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EFFECT OF PLANTING ARRANGEMENTS ON PRODUCTIVITY OF COTTON + MUNGBEAN INTERCROPPING SYSTEMS

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Abstract

An experiment was conducted at the Cotton Research Farm, Sreepur, Gazipur during 2009-10 growing season to maximize the benefit of cotton + mungbean intercropping system through appropriate planting arrangement of component crops in the system. Performance of eight different planting arrangements, such as 1, 2, 3 and 4 rows of mungbean in between single row of cotton and 4, 5, 6 and 7 rows of mungbean in between paired row cotton ware compared against their sole cropping. Intercropping and mungbean density reduced individual yield of cotton and mungbean compared to their sole cropping but increased equivalent yield of both cotton and mungbean. The highest seed cotton (2951 kg ha^{-1}) and mungbean (3373 kg ha^{-1}) equivalent yield was recorded from the paired row cotton +4-row mungbean. The land equivalent ratio of the same combination indicated 31% yield advantage over sole cropping. The same plating arrangement also recorded the highest gross return (Tk. 118039 ha^{-1}), gross margin (Tk. 60220 ha^{-1}) and BCR (2.04). Thus, the panting arrangement of paired row cotton and 4 rows of mungbean could be grown for higher productivity and economic return in the system.

Introduction

Cotton is an industrial crop as well as cash crop to the farmer's in Bangladesh. The area and production of cotton in the country are limited compared to its annual demand of 4.2 million bales in 2011 (Anon., 2011; Adams *et al.*, 2011). To meet the demand vertical expansion is the appropriate option rather than horizontal one from the limited land resources of the country. Intercropping is the proven option of vertical expansion of cotton that can help to ensure both subsistence and disposable income to the farmers (Singh and Jodha, 1990). Long duration with initially slow growing cotton and short duration fast maturing mungbean appeared to be the most compatible companion crops in the intercropping system (Rao, 1991) and also been proved to be productive and economic in the tropical countries (Sayampol and Changsalak, 1997). The overall productivity in terms of cotton equivalent yield was generally higher in intercropping system than that in sole stand (Maitra *et al*., 2000).The productivity and efficiency of intercropping system depends, to a large extent, on the nature and extent of plant competition (Harper, 1977) and the spatial arrangement and densities of the component crops (Nataranjan, 1990). Aasim *et al.* (2008) revealed that paired row cotton seemed well compared to single row cultivation for easy harvesting and handling of intercrop without any damage to the base crop cotton.

Mungbean (*Vigna radiata*) is a short duration crop that matures at around 60-70 days, which could be fitted well in cotton + mungbean intercropping system. However, it is necessary to determine the optimum population of mungbean as a companion crop to minimize competition with the main cotton crop. This experiment was therefore, undertaken to determine the appropriate planting arrangement of both cotton and mungbean in order to achieve maximum productivity and economic return from cotton + mungbean intercropping system.

Materials and Methods

The experiment was conducted at the Cotton Research Farm, Sreepur, Gazipur during 2009-10 growing season. The site was high land and located in the centre of Madhupur Tract of agro-ecological zone (AEZ)-28. The soil of the experimental site belongs to the Salna series and is classified as Shallow Red-Brown Terrace type which falls under the order Inceptisols of soil taxonomy (Anon., 1988; Brammer, 1996). Experiment was laid out in randomized complete block design (RCBD) with three replications. The unit plot size was 5.4 m x 4.5 m. Eight different plating arrangements of cotton and mungbean were compared with paired row and single row sole cotton and sole mungbean. Cotton population was 100% of sole cropping in all arrangements but mungbean population was 28, 44, 56, 67, 78, 83 and 111% of sole mungbean. Cotton var. CB-10 and mungbean var. BUmung-4 were used for the experiment.

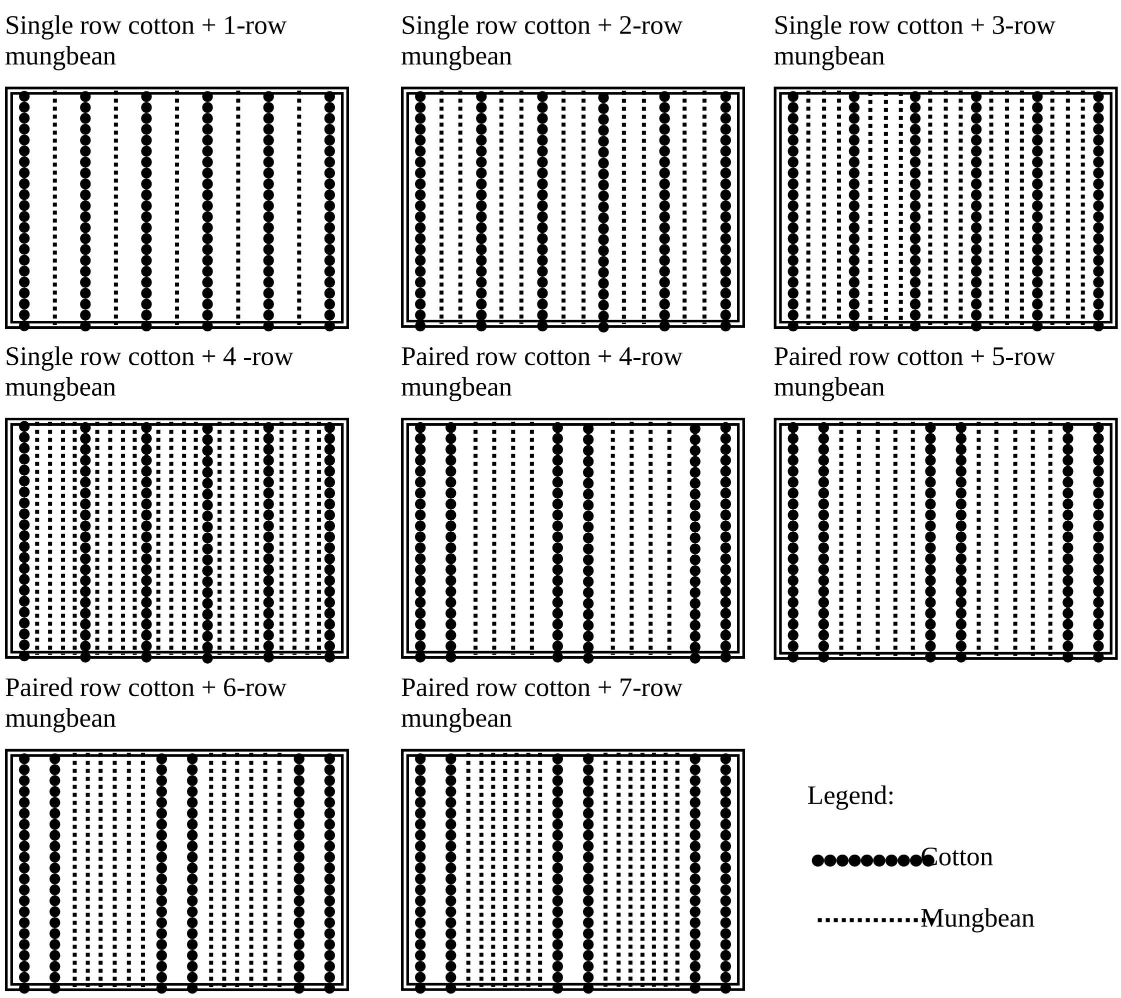

Fig. 1. Sketch of the different spatial arrangements of cotton and mungbean

All the treatments except sole mungbean was fertilized with 23-34-17.5-18-4.60-2.2-1.90 kg of N P K S Zn B and Mg ha^{-1}, respectively as urea, triple super phosphate, muriate of potash, gypsum, zinc sulphate, borax and magnesium sulphate. Additional three top dressing of 23 kg N each and 22.5-30-17.5 kg K were applied at 20, 40 and 60 days after sowing (Anon., 2009). Sole mungbean was fertilized at the rate of 23-17-18 kg of N P K ha^{-1}, respectively. Liming was done 25 days before sowing by using dolochun $CaMg(CO_3)_2$ at the rate of 2 tons ha^{-1} while 5 tons of cowdung ha^{-1} was incorporated with the soil at the time of final land preparation. Both cotton and mungbean were sown on 21 July 2009. Cotton and mungbean seeds were soaked into water for 3 hours just before sowing. The mungbean seeds were treated with Vitavex-200 at the rate of 3g kg^{-1} and cotton seed with gaucho at the rate of 5g kg^{-1}. Three seeds of cotton and 3-4 seeds of mungbean per hill were hand planted in dibbling method. Cotton took 5-7 days and mungbean took 3-5 days to emergence. Immediately after sowing light irrigation was given to ensure uniform crop emergence. Subsequent irrigation was also provided to avoid any moisture stress. Two times weeding, eight times insecticide spraying, two times hand picking of bollworm larvae were performed to keep the field free from pest. Mature mungbean pods were harvested at 55 and 65 DAS and mature seed cotton in three installments at 150, 165 and 180 DAS.

Data on agronomic traits of cotton and qualitative characters of cotton including fibre length, fibre strength, micronaire and ginning out turn was also recorded. Lint and seed yield was recorded after separation of seed and lint from seed cotton by using 'Lummus 20- saw' ginning machine. Fibre length, fibre strength and micronaire were measured by using Fibrograph instrument, Pressly meter and micronaire testing instruments, respectively. Data on yield and yield components of mungbean was measured at harvest from randomly selected plants. The productivity of cotton + mungbean intercropping system was assessed by land equivalent ratio (LER), monetary advantage index (MAI) and equivalent yield of cotton and mungbean by using the standard formula as well as cost and benefit analysis was also calculated. The data were analyzed statistically and means were separated by Least Significance Difference (LSD) test at 5% level of significance (Gomez and Gamez, 1984).

The formula used for different parameters are given below.

$$\text{Ginning outturn (\%)} = \frac{\text{Weight of lint}}{\text{Weight of seed cotton}} \times 100$$

Seed index = Weight of 100-seed

$$\text{Lint Index} = \frac{\text{Weight of lint}}{\text{Weight of seed}} \times \text{Seed index}$$

$$\text{Harvest index (HI\%)} = \frac{\text{Grain yield}}{\text{Total biological yield}} \times 100$$

$$\text{Land equivalent ratio (LER)} = \frac{\text{Intercrop yield of cotton}}{\text{Sole crop yield of cotton}} + \frac{\text{Intercrop yield of mungbean}}{\text{Sole crop yield of mungbean}}$$

$$\text{Monetary advantage index (MAI)} = \text{Value of combined intercrop} \times \frac{\text{(LER-1)}}{\text{LER}}$$

$$\text{Seed cotton equivalent yield} = \text{Intercrop yield of seed cotton (kg ha}^{-1}\text{)} + \frac{\text{Intercrop yield of mungbean (kg ha}^{-1}\text{)} \times \text{Selling price of mungbean}}{\text{Selling price of seed cotton (Tk)}}$$

$$\text{Mungbean equivalent yield} = \text{Intercrop yield of mungbean (kg ha}^{-1}\text{)} + \frac{\text{Intercrop yield of seed cotton (kg ha}^{-1}\text{)} \times \text{Selling price of seed cotton}}{\text{Selling price of mungbean (Tk)}}$$

Gross return (Tk. ha^{-1}) = Total yield (kg ha^{-1}) × Unit market price (Tk. kg^{-1})
Gross margin (Tk. ha^{-1}) = Gross return- Total variable cost

Benefit cost ratio (BCR) = Gross return / Total variable cost

Results and Discussion

Yield components and seed cotton yield

Number of sympods and monopods plant^{-1} in cotton

Number of sympods and monopods plant^{-1} varied with the variation in spatial arrangement of cotton and mungbean in intercropping systems (Table 1). Cotton under single row sole cropping produced the highest number of sympods plant^{-1} (17.97) but lowest number of monopods plant^{-1} (0.73), which was significantly different from intercropping treatments. Sympods plant^{-1} was decreased with increased in mungbean row number in between cotton rows and the lowest number of sympods plant^{-1} (8.67) was in single row cotton+4-row mungbean arrangement (T_7). But monopods plant^{-1} was increased with the increasing competition between component crops under intercropping systems and the highest was observed in single row cotton + 4-row mungbean arrangement (T_7). Higher number of branches plant^{-1} in sole cotton was also reported by Oad *et al.* (2007) under cotton + pigeaon pea intercropping system and Mahatale *et al.* (2008) in cotton based intercropping system.

Number of bolls plant^{-1} and single boll weight in cotton

Cotton yield was determined by the number of bolls plant^{-1} and single boll weight, which was significantly differed by the spatial arrangements of cotton and mungbean under cotton + mungbean intercropping systems (Table 1). Cotton under single row sole cropping produced the highest number of bolls plant^{-1} (28.73) and single boll weight (6.24 g) compared to other intercropping treatments. The spatial arrangement of densely populated and closer spacing produced lower number of bolls plant^{-1} and single boll weight. The lowest number of bolls plant^{-1} (14.60) and single boll weight (5.00 g) was recorded from single row cotton + 4-row mungbean (T_7). Higher number of bolls plant^{-1} under sole cropping was also reported by Oad *et al*. (2007) and reduced bolls weight from densely populated cotton was reported by Junior *et al.* (2003).

Seed cotton yield

Seed cotton yield is considered as economic yield, which is the function of number of bolls palnt^{-1} and single boll weight although it was considerably influenced by the variations in spatial arrangements of cotton and mungbean under cotton + mungbean intercropping systems (Table 1). The maximum seed cotton yield (2885 kg ha^{-1}) was recorded in single row sole cotton (T_1) followed by paired row sole cotton (T_2). Intercropping reduced the seed cotton yield by 2.43 to 30.16%. This yield reduction was occurred due to the competition for growth resources between component crops under intercropping systems. Under intercropping conditions, the highest seed cotton yield was recorded from the treatment of paired row cotton + 4-row mungbean (T_8) and the lowest (2015 kg ha^{-1}) single row cotton + 4-row mungbean arrangement (T_7). The reduction in seed cotton yield due to growing intercrops in association with cotton was also reported by Sanjay *et al.* (2003), Basavarajappa *et al.* (2003) and Khan *et al.* (2001).

Table 1. Seed yield and yield components of cotton as influenced by different planting arrangements of cotton and mungbean in intercropping systems

Treatments	No. of sympods plant^{-1}	No. of monopods plant^{-1}	No. of bolls plant^{-1}	Single boll weight (g)	Seed cotton yield (kg ha^{-1})
T_1	17.97	0.733	28.73	6.237	2885
T_2	16.87	0.900	25.27	6.187	2639
T_4	16.33	1.267	23.50	5.940	2543

T_5	15.43	1.533	20.70	5.800	2520
T_6	10.07	2.133	18.33	5.163	2280
T_7	8.667	2.500	14.60	5.000	2015
T_8	16.43	1.267	23.83	6.047	2575
T_9	15.50	1.433	23.07	5.917	2460
T_{10}	12.97	1.667	20.65	5.560	2343
T_{11}	11.20	1.967	19.20	5.467	2292
LSD $_{(0.05)}$	1.07	0.23	1.77	0.196	132.80
CV (%)	4.40	8.59	4.73	2.01	3.16

T_1=Sole single row cotton, T_2= Sole paired row cotton, T_4= Single row cotton+1-row mungbean, T_5= Single row cotton+2-row mungbean, T_6= Single row cotton+3-row mungbean, T_7= Single row cotton+4-row mungbean, T_8= Paired row cotton+4-row mungbean, T_9= Paired row cotton+5-row mungbean, T_{10}= Paired row cotton+6-row mungbean, T_{11}= Paired row cotton+7-row mungbean.

Yield and yield components of mungbean

Number of pods plant^{-1}, single pod weight, number of seeds pod^{-1} and 1000-seed weight is an important attribute of yield in grain legumes. These attributes are varied significantly with the variations in spatial arrangements of cotton and mungbean (Table 2). Mungbean under sole cropping (T_3) recorded the highest number of pods plant^{-1} (26.27), single pod weight (0.70 g), number of seeds pod^{-1} (12.93) and 1000-seed weight (43.70 g). All the yield components were reduced with increasing mungbean density in closer spatial arrangements under intercropping systems. The lowest number of pods plant^{-1} (15.40), single pod weight (0.48 g), number of seeds pod^{-1} (10.43) and 1000-seed weight (34.88 g) was recorded from the treatment of single row cotton+4-row mungbean (T_7). Similar result of the highest number of pods plant^{-1}, seeds pod^{-1} and 1000-seed weight from sole cropping compared to intercropped mungbean was reported by Khan *et al.* (2012).

Harvest index in mungbean

Variations in spatial arrangements of cotton and mungbean in intercropping systems significantly affected the harvest index of mungbean (Table 2). The highest harvest index (33.64%) was found in sole cropping while lowest harvest index (16.72%) was recorded from the single row cotton + 4-row mungbean (T_7). Bhatti *et al.* (2008) reported a higher harvest index in sole mungbean than the intercropped mungbean.

Seed yield

Seed yield in mungbean was found to be varied with the variations in spatial arrangements of cotton and mungbean in intercropping systems (Table 2). Sole cropping of mungbean showed superiority in seed yield (1322 kg ha^{-1}), which was significantly different from other treatments due to the highest number of pods plant^{-1}, single pod weight, seed pod^{-1}, 1000-seed weight and plant population. Under intercropping condition the highest seed yield was found in paired row cotton + 7-row mungbean (T_{11}). Crop competition in densely populated spatial arrangement reduces seed yield in mungbean and the lowest seed yield (301.7 kg ha^{-1}) was recorded from the treatment of single row cotton + 1-row mungbean (T_4). Onuh *et al.* (2011) recorded the highest seed yield from the sole mungbean compared to the intercrop mungbean.

Table 2. Seed yield and yield components of mungbean as influenced by different spatial planting arrangements of cotton and mungbean intercropping systems

Treatments	No. of pods plant^{-1}	Single pod weight (g)	No. of seeds pod^{-1}	1000-seed weight (g)	Harvest index (%)	Seed yield (kg ha^{-1})
T_3	26.27	0.700	12.93	43.70	33.64	1322.0

T_4	23.60	0.583	12.37	41.28	21.87	301.7
T_5	19.87	0.576	11.47	38.70	23.05	453.0
T_6	16.80	0.503	11.23	35.85	20.13	566.0
T_7	15.40	0.483	10.43	34.88	16.72	526.7
T_8	23.67	0.620	12.47	41.36	29.55	441.0
T_9	21.53	0.580	11.77	39.73	21.12	472.0
T_{10}	19.07	0.556	11.40	38.51	20.17	519.0
T_{11}	18.40	0.530	11.27	37.90	20.80	571.0
LSD $_{(0.05)}$	2.05	0.017	0.59	1.92	3.66	76.21
CV (%)	5.78	3.76	2.92	2.84	9.18	7.66

T_3= Sole mungbean, T_4= Single row cotton+1-row mungbean, T_5= Single row cotton+2-row mungbean, T_6= Single row cotton+3-row mungbean, T_7= Single row cotton+4-row mungbean, T_8= Paired row cotton+4-row mungbean, T_9= Paired row cotton+5-row mungbean, T_{10}= Paired row cotton+6-row mungbean, T_{11}= Paired row cotton+7-row mungbean.

Gin and fibre quality of cotton

Gin properties

Gin properties of cotton was determined by GOT, seed index and lint index and these properties were significantly varied with the variations in spatial arrangements of cotton and mungbean in intercropping systems (Table 3). Cotton under sole cropping showed better performance in GOT (38.07%), seed index (10.67g) and lint index (6.81g). The spatial arrangement of single row cotton + 4-row mungbean (T_7) was found lowest GOT (30.12%), seed index (7.87g) and lint index (3.52g) of cotton. The reasons for that reduction may be due to the intercropping and spatial arrangements.

Fibre quality of cotton

Fibre length, strength and micronaire are the measure of fibre quality of cotton and which was significantly affected by the different spatial arrangements of cotton and mungbean in intercropping systems (Table 3). Cotton under sole cropping showed better in fibre length (2.81 cm), fibre strength (84.92) and micronaire value (4.53) compared to intercrop. The lowest fibre length (2.60 cm), poor strength and low micronaire were measured in cotton under single row cotton+4-row mungbean (T_7). The result indicated that the increase in plant density, decreasing the fibre length, strength and micronaire in cotton.

Table 3. Gin and fibre quality of cotton as influenced by different spatial arrangements of cotton and mungbean under intercropping systems

Treatments	GOT (%)	Seed index (g)	Lint index (g)	Fibre length (cm)	Fibre strength (PSI)	Micronaire value
T_1	38.07	10.67	6.810	2.81	84.92	4.533
T_2	37.76	10.50	6.580	2.80	84.60	4.433
T_4	35.11	10.11	5.680	2.72	83.69	4.400
T_5	33.57	9.757	5.130	2.66	83.09	4.400
T_6	31.98	8.407	4.063	2.62	82.78	4.100
T_7	30.41	7.867	3.523	2.60	82.73	4.067
T_8	36.24	10.15	6.053	2.73	84.23	4.433
T_9	34.19	9.817	5.303	2.70	83.50	4.400
T_{10}	30.12	9.607	4.297	2.65	82.92	4.367

T_{11}	32.78	9.563	4.797	2.64	82.87	4.267
$LSD_{(0.05)}$	2.86	0.597	0.80	0.15	1.86	0.31
CV%	4.91	3.61	8.94	3.39	1.30	4.90

T_1=Sole single row cotton, T_2= Sole paired row cotton, T_4= Single row cotton+1-row mungbean, T_5= Single row cotton+2-row mungbean, T_6= Single row cotton+3-row mungbean, T_7= Single row cotton+4-row mungbean, T_8= Paired row cotton+4-row mungbean, T_9= Paired row cotton+5-row mungbean, T_{10}= Paired row cotton+6-row mungbean, T_{11}= Paired row cotton+7-row mungbean

Assessment of intercrop productivity

Land equivalent ratio

The land equivalent ratio (LER) is the main index of intercropping advantage and intercrop productivity. The LER varied significantly due to the variations in spatial arrangements of cotton and mungbean in intercropping systems (Table 4). The highest LER (1.31) was recorded in paired row cotton + 4-row mungbean (T_8) and the lowest (1.10) from single row cotton+4-row mungbean (T_7). Yield advantages in intercropping system over sole cropping was also reported by Eskandari (2012), Das *et al.* (2012) and Islam *et al.* (2004).

Equivalent yield

Intercrop productivity was evaluated by the equivalent yield of the component crops. The highest seed cotton (2951 kg ha^{-1}) and mungbean equivalent yield (3373 kg ha^{-1}) was achieved from the treatment of paired row cotton + 4-row mungbean (T_8) and the lowest seed cotton (2475 kg ha^{-1}) and mungbean (2829 kg ha^{-1}) from single row cotton + 4-row mungbean (T_7). The result indicated a definite yield and intercropping advantage with paired row cotton+4-row mungbean in intercropping systems. Islam *et al.* (2004) also found the highest maize equivalent yield from maize paired row plus four rows of bushbean combination in maize + bushbean intercropping system. Higher equivalent yield under intercropping situation than that of sole crops was also reported by Patel *et al.* (2010), Das *et al.* (2012) and Ali *et al.* (2007).

Monetary advantage index

Another productivity indices monetary advantage index (MAI) significantly varied due to the variations in spatial arrangements of cotton and mungbean in intercropping systems (Table 4). The highest MAI (27670) was calculated from the treatment of paired row cotton + 4-row mungbean (T_8) and the lowest MAI (8931) was found in single row cotton + 4-row mungbean ($T_{7)}$. The result indicated that paired row cotton is advantageous over single row in intercropping situation and 4-row mungbean in between paired row cotton performed the best in terms of MAI. Aasim *et al.* (2008) also revealed that positive monetary index obtained from intercropping cotton with cowpea and sorghum.

Table 4. Land equivalent ratio (LER), equivalent yield of cotton and mungbean and monetary advantage index (MAI) as influenced by different spatial arrangements in intercropping systems

Treatments	LER	Seed cotton equivalent yield kg ha^{-1}	Mungbean equivalent yield kg ha^{-1}	MAI
T_1	1.00	2885	3297	-
T_2	1.00	2639	3016	-
T_3	1.00	1156	1322	-
T_4	1.11	2807	3208	11030
T_5	1.22	2916	3333	20800
T_6	1.22	2776	3172	20010
T_7	1.10	2475	2829	8931

T_8	1.31	2951	3373	27670
T_9	1.29	2857	3265	25290
T_{10}	1.28	2797	3197	24550
T_{11}	1.30	2791	3190	25790
$LSD_{(0.05)}$	0.05	145.40	166.20	5825
CV%	2.70	3.23	3.23	16.22

T_4= Single row cotton+1-row mungbean, T_5= Single row cotton+2-row mungbean, T_6= Single row cotton+3-row mungbean, T_7= Single row cotton+4-row mungbean, T_8= Paired row cotton+4-row mungbean, T_9= Paired row cotton+5-row mungbean, T_{10}= Paired row cotton+6-row mungbean, T_{11}= Paired row cotton+7-row mungbean.

Market price (Tk kg^{-1}): Seed cotton-40/-, Mungbean-35/-

Economic evaluation

Monetary advantages obtained from different spatial arrangements of cotton and mungbean in intercropping systems varied significantly (Table 5). Higher values of gross return (Tk.118039 ha^{-1}), gross margin (Tk.60220 ha^{-1}) and BCR (2.04) obtained from paired row cotton + 4-row mungbean (T_8) than the sole cropping. Under intercropping systems, single row cotton + 4-row mungbean (T_7) showed lower values of gross return (Tk. 88270 ha^{-1}), gross margin (Tk. 26930 ha^{-1}) and BCR (1.44). The result of the present study was supported by the findings of Sankaranarayanan *et al.* (2010) in cotton with vegetables and legumes and Bhatt *et al.* (2010) in cotton + sesame intercropping system. Higher economic returns from intercropping compared to monocropping was also reported by Macuacua and Santos (2007).

Table 5. Total cost, gross return, gross margin and benefit cost ratio (BCR) as influenced by different spatial arrangements of cotton and mungbean in intercropping systems

Treatments	Total cost (Tk. ha^{-1})	Gross return (Tk. ha^{-1})	Gross margin (Tk. ha^{-1})	Benefit cost ratio
T_1	59830	115407	55570	1.93
T_2	57380	105576	48190	1.84
T_3	26100	46258	20150	1.77
T_4	59840	112277	52440	1.87
T_5	60370	116655	56290	1.93
T_6	60840	111022	50180	1.82
T_7	61340	88270	26930	1.44
T_8	57810	118039	60220	2.04
T_9	58390	114269	55880	1.96
T_{10}	58560	111889	53330	1.90
T_{11}	58750	111652	52900	1.90
$LSD_{(0.05)}$	502.2	11010	10930	0.1942

T_1=Sole single row cotton, T_2= Sole paired row cotton, T_3= Sole mungbean, T_4= Single row cotton+1-row mungbean, T_5= Single row cotton+2-row mungbean, T_6= Single row cotton+3-row mungbean, T_7= Single row cotton+4-row mungbean, T_8= Paired row cotton+4-row mungbean, T_9= Paired row cotton+5-row mungbean, T_{10}= Paired row cotton+6-row mungbean, T_{11}= Paired row cotton+7-row mungbean.

Market price (Tk kg^{-1}): Seed cotton- 40/-, Mungbean- 35/-

Conclusion

Based on the results of the present experiment it was concluded that paired row cotton + 4-row mungbean was the best combination in relation to LER, equivalent yield, monetary advantage index, economic returns and benefit cost ratio.

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