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INTERCROPPING SPINACH AND RED AMARANTH WITH BRINJAL UNDER DIFFERENT PLANTING SYSTEM

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Abstract

The experiment was conducted at Agronomy Research Field of Bangladesh Agricultural Research Institute, Gazipur, during the rabi season of 2018 to 2019 and 2019 to 2020 to find out the suitable crop combination of spinach (*Spinacia oleracea*) and red amaranth (*Amaranthus cruentus*) with brinjal (*Solanum melongena*) for higher brinjal equivalent yield, monetary advantage and maximize land utilization through intercropping system. Treatments were: T_1 = 2 rows spinach (50%) in between two rows of brinjal (100%), T_2 = 3 rows Spinach (75%) in between two rows of brinjal (100%), T_3 = 2 rows red amaranth (50%) in between two rows of brinjal (100%), T_4 = 3 rows red amaranth (75%) in between two rows of brinjal (100%), T_5 = Sole brinjal (80 cm × 60 cm), T_6 = Sole spinach (Line to line 20 cm) and T_7 = Sole red amaranth (Line to line 20 cm) were used in the study. All the intercropping combinations showed better performance in terms of brinjal equivalent yield, gross return and benefit cost ratio (BCR) over sole crops. Among the intercropping combinations, 3 row spinach (75%) in between two rows of brinjal (100%) was the most feasible and profitable intercropping system in respect of brinjal equivalent yield (34.72 t ha^{-1}), land equivalent ratio (1.57), gross return (Tk. 6,94,346 ha^{-1}), gross margin (Tk. 4,59,088 ha^{-1}) and benefit cost ratio (2.95). From the two years, results revealed that all intercropping treatments were productive as compared to sole treatments but 3 rows spinach (line to line 20 cm) 75% in between two rows of brinjal (80 cm × 60 cm) 100% intercropped combination might be agronomically feasible and economically profitable.

Introduction

Intercropping is a traditional practice in Bangladesh and it increases total productivity per unit area through maximum utilization of land, labour, and growth resources (Ahmed *et al*., 2013; Islam *et al*., 2006; Mahfuza *et al*., 2012). By judicious choice of compatible crops and adopting appropriate planting geometry, inter/intraspecific competition may be minimized resulting in higher total productivity (Alom *et al.,* 2013). Canopy architecture of tall stature crop regulates the availability of light on under storied crop (Faruque *et al.*, 2006). In Bangladesh, small farmers constitute 79.4% of our farming community and their cultivated lands are shrinking day by day (MOA, 2014). In that context, intercropping is one of the viable technologies to ensure the efficient utilization of their resources for increased production and family income. Intercropping offers the possibility of yield advantage relative to sole cropping through yield stability and improved yield in tropical and sub-tropical areas (Nazir *et al*., 2002; Malik *et al*., 2002; Bhatti *et al*., 2005). Brinjal (*Solanum melongena*) is an important vegetable crop is cultivated round the year throughout the country in Bangladesh. It is a tall structure, long duration (140-180 days), and wide spaced (80 cm × 60 cm) crop. So, there is a great scope to cultivate short duration (30-45 days) leafy vegetables like red amaranth, and spinach in the inter row space of brinjal as intercrop. Leafy vegetables like red amaranth and spinach being short structure quick growing crops can be easily intercropped between two rows of brinjal at early growth stage for getting the higher economic returns. The nutritive value of red amaranth lies in their content of β-carotene (precursor of vitamin A**)** and vitamin C. It contains carotene (11.94 mg), vitamin C (43 mg), calcium (374 mg), carbohydrate (5.0 g), protein (5.3 g), fat (0.1 g) and calories (43 K Cal.) 100 g^{-1} of an edible portion (Begum, 2000). Spinach (*Spinacia oleracea*) is a green-leafy vegetable that belongs to the family *Amaranthaceae*. It is often recognized as one of the functional foods for its wholesome nutritional, antioxidants, and anti-cancer composition. The major micronutrients in spinach are vitamins A (from â-carotene), C, K, and folate, and the minerals, calcium, iron, and potassium. Spinach also provides fiber and is low in calories. Its tender, crispy, dark green leaves are one of the favorite ingredients of chefs all around the world. Spinach vegetables are also valuable in maintaining the alkaline reserve of the body. They are valued mainly for high protein (2.9 g), calcium (30 mg), iron (0.81 g), magnesium (24 mg), potassium (167 g), carbohydrate (3.6 g), vitamin, fiber (2.2 g), and mineral contents (Rumeza *et al.*, 2006). However, the literature regarding spinach-brinjal and red amaranth- brinjal intercropping is very scarce. Keeping this view in mind, the experiment was conducted to find out the suitable crop combination of spinach and red amaranth with brinjal for increasing total productivity, economic return and maximize land utilization through an intercropping system.

Materials and Methods

A field experiment was conducted at Agronomy Research Field of Bangladesh Agricultural Research Institute, Joydebpur, Gazipur, during the rabi season of 2018 - 2019 and 2019 - 2020. The soil was silty clay loam with pH 6.3 belonging to Agro Ecological Zone (AEZ) 28. The treatments were: T_1 = 2 rows spinach (50%) in between two rows of brinjal (100%), T_2 = 3 rows spinach (75%) in between two rows of brinjal (100%), T_3 = 2 rows red amaranth (50%) in between two rows of brinjal (100%), T_4 = 3 rows red amaranth (75%) in between two rows of brinjal (100%), T_5 = Sole brinjal (80 cm × 60 cm), T_6 = Sole spinach (Line to line 20 cm) and T_7 **=** Sole red amaranth (Line to line 20 cm). The trial was set up in a randomized complete block design with three replications. The unit plot size was 4.2 m × 3.2 m. The sole crop of brinjal and intercropped treatments were fertilized with cow dung @ 5 t/ha and 120-31-120-13-3-1.5 kg/ha of N-P-K-S-Zn-B in the form of urea, triple super phosphate, muriate of potash, gypsum, zinc sulphate, and boric acid, respectively. For sole brinjal and intercrop, full amount of all other fertilizer except N and K were applied in the pit before one week of transplanting brinjal. N and K were applied in three equal splits at 21, 40, and 60 days after transplanting (DAT) of brinjal as ring method followed by irrigation. Sole spinach fertilized with 50-13-18-5 kg/ha of N-P-K-S. Half N and all other fertilizers were applied at the time of final land preparation and the rest N was applied at 10 days after emergence (DAE) of spinach. Sole red amaranth fertilized with 78-18-35-4 kg/ha of N-P-K-S. Half N and all other fertilizers were applied at the time of final land preparation and the rest N was applied at 10 DAE of red amaranth (FRG, 2018). Brinjal (var. BARI Begun-8) as main crop and red amaranth (var. BARI Lalshak-1) and spinach (var. BARI Spinach-1) were used as intercrops in this study. The sole crop of brinjal was planted at a spacing of 80 cm × 60 cm. After the establishment of brinjal seedling (12 days after transplanting) spinach and red amaranth seeds were sown as per treatments. Brinjal (thirty-days-old seedling) was transplanted on 29 November, 2018 and 10 December 2019. Seed of spinach and red amaranth sown on 11 December, 2018 and 23 December, 2019. Brinjal was harvested four times and it was harvested in 2019 on 04 March, 11 March, 18 March, 29 March and in 2020 harvested on 03 April, 13 April, 21 April, and 2 May. Both spinach and red amaranth were harvested on 13 January, 2019 and 27 January, 2020. Four irrigations were done in the experimental field. First irrigation was applied just after transplanting (brinjal) and sowing of the component crops for proper germination. Second, third and fourth irrigation was applied at 45, 60, and 90 days after transplanting (DAT) of brinjal. Weeding was done as per requirement. Sex pheromone trap was used for controlling of brinjal shoot and fruit borer from active vegetative stage up to fruit developing stage. Yield and yield contributing characters were recorded and pooled data analyzed statistically and means separations were done by LSD test at a 5% level of significance. Brinjal equivalent yield (BEY) was converted by converting yield of intercrops on the basis of the market price of the individual crop following the formula Islam *et al*. (2012):

$$\text{BEY} = \text{Yield of intercrop brinjal} + \frac{\text{Yi} \times \text{Pi}}{\text{Price of brinjal}}$$

Where, Yi = yield of intercrops (Spinach/ Red amaranth) and Pi = Price of intercrop (Spinach/ Red amaranth). Land equivalent ratio (LER) values were determined from the yield data of the crops according to Mian (2008).

$$\text{LER} = \frac{\text{BIY}}{\text{BSY}} + \frac{\text{RIY}}{\text{RSY}}$$

Where,
B_{IY} = Intercrop yield of brinjal
B_{SY} = Sole crop yield of brinjal
R_{IY} = Intercrop yield of component crops (spinach/ red amaranth).
R_{SY} = Sole crop yield of component crops (spinach/ red amaranth).

Results and Discussion

Yield and yield contributing characters of brinjal

Plant height, number of fruits plant^{-1}, single fruit weight, fruit length, fruit diameter, and yield of brinjal (t ha^{-1}) was significantly influenced by intercropping (Table 1). The maximum plant height of 102.79 cm was obtained from T_5 treatment (sole brinjal) which was statistically similar to that of T_3 (101.84cm), T_4 (98.40 cm), and T_1 (97.60 cm) treatments and the lowest plant height 96.78 cm from T_2 treatment.

Table 1. Fruit yield and yield attributes of brinjal under sole and intercropping system.

Treatment	Plant height (cm.)	Number of fruits plant^{-1}	Single fruit weight (g)	Fruit length (cm)	Fruit diameter (cm.)	Fruit Yield (t ha^{-1})
T_1	97.60	25.53	86.86	20.88	4.32	19.44
T_2	96.78	24.37	86.34	19.47	4.12	18.39
T_3	101.84	27.36	91.01	23.38	4.77	20.81
T_4	98.40	26.31	89.67	21.98	4.50	19.80
T_5	102.79	29.93	96.10	25.27	4.95	21.21
$LSD_{(0.05)}$	8.49	3.49	7.26	2.64	0.45	2.99
CV (%)	4.53	6.94	4.28	6.31	5.22	7.96

Note: T_1 = 2 rows spinach (50%) in between two rows of brinjal (100%), T_2 = 3 rows spinach (75%) in between two rows of brinjal (100%), T_3 = 2 rows red amaranth (50%) in between two rows of brinjal (100%), T_4 = 3 rows red amaranth (75%) in between two rows of brinjal (100%), T_5 = Sole brinjal (80 cm × 60 cm), T_6 = Sole spinach (Line to line 20 cm) and T_7 = Sole red amaranth (Line to line 20 cm).

Among the intercropping combinations, the maximum number of fruits plant^{-1} (27.36), the highest single fruit weight (91.01 g), fruit length (23.38 cm), and fruit diameter (4.77 cm) were recorded in T_3 treatment which followed by T_4 and T_1 treatments and the minimum number of fruits plant^{-1} (24.37), lowest single fruit weight (86.34 g), fruit length (19.47 cm), and fruit diameter (4.12 cm) were recorded in T_2 treatment. The maximum brinjal fruit yield (21.21 t ha^{-1}) was obtained from T_5 treatment (sole brinjal) which was statistically similar with T_3 (20.81 t ha^{-1}), T_4 (19.80 t ha^{-1}) and T_1 (19.44 t ha^{-1}) treatments and the lowest (18.39 t ha^{-1}) in T_2 treatment. Under intercropping, the maximum fruit yield (20.81 t ha^{-1}) was recorded in T_3 treatment (2 rows red amaranth 50% in between two rows of brinjal 100%) and the lowest fruit yield (18.39 t ha^{-1}) in T_2 treatment (3 rows spinach 75% in between two rows of brinjal 100%). The higher fruit yield in the sole crop was attributed due to more number of fruit plant^{-1} and higher single fruit weight. Islam *et al.* (2014) also reported a similar result.

Yield of spinach and red amaranth

The yield of spinach and red amaranth was significantly influenced by intercrop spinach and red amaranth with brinjal (Figure 1). The higher spinach yield (31.93 t ha^{-1}) and red amaranth yield (22.62 t ha^{-1}) were recorded in sole spinach and sole red amaranth. Among the intercropping combinations, the higher spinach yield (22.47 t ha^{-1}) was recorded in T_2 Treatment (3 rows Spinach 75% in between two rows of brinjal 100%) and the lowest spinach yield (15.89 t ha^{-1}) from T_1 treatment (2 rows Spinach 50% in between two rows of brinjal 100%). In the case of red amaranth, a similar trend was also observed. Higher red amaranth biomass yield (14.96 t ha^{-1}) was recorded in T_4 treatment (3 rows red amaranth 75% in between two rows of brinjal 100%) and the lowest red amaranth yield (11.61 t ha^{-1}) from T_3 treatment (2 rows red amaranth 50% in between two rows of brinjal 100%). Faruque *et al.* (2006) also reported a similar result.

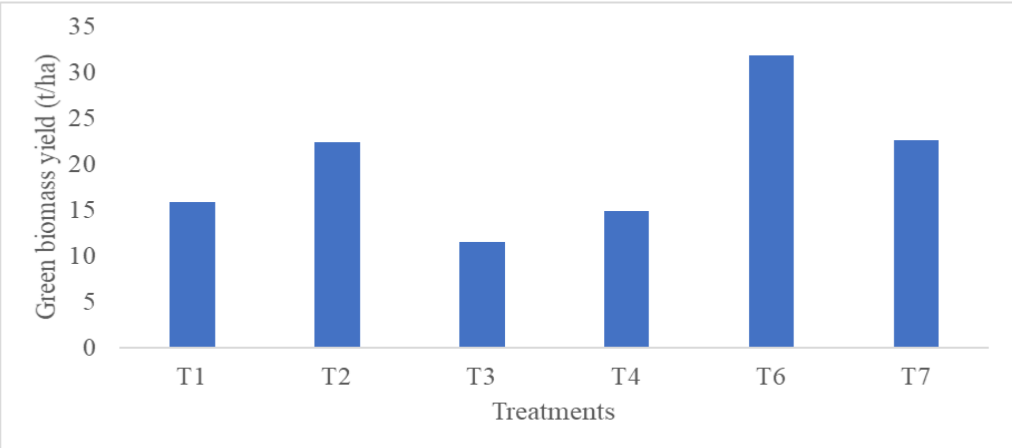

Fig. 1. Green biomass yield of spinach and red amaranth under sole and intercropping system ($LSD_{0.05}$ = 2.71).

Brinjal equivalent yield (BEY)

Brinjal equivalent yield expressed total productivity. Brinjal equivalent yield was higher in all the intercrops (27.20 to 34.72 t ha^{-1}) than the sole crop of brinjal 22.08 t ha^{-1} (Table 2). In intercrop combination, the maximum brinjal equivalent yield (34.72 t ha^{-1}) was recorded in T_2 treatment which was followed by T_4 treatment (31.57 t ha^{-1}). The lowest brinjal equivalent yield (27.20 t ha^{-1}) was obtained from T_3 treatment over the sole brinjal. Total productivity also increased by 57.23, 43.00, 33.39, and 23.21% at T_2, T_4, T_1 and T_3 treatments, respectively. Ahmed *et al.* (2013) also reported that intercrop combination increases the equivalent yield.

Land equivalent ratio (LER)

The maximum land equivalent ratio (1.57) was recorded in T_2 treatment (3 rows Spinach (75%) in between two rows of brinjal 100%) followed by T_4 treatment 1.43 (3 rows red amaranth (75%) in between two rows of brinjal 100%) (Table 3). The LER of different crop combinations ranged from 1.23 to 1.57% indicating that land utilization was increased 23 to 57% by intercropping. The mean values of LER (more than one) in all intercropping treatments revealed that land was more efficiently utilized under intercropping than under sole cropping of brinjal, spinach, and red amaranth. Nazir *et al.* (2002) also reported that intercrop combinations always increases the land equivalent ratio (LER).

Table 2. Brinjal equivalent yield (BEY), land equivalent ratio (LER) and % increase of BEY over sole brinjal in brinjal + spinach/ red amaranth intercropping system.

Treatment	BEY (t ha^{-1})	LER	% increase of BEY over sole brinjal
T_1	29.45	1.33	33.39
T_2	34.72	1.57	57.23
T_3	27.20	1.23	23.21
T_4	31.57	1.43	43.00
T_5	22.08	1.00	-

Note: T_1 = 2 rows spinach (50%) in between two rows of brinjal (100%), T_2 = 3 rows spinach (75%) in between two rows of brinjal (100%), T_3 = 2 rows red amaranth (50%) in between two rows of brinjal (100%), T_4 = 3 rows red amaranth (75%) in between two rows of brinjal (100%), T_5 = Sole brinjal (80 cm × 60 cm), T_6 = Sole spinach (Line to line 20 cm) and T_7 = Sole red amaranth (Line to line 20 cm).

Cost and return analysis

Intercropping combination of spinach and red amaranth with brinjal showed higher monetary return than sole crop (Table 3). Among the intercropping situation, the highest gross return (Tk. 6,94,346 ha^{-1}) was recorded from T_2 treatment (3 rows Spinach (75%) in between two rows of brinjal 100%). This intercropping combination also gave the highest gross margin (Tk. 4,59,088 ha^{-1}) and benefit cost ratio (2.95). The results of increased productivity and returns were consistent with the earlier reports of yield advantage of crop mixture compared to monoculture (Akhteruzzaman and Quayyum,1991, Islam *et al*., 2012 and Ahmed *et al*., 2013).

Table 3. Cost- benefit analysis of brinjal, spinach and red amaranth under sole and intercropping situation.

Treatment	Gross return (Tk ha^{-1})	Cost of production (Tk ha^{-1})	Gross margin (Tk ha^{-1})	Benefit cost ratio (BCR)
T_1	5,89,049	2,34,058	3,54,991	2.52
T_2	6,94,346	2,35,258	4,59,088	2.95
T_3	5,44,083	2,32,789	3,11,294	2.34
T_4	6,31,488	2,33,289	3,98,199	2.71
T_5	4,41,533	1,98,851	2,42,682	2.22

Price: Brinjal: Tk. 20/kg, Red amaranth: Tk. 15/kg, Spinach: Tk. 15/kg

Note: T_1 = 2 rows spinach (50%) in between two rows of brinjal (100%), T_2 = 3 rows spinach (75%) in between two rows of brinjal (100%), T_3 = 2 rows red amaranth (50%) in between two rows of brinjal (100%), T_4 = 3 rows red amaranth (75%) in between two rows of brinjal (100%), T_5 = Sole brinjal (80 cm × 60 cm), T_6 = Sole spinach (Line to line 20 cm) and T_7 = Sole red amaranth (Line to line 20 cm).

Conclusion

From the two years results revealed that all intercropping treatments were productive as compared to sole treatments but 3 rows spinach (line to line 20 cm) 75% in between two rows of brinjal (80 cm × 60 cm) 100% intercropped combination might be agronomically feasible and economically profitable.

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