) Feasibility of intercropping in autumn planted sugarcane. Indian Sugar. 39(10), 755-778.

Parashar KS, Arora PN, Sharma RP (1979) Effect of short duration winter vegetable as intercrop grown in autumn planted cane on the yield of millable juice quality and economics. Indian Sugar. 29(4), 217-223.

Umrani NK (1981) Intercropping for higher production of pulses. Indian Farming. 31(9), 25-30.

Yadava RL (1987) Soil fertility improvement through legumes in sugarcane. Fertilizer- News. 32(10), 29-31.