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Suitability of intercropping red amaranth, coriander and radish with bottle gourd to intensify winter cropping systems

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ABSTRACT

A field experiment on intercropping of red amaranth, coriander and radish with bottle gourd was conducted at farmer's field of Netrakona and Mymensingh district during Rabi season of 2013-2014 and 2014-2015 to evaluate the performance of bottle gourd production and to increase land use efficiency. Four intercrop combinations such as 100% Bottle gourd + Red amaranth, 100% Bottle gourd + Coriander (leaf), 100% Bottle gourd + Radish (leaf) and Sole bottle gourd were used in the experiment. Results indicated that bottle gourd yield was reduced 5 to 20% due to the cultivation of companion crops (red amaranth, coriander and radish) but total productivity increased due to the contribution of companion crop. The highest bottle gourd yield (66.36 tha^{-1} in 2013-2014 and 47.42 tha^{-1} in 2014-2015) was obtained from sole cropping and the lowest yield (55.0 tha^{-1} in 2013-2014 and 39.73 tha^{-1} in 2014-2015) from 100% Bottle gourd + Radish (leaf) crop combination. The highest bottle gourd equivalent yield (79.63 tha^{-1} in 2013-2014 and 54.45 tha^{-1} in 2014-2015) was recorded from 100% Bottle gourd + Coriander (leaf) crop combination while the lowest bottle gourd equivalent yield (66.36 tha^{-1} in 2013-2014 and 47.42 tha^{-1} in 2014-2015) was calculated from sole bottle gourd. The treatment, 100% Bottle gourd + Coriander (leaf) also gave the highest gross margin (Tk. 199650 ha^{-1} in 2013-2014, Tk. 359380 ha^{-1} in 2014-2015) and highest BCR (2.07 in 2013-2014 and 2.94 in 2014-2015). In both the years, the lowest gross margin (Tk.148895 ha^{-1}, Tk. 292366 ha^{-1}) and BCR (1.81 and 2.61) was recorded in sole cropping. Results revealed that coriander (leaf) might be suitable for intercropping with 100% Bottle gourd for higher productivity and economic return in the study areas.

Introduction

Intercropping is one of the techniques of vertical expansion of crop production that increase cropping intensity in developing countries like Bangladesh. In this system, two or more crops are grown together to increase productivity per unit area of land. Most intercropping research has focused on field crops (Tsubo et al. 2005; Ghosh et al. 2006). Intercropping vegetables with bottle gourd in tropical and subtropical regions is a way to grow a main crop while obtaining several benefits from the additional crop. It is the most appropriate cropping system for maintenance of soil productivity in the tropics (Ijoyah & Dzer, 2012), and ensures good soil cover throughout the year (Beets, 1990). These practices have been so interwoven in the socio-economic lives of peasant farmers (Sadashiy, 2004). The reason for the persistence of this practice is not only that gross returns per unit area of land are usually higher under intercropping than in sole cropping (Brintha & Seran, 2009), the system also offers the farmers insurance against crop failure, helps control erosion, weeds and insect infestation and brings about a more distribution of farm labour than sole cropping (Ali et al. 2000). There are also some socio-economic, biological and ecological advantages in intercropping over monocropping (Maluleke et al. 2005). Intercropping field crops with vegetables has been intensively investigated (Ahmed et al. 2006; El-Shaikh & Bekheet, 2004).

Bottle gourd (*Lagenaria siceraria*) is one of the most common and favorite cucurbit vegetable belonging to the family Cucurbitaceae. Bottle gourd is rich in fiber, essential minerals, iron and protein. It contains almost 96.1% water. So it is light on the stomach and aids digestion. A 100 g serving of bottle gourd contains only 12 calories. In Bangladesh, the annual production of bottle gourd is 166 thousand tons during 2011-2012 (BBS, 2012). Crop productivity may increase by cultivating short duration crop like red amaranth, coriander (leaf) and radish (leaf) with bottle gourd. It was observed that up to 40 days the canopy of the bottle gourd cannot cover the whole plot. Therefore, to utilize the land intensively this experiment was conducted to find out suitable crop combination for intercropping with bottle gourd for higher productivity and economic return.

Materials and Methods

The field experiment was carried out at Shamgonj, Netrakona and Langrabazar, Muktagacha, Mymensingh district of Bangladesh during Rabi season of 2013-2014 and 2014-2015. Four intercrop combinations viz., 100% bottle gourd + red amaranth (T_1), 100% bottle gourd + coriander (leaf) (T_2), 100% bottle gourd+ radish (leaf) (T_3) and Sole bottle gourd (T_4) were used. The trial was set up in a randomized complete block design with six replications. The unit plot size was 6 m × 2.5 m. Seeds of bottle gourd (*Lagenaria siceraria* var. BARI Lau 3), red amaranth (*Amaranthus gangeticus* var. BARI Lalshak 1), coriander (*Coriandrum*

sativum var. BARI Dhania 1) and radish (*Raphanus sativus* var. BARI Mula 1) were sown on same day i.e. 20 October, 2013 at Netrakona and 2 November 2014 at Mymensingh. Bottle gourd seeds were sown in pits whereas companion crops seeds were sown following broadcasting method. Distance between two pits was 2 m. Seed rate of bottle gourd, red amaranth, and radish were 5 kgha^{-1}, 2.5 kgha^{-1}, and 2.5 kgha^{-1}, respectively (BARI, 2006) and coriander seed rate for broadcasting method was 15 kg ha^{-1} (Mallik, 2010). Intercrops were sown in the whole plot excluding pit areas and therefore the approximate intercrop areas were 95%.

The soil of the experimental sites belongs to AEZ-9. Both the soils of the experimental site were acidic in nature and sandy loam in texture. Soil sample were collected and analyzed following standard method in the laboratory of Soil Science Division of BARI.

Table 1. Chemical properties of initial soil (0-15 cm depth) of the experimental field.

Location	pH	Organic matter (%)	Total N (%)	K (meq/ 100 g soil)	P	S	Zn	B
					µg/ g soil			
Shamgonj, Netrakona	5.5 Acidic	1.96 low	0.13 low	0.10 low	6.05 low	15.82 low	1.06 medium	0.25 low
Langrabazar, Muktagacha	6.0 Acidic	1.57 low	0.07 Very low	0.14 low	11.20 optimum	18.55 optimum	1.09 medium	0.29 medium

The crop was fertilized with N_{80} $P_{35}K_{75}S_{18}Zn_4B_2$ kg ha^{-1} + cowdung @ 10 tha^{-1}. The sources of N, P, K, S, Zn and B were urea, TSP, MoP, gypsum, zinc sulphate and boric acid, respectively. Entire cowdung, TSP, gypsum, zinc sulphate, boric acid and 2/6 of K were applied during pit making. Total amount of Urea and rest of MoP were applied in four equal installments at 15, 35, 55, and 75 days after transplanting. In 2013-2014 at Netrakona, farmers used additional compost manures and water hyacinth mulch different times at different growing stage of bottle gourd. They gave furrow irrigation as and when required. In 2014-2015 at Muktagacha, farmers gave mainly drip irrigation. All intercultural operations were done timely in both of the locations. Sex pheromone trap was used in both the year to control pest. Leaves of red amaranth, coriander and radish were harvested at 29, 35 and 38 days after sowing (DAS) in 2013-2014 and 32, 35 and 37 DAS in 2014-2015. In 2013-2014, first harvest of bottle gourd was on 21 January, 2014 and continued up to 17 April, 2014. In case of second year cultivation, first bottle gourd was harvested on 26 January, 2015 and it was continued up to 15 April, 2015. Data on yield and yield contributing characters were recorded plot wise and converted into tha^{-1}. Collected data were analyzed statistically with the help of MSTAT-C program and mean separation was done as per Least Significant Difference (LSD) test at 5% level of significance. Economic analyses were done to assess the economic productivity of the intercropping systems.

Bottle gourd equivalent yield (BEY) was calculated following the formula of Prasad and Srivastava (1991).

$$\text{BEY (t/ha)} = Y_{bg} + \frac{Y_{int} \times P_{int}}{P_{bg}}$$

Y_{bg} = Yield of main crop (bottle gourd), Y_{int} =Yield of intercrop vegetables, P_{int} = Market price of intercrop vegetables, P_{bg} = Market price of bottle gourd

Results and Discussion

Yield and yield components of Bottle gourd

Fruit length and breadth, fruits plant^{-1}, average fruit weight, fruit yield plant^{-1} and yield ha^{-1} as influenced by intercropping system (Table 2a & 2b). All the parameters in sole bottle gourd showed better performance over T_1, T_2 and T_3 crop combination. Fruit length varied from 33.70 to 35.52 cm in 2013-2014 and 32.93 to 37.35 cm in 2014-2015 while fruit breadth varied from 10.25 to 13.22 cm and 11.12 to 13.20 cm, respectively. Number of fruits plant^{-1} was significantly affected by the intercrop combinations in 2014-2015 but not in 2013-2014 (Table 2a). The number of fruits plant^{-1} ranged from 10.0 to 11.5 in 2013-2014 and 8.5 to 10.7 in 2014-2015. Similar trend was found in case of average fruit weight which is supported by the result of other researcher (Sit & Sirohi, 2002; Singh et al. 1998). Janakiram and Sirohi (1989) concluded that the increase in yields of hybrids was mainly due to fruits number per plant, single fruit weight and fruit size. The yield of fruit plant^{-1} varied significantly with different treatments in both the years. The highest fruit yield plant^{-1} (33.18 kg in 2013-2014 and 23.68 kg in 2014-2015) were recorded in sole bottle gourd. The lowest fruit yield plant^{-1} (27.50 kg in 2013-2014 and 18.87 kg in 2014-2015) were found in 100% bottle gourd + radish (leaf) intercrop combination.

Yield of bottle gourd ha^{-1} was significantly influenced by different treatment combinations in both the years (Table 2b). In 2013-2014 at Netrakona, the highest yield of bottle gourd (66.36 tha^{-1}) was found from sole cropping and it was statistically at par with T_2 but different from T_1 and T_3. In 2014-2015 at Muktagacha, Mymensingh, the highest bottle gourd yield (47.42 tha^{-1}) was obtained from T_4 and it was statistically identical with T_1 and T_2 but differed from T_3 intercrop combination. The lowest fruit yield (55.0 tha^{-1} in 2013-2014 and 39.73 tha^{-1} in 2014-2015) was found in 100% bottle gourd + radish (leaf) intercrop combination. Bottle gourd yield was reduced 5 to 20% due to cultivation of vegetables with bottle gourd. The results are in

agreement with the findings of earlier studies (Muoneke & Ndukwe, 2008; Manga et al. 2003).

Bottle gourd yield difference in these two years might be occurred due to change of locations as well as soil and climatic condition of the two sites. In 2013-2014 at Netrakona, farmers used compost manures along with chemical fertilization. Water hyacinth mulch and furrow irrigation were used. However, in 2014-2015 at Muktagacha, Mymensingh, farmers did not use compost manures except chemical fertilization. There were minimal facilities of furrow irrigation. These management practices influenced higher fruits plant^{-1}, fruit weight as well as fruit yield in Netrakona compared to Mymensingh. It was also identified that, if grown without reliable irrigation supply during the dry season they usually succumb to large yield losses. Moreover, water use of the crops may be greatly lowered by mulching to conserve soil moisture. This can be an important practical aid in water saving and to minimize the cost of water fees for the resource poor farmers. Increased soil-water storage due to mulching could also help increased availability and uptake of nutrients by plants root (Yih-chi et al. 2009). The role of irrigation at proper level and stages of plant growth has great significance in improving the yield (Singh et al. 1990).

Bottle gourd yield was lower in 100% bottle gourd + radish crop combination for both the years. It may be due to radish needs more days to maturity than red amaranth and coriander (leaf) and it's a root crop. So, radish uptake more nutrients and moisture among the intercrops and more competition occurs with bottle gourd which minimize bottle gourd yield. The presence of ample humus and the ability of the soil to retain moisture are the important factors to be considered in radish production (Salunkhe & Kadam, 1998).

Table 2a. Fruit length, fruit breadth and number of fruits/ plant of bottle gourd as influenced by vegetables intercropping in 2013-2014 and 2014-2015.

Intercrop combination	Fruit length (cm)		Fruit breadth (cm)		Fruits plant^{-1}	
	2013-2014	2014-2015	2013-2014	2014-2015	2013-2014	2014-2015
100% Bottle gourd + Red amaranth	34.48	32.93	10.97	11.45	10.5	9.5
100% Bottle gourd + Coriander (leaf)	34.82	36.60	10.25	12.73	10.3	10.2
100% Bottle gourd + Radish (leaf)	33.70	34.48	12.12	11.12	10.0	8.5
Sole Bottle gourd	35.52	37.35	13.22	13.20	11.5	10.7
LSD (0.05)	NS	2.62	1.984	NS	NS	1.378
CV%	5.99	6.19	13.86	12.87	10.97	11.88

NS= Not significant

Table 2b. Average fruit weight, fruit yield/ plant and yield/ ha of bottle gourd as influenced by vegetables intercropping in 2013-2014 and 2014-2015.

Intercrop combination	Average fruit weight (kg)		Fruit yield plant^{-1} (kg)		Yield (tha^{-1})	
	2013-2014	2014-2015	2013-2014	2014-2015	2013-2014	2014-2015
100% Bottle gourd + Red amaranth	2.95	2.28	28.50	21.06	57.0 (16.42%)	42.18 (12.42%)
100% Bottle gourd + Coriander (leaf)	2.90	2.53	31.06	22.57	62.13 (6.80%)	45.15 (5.02%)
100% Bottle gourd + Radish (leaf)	2.75	1.85	27.50	18.87	55.0 (20.65%)	39.73 (19.35%)
Sole Bottle gourd	3.2	2.80	33.18	23.68	66.36	47.42
LSD (0.05)	NS	0.37	3.61	3.06	7.22	6.09
CV%	15.31	13.13	9.75	11.88	9.75	11.70

In 2013-2014, experimental location was at Netrakona and in 2014-2015; experimental location was at Muktagacha, Mymensingh. Value in the parentheses represents reduction of bottle gourd yield.

Table 3. Individual crop yield and bottle gourd equivalent yield in bottle gourd-red amaranth, coriander and radish intercropping system in 2013-2014 and 2014-2015.

Intercrop combination	Bottle gourd yield (t ha^{-1})		Vegetable yield (t ha^{-1})		Bottle gourd equivalent yield (t ha^{-1})		
	2013-14	2014-15	2013-14	2014-15	2013-2014	2014-2015	Mean
100% Bottle gourd+ Red amaranth	57.0	42.18	5.33	8.18	67.66	50.36	59.01
100% Bottle gourd + Coriander (leaf)	62.13	45.15	2.5	3.10	79.63	54.45	67.04
100% Bottle gourd + Radish (leaf)	55.0	39.73	8.67	9.51	67.14	49.24	58.19
Sole Bottle gourd	66.36	47.42	-	-	66.36	47.42	56.89

Selling price (Tk/kg): Red amaranth = Tk. 10/ kg (Both year), Coriander = Tk. 30/ kg (Both year), Radish = Tk.7/ kg (2013-2014) and Tk.10/kg (2014-2015) and Bottle gourd = Tk. 5/ kg (2013-2014) and Tk. 10/ kg (2014-2015).

Yield of companion crop

In 2013-2014, the yield of red amaranth, leaf of coriander and leaf of radish under intercropping (T_1, T_2 and T_3) were 5.33, 2.5 and 8.67 tha^{-1}, respectively. During 2014-2015, the corresponding figures were 8.18, 3.1 and 9.51 tha^{-1}. Leaf of red amaranth and leaf of radish showed higher yield in intercropping (Table 3).

Bottle gourd equivalent yield

Total productivity was expressed in bottle gourd equivalent yield (Table 3). Bottle gourd equivalent yields were higher in all the intercrops than the sole crops. The highest bottle gourd equivalent yield (79.63 tha^{-1} in 2013-2014 and 54.45 tha^{-1} in 2014-2015) was obtained from 100% bottle gourd with coriander (leaf) crop combination (T_2) followed by 100% bottle gourd + red amaranth crop combination. The lowest equivalent yield (66.36 tha^{-}

^{1} in 2013-2014 and 47.42 tha^{-1} in 2014-2015) was obtained from sole bottle gourd. The highest mean equivalent yield of bottle gourd (57.04 tha^{-1}) and the lowest (56.89 tha^{-1}) were found from T_2 and T_4, respectively.

Economic performance

Cost and return analysis of intercropping vegetables with bottle gourd are presented in Table 4. Result showed that the maximum gross return (Tk. 3,85,650 ha^{-1} in 2013-2014 and Tk. 5,44,500 ha^{-1} in 2014-2015) was recorded in 100% bottle gourd + coriander (leaf) combination followed by 100% bottle gourd + red amaranth combination. The lower gross return (Tk. 3318100 ha^{-1} in 2013-2014 and Tk. 474200 ha^{-1} in 2014-2015) was calculated from sole bottle gourd. Cultivation cost of sole bottle gourd was lower than intercropping. The highest BCR 2.07 in the 1st year and 2.94 in the 2nd year was recorded in 100% bottle gourd + coriander (leaf) followed by 100% bottle gourd + red amaranth (1.83 and 2.74, respectively). In both the years, the lowest BCR (1.81 in 2013-2014 and 2.61 in 2014-2015) was recorded in sole cropping. In 2013-2014 at Netrakona, farmers sold bottle gourd to wholesalers @ 5 Tk. kg^{-1} but in 2014-2015 at Mymensingh, farmers go to the market and sold their crop by themselves @ 10 Tk. kg^{-1}. Except bottle gourd, in the second year farmers of Mymensingh sold radish (leaf) at a high price (10 Tk. kg^{-1}) than in the first year (7 Tk. kg^{-1}). Thus total gross return, gross margin and BCR calculated higher in the second year than in the first year, although bottle gourd yield was higher in the first year. Additional yield of companion crops has contributed to increase the profitability over sole bottle gourd. Ijoyah and Dzer (2012) also reported that intercropping gave greater combined yields and monetary returns than those obtained from either crop grown alone.

Table 4. Economic performance of bottle gourd-red amaranth, coriander and radish intercropping system in 2013-2014 and 2014-2015.

Intercrop combination	Gross return (Tk. ha^{-1})		Variable cost (Tk.ha^{-1})		Gross margin (Tk. ha^{-1})		BCR	
	2013-2014	2014-2015	2013-2014	2014-2015	2013-2014	2014-2015	2013-2014	2014-2015
100% Bottle gourd + Red amaranth	338300	503600	184905	183925	153395	319675	1.83	2.74
100% Bottle gourd + Coriander (leaf)	385650	544500	186000	185120	199650	359380	2.07	2.94
100% Bottle gourd + Radish (leaf)	335690	492400	184800	183700	150890	308700	1.82	2.68
Sole Bottle gourd	331800	474200	182905	181834	148895	292366	1.81	2.61

Price of input**:** Urea = 20 Tk. kg^{-1}, TSP = 22 Tk. kg^{-1}, MoP = 15 Tk. kg^{-1}, Gypsum = 10 Tk. kg^{-1}, Zinc sulphate = 130 Tk. kg^{-1}, boric acid = 130 Tk. kg^{-1}.

Conclusion

From the two years study, it can be concluded that it is advantageous intercropping bottle gourd with red amaranth, coriander and radish crops. This is associated with greater intercropped yields, higher bottle gourd equivalent yields and greater monetary returns. Among them coriander intercrops with bottle gourd in intercropping system was therefore found to be highly complementary and suitable in mixture. Farmers in these areas can be grown coriander as intercrop with bottle gourd.

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