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Intercropping of carrot and bush bean with maize at different planting systems

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Abstract

Performance of carrot and bush bean under intercropping systems with maize at different planting systems was studied in two successive rabi seasons (2001-2003) to find out suitable crop combination and planting systems. Maize was grown as normal and paired row systems. One and two rows of carrot as well as bush bean were grown with normal row maize while 3 and 4 rows of carrot as well as bush bean in paired row maize. Maize gave higher grain yield when grown with bush bean than that of carrot in both the years. Carrot and bush bean yield were greatly influenced by the planting systems. In both the years, the highest carrot yield was obtained when 2 rows of carrot were grown in the inter-row space of normal maize rows. But the highest bush bean yield was obtained when 4 rows of bush bean were grown in the inter-row space of two pairs of maize rows and this combination also gave the highest benefit cost ratio. The results suggested that bush bean is more compatible with maize than carrot and 4 rows of bush bean with maize in paired row planting system is feasible for higher economic return.

Keywords: Maize, Carrot, Bush bean, Intercropping and Yield

Introduction

Intercropping is widely practiced in tropical and subtropical regions. It increases total productivity of unit area through maximum utilization of land, labor and growth resources (Quayyum *et al.*, 1999; Craufard, 2000; Faruque *et al.*, 2000). Usually plants differing in growth duration, height, root systems and nutrient requirements are considered to grow together in intercropping systems to maximize complementarity between the component crops and minimize intercrop competition (Reddy and Willey, 1981; Marshal and Willey, 1983). Complementarity can occur when the growth patterns of the component crops differ in time so that the crops make their major demands on resources at different times. Spatial complementarity is also possible. Combined leaf canopy may make better spatial use of light, or combined root systems may make better spatial use of nutrients and water (Willey, 1979). Variation in root systems of the component crops can exploit different soil layer for nutrient. In cereal-legume intercropping, legume component is capable of fixing atmospheric nitrogen that can reduce the competition for N with the cereal component (Trenbath, 1986).

Farmers can choose cereal/legume or cereal/non-legume combination according to their demand. They can manipulate plant population and planting geometry to reduce the competition and increase complementarity between component crops for growth resources. Maize is an important cereal crop in Bangladesh and it is mainly used as poultry feed. With the development of poultry industry, the demand of maize is increasing day by day. Maize is a long duration tall statured wide-spaced cereal crop. With or without modification of planting geometry, inter-row space of maize can be used for growing short duration vegetable (eg. carrot) or legume (eg. bush bean). Several studies have showed the advantage of maize based intercropping elsewhere in the world (Wahua, 1985; Shivay *et al.*, 1999; Santalla *et al.*, 2001). In the present study carrot and bush bean were intercropped with maize focusing mainly on compatibility of the component crops, row arrangement and planting geomets to find out suitable intercrop combination and planting geometry.

Materials and Methods

The experiment was conducted at the Farm of Central Research Station of BARI, Joydebpur, Gazipur during the rabi season of 2001-2002 and 2002-2003. The soil was slightly clay loam belonging to the Chhiata Series under Agro-Ecological Zone-28 (AEZ-28). Soil of the experimental plots prior to experiment was collected and analyzed for some physical and chemical properties. The soil was slightly acidic (pH 6.10), having organic matter 0.99%, total nitrogen 0.062%, phosphorus 25 µg/ml, potassium 0.09 meq/100ml, available sulphur 12 µg/ml and zinc 7 µg/ml. The amount of rainfall received during cropping periods were 168 mm in 2001-02 and 119 mm in 2002-03. The mean monthly maximum temperatures were 31.96 and 33.93 °C, and the mean minimum temperatures were 13.09 and 10.06 °C in 2001-02 and 2002-03, respectively. Eight treatments were tested in randomized complete block design with three replications. The treatments were as follows:

T_1 = Maize paired row + 3 rows of carrot
T_2 = Maize paired row + 4 rows of carrot
T_3 = Maize normal row + 1 row of carrot
T_4 = Maize normal row + 2 rows of carrot
T_5 = Maize paired row + 3 rows of bush bean
T_6 = Maize paired row + 4 rows of bush bean
T_7 = Maize normal row + 1 row of bush bean
T_8 = Maize normal row + 2 rows of bush bean

Advantage of intercropping over sole cropping is well established. But in the present study, no sole crop treatment was included as compatibility of the intercrops (carrot and bush bean) with maize was under investigation. The unit plot size was 4.5m x 4m. Seeds of maize, carrot and bush bean were sown on November 25, 2001 and December 2, 2002. Maize variety BARI-hybrid maize-1 was used in the 1st year. But in the 2nd year due to scarcity of BARI-hybrid maize-1 seed, Pacific-988 was used. In maize normal row planting systems, inter-row distance was 75 cm while in paired row planting systems, inter-row distance within paired rows was 37.5 cm but inter-row distance from one paired rows to another paired rows was 150 cm. In both planting systems, plant to plant distance was 25 cm. Fertilizers were applied at the rate of 250-120-120-40 kg/ha N, P_2O_5, K_2O and S as urea, triple super phosphate (TSP), muriate of potash (MP) and gypsum. One third of N and whole amount of TSP, MP and gypsum were applied as basal. Remaining 2/3rd N was top-dressed in two equal splits only in maize rows at 30 and 55 days after sowing. After seed sowing, a light irrigation was given for proper emergence of the plants. Subsequently two more irrigations were done at 30 and 55 DAS (i.e. at the tome of urea split application). Two hand pickings were done for bush bean, first at 70 days after sowing (DAS) and final at 80 DAS. Carrot and maize were harvested at 102 and 146 DAS, respectively. The yield component data for each crop was collected from 5 randomly selected plants prior to harvest from each plot. At harvest, the yield data were recorded plot wise.

Maize equivalent yield (MEY) in different treatments were computed by converting yield of intercrops on the basis of prevailing market price of the individual crops according to the formula of Bandyopadhyay (1984).

$$\text{Maize equivalent yield} = \text{Yim} + \frac{\text{Yib x Pb}}{\text{Pm}}$$

Where,

Yim	= Yield of maize in intercrop plots
Yib	= Yield of carrot/bush bean in intercrop plots
Pm	= Selling price of maize
Pb	= Selling price of carrot/bush bean

Economic analyses of different treatments were done to assess the economic productivity of the intercropping systems. The data were analyzed statistically and mean separation was done by DMRT.

Results and Discussion

Yield and yield contributing characters

Maize: The number of grains per cob, 1000-grain weight and grain yield were significantly influenced by planting systems in 2001-2002, but not in 2002-2003 (Table 1). In the first year, the higher number of grains per cob was observed in T_5 treatment (maize paired row + 3 rows bush bean) which was statistically identical to treatment T_4, T_6, T_7 and T_8. Though grains per cob were not significantly influenced by different planting systems, higher number of grains per cob was recorded in 2001-02 due to change of variety. Almost similar trend was observed in 1000-grain weight. Higher grain yield was obtained from the treatment T_5, which was at par with the treatments T_6, T_7 and T_8 where bush bean was intercropped with maize. The grain yield of maize in different combinations with bush bean was identical, which was markedly higher than maize-carrot combinations. Plant height, number of grains per cob and 1000-grain weight did not follow any definite trend in the second year, but comparatively higher grain yield was recorded in maize-bean combination due to combined effect of higher number of cobs per plant, grains per cob and 1000-grain weight. The grain yield of maize in different treatments in the second year was higher than first year due to high potential of Pacific-988. Stover yields in different treatments were statistically identical in both the years. However, comparatively higher stover yield was recorded in maize-bean combination than that of maize-carrot combination. Over the years, maize showed better performance with bush bean than carrot. Better performance of maize in association with bush bean might be due to addition of N in to the soil through fixation by bush bean (Patra *et al.*, 1990; Midmore, 1993). The results indicate that being a legume crop bush bean might have a complementary relationship with maize, whereas carrot had a competitive relationship.

Carrot: Root length, root diameter and root yield per plant did not vary significantly due to variations in planting systems but only yield per hectare was significantly influenced by the same in both the years (Table 2). Though yield attributes of carrot were statistically identical, higher yield attributes were recorded in 2002-03 due to higher root length and diameter. The highest root yield was recorded from the treatment T_4 (maize normal row + 2 rows carrot) in 2001-02. In 2002-03, higher root yield was obtained from the treatment T_4 that was statistically identical to treatment T_2. Higher root yield in T_4 and T_2 were attributed due to more number of roots per unit area. Similar trend of yield was observed in both the years.

Bush bean: Planting systems had no significant influence on pod length in both the years (Table 3). However, the number of pods per plant was significantly influenced by planting systems in the 1st year, which was statistically identical to second year. In general, bush bean with maize paired row planting system showed higher number of pods per plant than bush bean with maize normal row planting system. It might be due to the reason that bush bean got wider space (150 cm) in paired row planting system that allowed more light for better growth of bush bean. The similar trend was followed in pod yield per plant. The highest pod yield per plant was observed in maize paired row + 4 rows bush bean (T_6), while the lowest was found in maize normal row + 2 rows bush bean (T_8). Planting systems showed significant influence on the pod yield per hectare in both the years. Over the years, the highest pod yield was obtained from T_6 treatment and the lowest was found in T_5 treatment (maize paired row + 3 rows bush bean). The pod yields of T_7 (maize normal row + 1 row bush bean) and T_8 (maize normal row + 2 row bush bean) were identical in both the years.

Table 1. Yield and yield attributes of maize in intercropping with carrot and bush bean

Treatments	Plant height (cm)		No. of cobs/plant		No. of grains/cob		1000-grain weight (g)		Grain yield (t/ha)		Stover yield (t/ha)	
	2001-2002	2002-2003	2001-2002	2002-2003	2001-2002	2002-2003	2001-2002	2002-2003	2001-2002	2002-2003	2001-2002	2002-2003
T_1	171.47	172.73	1.00	1.13	348bcd	497.60	304c	338.37	5.48d	7.90	6.93	9.96
T_2	166.00	174.93	1.02	1.20	342d	460.00	324ab	340.09	5.78cd	7.07	7.35	8.93
T_3	168.73	160.40	1.04	1.13	344cd	487.73	314bc	342.28	5.89cd	7.85	7.35	9.81
T_4	172.73	173.27	1.00	1.13	386ab	451.47	319bc	339.45	5.86bcd	7.74	7.75	9.63
T_5	171.40	173.47	1.01	1.27	390a	545.60	336a	330.29	6.57a	8.22	8.23	10.12
T_6	172.33	170.00	1.02	1.20	384abc	497.33	327ab	335.93	6.5ab	8.17	8.31	10.15
T_7	166.53	176.00	1.02	1.27	374a-d	488.00	318bc	333.36	6.28abc	8.15	8.01	10.13
T_8	165.40	167.40	1.01	1.33	377a-d	549.33	325ab	332.01	6.09a-d	8.33	7.90	10.37
F-test	NS	NS	NS	NS	*	NS	**	NS	*	NS	NS	NS
CV (%)	3.4	5.00	2.60	12.0	5.90	15.1	2.70	3.00	5.50	11.9	5.50	10.4

*, ** and NS indicate significant at 5%, 1% levels and not significant, respectively. Columns with same letters are not different statistically

T_1 = Maize paired row + 3 rows of carrot
T_2 = Maize paired row + 4 rows of carrot
T_3 = Maize normal row + 1 row of carrot
T_4 = Maize normal row + 2 rows of carrot
T_5 = Maize paired row + 3 rows of bush bean
T_6 = Maize paired row + 4 rows of bush bean
T_7 = Maize normal row + 1 rows of bush bean
T_8 = Maize normal row + 2 rows of bush bean

Table 2. Yield and yield attributes of carrot in intercropping with maize

Treats.	Root length (cm)		Root dia (cm)		Root yield (g/plant)		Root yield (t/ha)	
	2001-2002	2002-2003	2001-2002	2002-2003	2001-2002	2002-2003	2001-2002	2002-2003
T_1	9.02	11.47	6.73	6.50	61.67	63.50	4.84c	5.63b
T_2	9.73	10.00	6.83	7.34	61.67	62.33	5.85b	6.22ab
T_3	9.07	10.47	6.57	7.65	55.33	59.17	3.40d	3.92c
T_4	9.73	10.67	6.50	6.87	54.33	59.00	6.93a	7.00a
F-test	NS	NS	NS	NS	NS	NS	**	**
CV (%)	7.70	9.4	5.10	9.2	6.60	2.9	4.70	7.0

** indicate significant at 1% level. NS indicate not significant. Columns with same letters are not different statistically

Table 3. Yield and yield attributes of bush bean in intercropping with maize

Treats.	Pod length (cm)		Pods/ plant		Green Pod yield (g/plant)		Green Pod yield (t/ha)	
	2001-2002	2002-2003	2001-2002	2002-2003	2001-2002	2002-2003	2001-2002	2002-2003
T_5	11.10	11.67	12.20a	12.13	71.92ab	68.21ab	3.61c	3.54c
T_6	10.52	11.67	13.00a	12.87	83.63a	76.08a	5.07a	4.96a
T_7	11.12	11.47	11.67ab	10.73	66.31b	64.04b	4.15bc	4.11b
T_8	10.90	12.27	10.00b	11.73	62.10b	60.37b	4.55ab	4.42b
F-test	NS	NS	*	NS	**	*	**	*
CV (%)	4.50	8.10	8.20	8.80	8.60	7.10	6.50	4.3

* and ** indicate significant at 5 and 1% level, respectively. NS indicate not significant. Columns with same letters are not different statistically

T_1 = Maize paired row + 3 rows of carrot
T_2 = Maize paired row + 4 rows of carrot

T_3 = Maize normal row + 1 row of carrot
T_4 = Maize normal row + 2 rows of carrot

T_5 = Maize paired row + 3 rows of bush bean
T_6 = Maize paired row + 4 rows of bush bean

T_7 = Maize normal row + 1 rows of bush bean
T_8 = Maize normal row + 2 rows of bush bean

Maize equivalent yield (MEY): Higher MEY was obtained from treatment T_4 which was closely followed by treatment T_6 (Table 4). Similar trend was followed in both the years. MEY variation was mainly due to the number of rows of carrot/bush bean in maize intercropping system. Bhuiyan *et al.* (1999) also reported highest maize equivalent yield in maize-bush bean combination.

Cost benefit analysis: Higher gross return was recorded from the treatment T_4 (maize normal row + 2 rows carrot) in 2000-01 due to higher root yield of carrot though grain yield of maize was much lower than the other treatments involving bush bean in the system (Table 4). Similar trend was observed in 2001-2002, but closely followed by treatment T_6. Higher gross return as well as higher cost of cultivation was recorded from treatment T_4. Accordingly net return was higher in treatment T_4 in both the years; however, due to higher production cost it gave lower BCR in comparison to T_6. Highest BCR was recorded from treatment T_6 (maize paired row + 4 rows bush bean) in both the years.

On an average, over the years the highest benefit cost ratio was obtained from treatment T_6; where 4 rows of bush bean were intercrooped with maize paired row. The results are in agreement with the findings of Saha *et al.* (2001) in maize-mungbean intercropping systems. From the above results it is revealed that 4 rows of bush bean with maize paired row planting system is suitable for higher economic benefit as well as helpful for the improvement of soil by inclusion of legume in the system.

Table 4. Cost and return analysis of maize/carrot/bush bean intercropping systems

Treats.	MEY (t/ha)		Gross return (Tk/ha)		Total variable cost (Tk/ha)		Net return (Tk/ha)		Benefit Cost ratio.		Mean
	2001-2002	2002-2003	2001-2002	2002-2003	2001-2002	2002-2003	2001-2002	2002-2003	2001-2002	2002-2003	BCR
T_1	11.01	14.33	75705	105320	25829	25829	49876	79491	4.08	2.93	3.51
T_2	12.47	14.18	90935	103715	26347	26347	64588	77368	3.94	3.45	3.70
T_3	9.78	12.33	72105	91215	26701	26701	45404	64514	3.42	2.70	3.06
T_4	13.78	15.74	100335	114995	29103	29103	71232	85892	3.95	3.45	3.70
T_5	11.73	13.28	78985	98000	25389	25389	53596	72611	3.86	3.11	3.49
T_6	13.74	15.22	90215	111585	25799	25799	64416	85786	4.33	3.50	3.92
T_7	12.22	14.02	81260	103215	25999	25999	55261	77218	3.97	3.12	3.55
T_8	12.59	14.64	82980	107695	27699	27699	55281	79996	3.89	3.00	3.45

MEY= Maize Equivalent Yield
T_1 = Maize paired row + 3 rows of carrot
T_2 = Maize paired row + 4 rows of carrot
T_3 = Maize normal row + 1 row of carrot
T_4 = Maize normal row + 2 row of carrot
T_5 = Maize paired row + 3 rows of bush bean
T_6 = Maize paired row + 4 rows of bush bean
T_7 = Maize normal row + 1 rows of bush bean
T_8 = Maize normal row + 2 rows of bush bean

Local market Price:
Maize harvested grain : Tk. 7/kg
Maize Stover : Tk. 0.5/kg
Carrot : Tk. 8/kg
Bush bean : Tk.10/kg

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