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ORIGINAL ARTICLE

On-farm study on intercropping of culinary coriander with carrot

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ABSTRACT

Intercropping gives the opportunity to engage nature's principle of diversity on agricultural farms. Therefore, to evaluate the performance of carrot production in intercropping system and to increase land use efficiency, a field experiment on intercropping of coriander with carrot was undertaken at farmer's field of Muktagacha, Mymensingh during *rabi* season of 2014- 2015. Three crop combinations viz., Carrot (100%) + Coriander (1 time cultivation), Carrot (100%) + Coriander (2 times cultivation) and Sole carrot (100%) were considered. Results revealed that sole carrot produced the highest yield (34.22t ha^{-1}). Among the intercropping treatments, the highest carrot root yields (31.92 t ha^{-1}) were obtained from carrot (100%) +Coriander (1 time cultivation). The lowest carrot yield (28.30 t ha^{-1}) was recorded in carrot (100%) + Coriander (2 times cultivation). The highest carrot equivalent yield (37.00 t ha^{-1}) was recorded in carrot (100%) + coriander (2 times cultivation). Though intercropping reduced carrot yield (7.21- 20.92%) but total productivity increased due to additional yield of coriander. Carrot (100%) + coriander (2 times cultivation) gave the highest gross return and gross margin (Tk. 740000 ha^{-1} and Tk. 595700 ha^{-1}, respectively). Highest BCR (5.12) was also calculated from the same treatment. The lowest gross return and gross margin (Tk. 684400 ha^{-1}, Tk. 543600 ha^{-1}) and BCR (4.86) was recorded in sole cropping. Experimental findings revealed that coriander (2 times cultivation) might be suitable for intercropping with 100% carrot for higher productivity and economic return in the study areas.

INTRODUCTION

Intercropping is the growing of two or more crops simultaneously in the same piece of land and one of the vital techniques of vertical expansion of crop production that increase cropping intensity in developing countries like Bangladesh. The trends in agricultural production systems have changed towards achieving high productivity per unit area of land and through better use of natural resources to promote sustainability. Among the crop production systems, intercropping has gained enormous popularity that increases total productivity through efficient utilization of land, labour and growth resources (Ahmed et al. 2006). Intercropping not only reduces the risk associated with input costs but also increases profit potential (Rathi and Verma 1979). Greater productivity in intercropping system is commonly achieved by minimizing inter-specific competition and maximizing complementary use of growth resources (Islam 2002). Inter-specific competition may be minimized through judicious choice of crops (Santalla et al. 2001). Usually plants differing in growth duration, height, rooting systems and nutrient requirements are considered to growth together in intercropping systems (Reddy and Willey 1981).

Carrot (*Daucus carota*) is highly appreciated because of its carotene and antioxidant nutrients (Ruiz-Cruz 2007). It is reported that world acreage and production of carrots for calendar year 2011 were almost 1195 thousand hectare and 36.18 million tons, respectively (FAO 2015). In Bangladesh, the crop occupies 3 thousand acres of land and the annual production is 15 thousand tons during 2010-2011 (BBS 2011). It is usually grown as sole at farmer's field in various parts of Bangladesh. Sometimes radish is planted with carrots in different countries. Unlike companion planting to deter pests, intercropping combines plants to save space. Crop productivity may increase by cultivating short duration crop like coriander for leaf purpose with carrot. Coriander (*Coriandrum sativum* L.) is a testy herb grown for its pleasant aromatic leaves in all

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parts of Bangladesh. Production of coriander for foliage purpose is increasing day by day in our country because of its high price and demand year round. Thamburaj and Singh (2004) reported that staggered sowing and harvesting makes the fresh green leaf available for longer periods. For foliage production it needs 35- 40 days. It should be harvested before bolting; otherwise it becomes little bitter in taste. More over Coriander can be grown at low N rate (60 kg ha^{-1}). Most intercropping research has focused on field crops (Tsubo et al. 2005; Ghosh et al. 2006). Intercropping field crops with vegetables has also been intensively investigated (Ahmed et al. 2006; El-shaikh and Bekheet 2004). One of the most important reasons to grow two or more crops together is the increase in productivity per unit of land. Therefore, this experiment was conducted to find out suitable crop combination in intercropping system with proportion for higher productivity and a maximum economic return.

MATERIALS AND METHODS

The experiment was conducted at Muktagacha, Mymensingh during Rabi season of 2014-2015. The experimental soil was acidic in nature and sandy loam in texture of the medium highland under the Agro-ecological Zone-9 (AEZ-9). Soil samples 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 100g $soil^{-1}$)	P	S	Zn	B
					Microgram g^{-1} soil			
Langrabazar, Muktagacha, Mymensingh	5.8 Acidic	1.57 low	0.07 Very low	0.15 low	11.20 optimum	18.58 optimum	1.09 medium	0.29 medium

The experiment was laid out in randomized complete block design with six replications. Three crop combinations viz. carrot (100%) + coriander (1 time cultivation), carrot (100%) + coriander (2 time cultivation) and sole carrot (100%) were used. The crop varieties were used in this intercropping system as New Quroda for carrot and BARI Dhania-1 for coriander. The unit plot size was 3 m×1 m. Before sowing seeds the field was fertilized with the rate of 100: 25: 60: 15 kg ha^{-1} of N: P: K: S in the form of urea, TSP, MoP and gypsum. Entire cowdung, TSP, gypsum, 1/3 of urea and ½ of MoP will be applied during final land preparation. Rest of urea and MoP will be applied in two equal installments at 4 weeks and 6 weeks after sowing. Coriander seeds (fruits) were rubbed for separating the mericarps (seeds). Seeds were treated with Bavistin @ 2 g per kg of seeds before sowing. Both seeds were soaked in water for 24 hours to enhance germination. Seeds of carrot were sown on 13 November 2014 in 5 rows. The row was 20 cm apart from each other. Coriander seeds were also sown in the same date, between the two rows of carrot. Second time sowing of coriander was done on 29 December' 2014. Both seeds were sown in rows 10 cm apart continuously by hand. First weeding was done at 20 days after sowing. For good germination, irrigation water was given to the plots every three days by water can with fine mashed nozzle till germination. In case of carrot, thinning was done after 20 days of germination where it was necessary. All the management practices were done timely.

First time sowing coriander was harvested at 35-38 days after sowing (DAS) and second time sowing coriander was harvested 36-39 DAS. Carrot was harvested on 24 February, 2015 (103 DAS) by uprooting the whole plant. Data were taken from inner rows of each plot to avoid the border effect. In each plot 1 m^2 area was selected and data were taken on plant height (cm), weight of leaves $plant^{-1}$ (g), root length (cm), wt. of root $plant^{-1}$ (g), root diameter (cm) and yield (ton ha^{-1}) were taken. 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.

Carrot equivalent yield (CEY) was calculated according to Prasad and Srivastava (1991).

$$\text{CEY}\ (t\ ha^{-1}) = \text{Yield of carrot} + \frac{\text{Yield of intercrop coriander} \times \text{market price of coriander}}{\text{Market price of carrot}}$$

Economic analyses were done to assess the economic productivity of the intercropping systems.

RESULTS AND DISCUSSION

Yield and Yield Components of Carrot

Plant height, fresh weight of leaves $plant^{-1}$, root length and diameter, fresh weight of root $plant^{-1}$ and marketable root yield as influenced by intercropping system are presented in Table 2. All the parameters in sole Carrot showed better performance over Carrot (100%) + Coriander (1 time cultivation) and Carrot (100%) + Coriander (2 times cultivation). Plant height showed significant difference due to different treatment combinations. Maximum plant height (61.60 cm) was found from sole carrot. This is might be because of no companion crops. This probably enhanced photosynthesis which resulted in the production of longer plants, more leaves and wider canopies. For the same reason fresh weight of leaves also recorded highest (27.27 g) in sole cropping. This result is in agreement with the results of Koriem and Farag (1990) who found that onions planted at a wider spacing, produced more leaves and higher foliage dry matter. No significant difference was observed among the treatments in respect of root length and diameter. Root length ranges from 11.63 cm to 12.43 cm. and diameter recorded from 3.21 cm to 3.30 cm. Dawuda et al. (2011) found similar results. Norman (1992) observed that higher plant density per unit area or closer spacing increases the competition for essential growth factors among individual plants which do not attain their normal size. However, significantly the highest fresh weight of root $plant^{-1}$ (92.67 g) was recorded in sole carrot. The lowest fresh weight of root $plant^{-1}$ (78.67 g) was found in carrot (100%) + coriander (2 times cultivation) combination. The highest marketable root yield (34.22 t ha^{-1}) was obtained from sole cropping (T_3) and it was statistically at par with T_1 but differed from T_2. The root yield of carrot was highest in sole cropping due to getting non inter-specific competition for soil nutrients, moisture, carbon dioxide and light. The lowest root

yield (28.30 t ha^{-1}) was found in carrot (100%) + coriander (2 times cultivation) combination. The results are in agreement with the findings of Muoneke and Ndukwe (2008) and Manga et al. (2003). The negative impact of yield of main crop in intercropping was reported by Varghese (2013) in cabbage plus radish intercropping system. The findings of higher yield of monoculture as compared to intercropped are agreement with those Akhtar et al. (2015) and Rodge and Yadlod (2009). Carrot yield was reduced 7.21% and 20.92% due to intercropping system.

Table 2. Yield components and fruit yield of carrot as influenced by coriander intercropping

Treatments	Plant height (cm)	Fresh wt. of leaves plant^{-1} (g)	Root length (cm)	Root diameter (cm)	Fresh wt. of root plant^{-1} (g)	Marketable root yield (t ha^{-1})
T_1: Carrot (100%) + Coriander (1 time cultivation)	58.50	25.12	11.92	3.23	85.83	31.92 (7.21%)
T_2: Carrot (100%) + Coriander (2 times cultivation)	54.98	22.38	11.63	3.21	78.67	28.30 (20.92%)
T_3: Sole carrot (100%)	61.60	27.27	12.43	3.30	92.67	34.22
LSD (0.05)	4.01	2.70	NS	NS	11.48	2.98
CV%	5.64	8.90	5.31	6.74	11.00	7.76

NS= Not significant Value in the parentheses represents reduction of carrot yield.

Yield of Companion Crop

The yield of intercrop varied due to combined cultivation with carrot (Figure 1). Average of 3.0 t ha^{-1} fresh leaf weight of coriander was obtained from coriander one time cultivation with carrot (T_1) and a total of 5.8 t ha^{-1} fresh leaf weight of coriander was found in coriander two times cultivation with carrot (T_2). In case of T_2 treatment, second time cultivation of coriander reduced leaf yield of coriander. This is because of large carrot plant and canopy structure increased inter-specific competition for light as well as photosynthesis and also for soil nutrient.

Carrot Equivalent Yield

Total productivity was expressed in carrot equivalent yield. The highest carrot equivalent yield (37.00 t ha^{-1}) was recorded in carrot (100%) + coriander (2 times cultivation) followed by carrot (100%) + coriander (1 time cultivation) combination. Carrot (100%) + coriander (1 time cultivation) and carrot (100%) + coriander (2 times cultivation) crop combination were increased total productivity 6.43% and 8.12% respectively over the sole carrot (Figure 2). Akhtar et al. (2015) also reported an increased productivity by 35.24 to 62.64% in Maize-leafy vegetables intercropping system whereas Islam et al. (2014) reported 11.17 to 26.67% in brinjal-leafy vegetables/legume intercropping system and Ahmed et al. (2013) found 28 to 45% yield advantages in okra-leafy vegetables intercropping system.

Economic Performance

Cost and return analysis of intercropping carrot with coriander is shown in Table 3. Intercropping of carrot with coriander showed higher monetary return than sole crop. Result showed that the highest gross return (Tk.740000 ha^{-1}) was recorded in carrot (100%) + coriander (2 times cultivation) followed by carrot (100%) + coriander (1 time cultivation) combination. The lowest gross return (Tk.684400 ha^{-1}) was found from sole cropping. The highest gross margin and BCR was calculated from carrot (100%) + coriander (2 times cultivation) and it was Tk. 5, 95,700 ha^{-1} and 5.12, respectively. In sole carrot lowest gross margin (Tk. 5, 43,600 ha^{-1}) and BCR (4.86) was found. Begum et al. (2015) and Farhad et al. (2014) also obtained more benefit from intercropping system compared to monocropping.

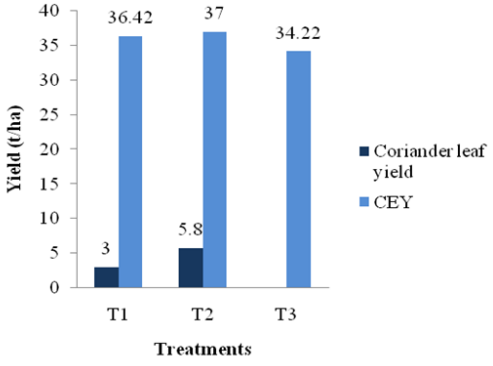

Figure 1. Yield of coriander (leaf) and Carrot equivalent yield (t ha^{-1}) in intercropping system. (Selling price: Carrot = 20.00 Tk.kg^{-1}, Coriander = 30.00 Tk.kg^{-1}).

Table 3. Economic performance of intercropping coriander with carrot

Treatments	Gross return (Tk ha^{-1})	Variable cost (Tk ha^{-1})	Gross margin (Tk ha^{-1})	BCR
T_1: Carrot (100%) + Coriander (1 time cultivation)	728400	143800	584600	5.07
T_2: Carrot (100%) + Coriander (2 times cultivation)	740000	144300	595700	5.12
T_3: Sole carrot (100%)	684400	140800	543600	4.86

Price of input and output: Urea 20.00 Tk.kg^{-1}, TSP 22.00 Tk.kg^{-1}, MoP 15.00 Tk.kg^{-1}, Gypsum 10.00 Tk.kg^{-1},Carrot: 20.00 Tk.kg^{-1}, Coriander: 30.00 Tk.kg^{-1}.

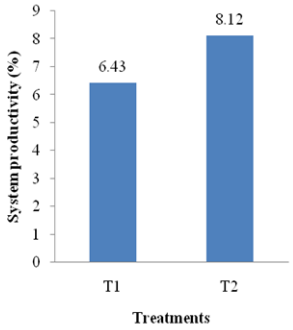

Figure 2. Increased productivity (%) over sole carrot in intercropping system. (Selling price: Carrot = 20.00 Tk.kg^{-1}, Coriander = 30.00 Tk.kg^{-1})

CONCLUSION

Crop diversification and total productivity of crop can be possible by intercropping. It is also found more profitable than the sole cropping and risk of cultivation of one crop can be reduced by intercropping. Cultivation of coriander with carrot would be highly remunerative compared to sole crop of carrot for higher productivity and maximum economic return of the selected area.

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CONFLICT OF INTEREST

The authors declare that there is no conflict of interests regarding the publication of this paper.

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