Original Research Article

Intercropping of Chilli with Carrot and Radish in Prayagraj Agro-climatic Conditions

ABSTRACT

A field experiment entitled "Intercropping of Chilli with Carrot and Radish in Prayagraj Agro-climatic Conditions" was conducted from November 2021-March 2022 at the Horticulture Research Farm, Department of Horticulture, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj. The experiment was laid out in Randomized Block Design (RBD) with three replications and 08 treatments. The experiment consisted of six cropping combinations *viz.*, sole chilli, sole carrot, sole radish, chilli + carrot, chilli+ radish, chilli + carrot + radish. The highest yield (green chilli) was obtained from treatment T_1 (sole chilli @ 100 % RDF) (13.09 t ha^{-1}). Among the intercropping treatments, the highest chilli yield (12.68 t ha^{-1}) was obtained from treatment T_6 (chilli @ 70% RDF + carrot @ 30% RDF) whereas the lowest (10.57 t ha^{-1}) was found in treatment T_8 (chilli @ 60% RDF + carrot @ 20% RDF + radish @ 20% RDF). Intercropping reduced chilli yield but total chilli with intercrop yield increased over sole chilli due to the contribution of companion crops. The highest chilli along with intercrop yield (150.71 t ha^{-1}), gross return (1101506 Rs. ha^{-1}), net return (817969 Rs. ha^{-1}) and benefit cost ratio (3.88) were obtained from treatment T_8 (Chilli @ 60 % RDF + Carrot @ 20 % RDF + Radish @ 20 % RDF). Considering the experimental findings, treatment T_8 (Chilli @ 60% RDF + Carrot @ 20 % RDF+ Radish @ 20 % RDF) found the most suitable combination for higher productivity and economic return under Prayagraj agro-climatic conditions.

1. INTRODUCTION

The most widespread practice in the agricultural and horticulture sectors is intercropping, which plays a significant role in boosting productivity and yield stability. Intercropping is the simultaneous growth of two or more cultivars in the same area to make better use of available resources. Intercropping was initially used in diverse cropping patterns as a kind of crop failure insurance. The production of

resources has risen thanks to the intercropping strategy. Contrary to sole crop cultivation, intercropping has a number of benefits. These include increased efficiency in the use of labour and environmental resources (such as light, nutrients, and soil moisture), reduction of the negative effects of various biotic and abiotic stress, diversity in food supply, increased income, insurance against crop failure, and higher return and overall productivity per unit area. While it is a traditional method of crop cultivation, Indian farmers haven't used it frequently. Compared to sole crop cultivation, intercropping has a number of benefits, including improved environmental factor efficiency (e.g., light, nutrient, and soil moisture) and labor utilization, decreased adverse effects of various biotic and abiotic stress, increased income generation, insurance against crop failure, higher return, and total productivity per unit area. Farhad *et al.* (2014). Intercropping's primary goals right now are increased productivity per unit area and production stability. Many studies have indicated that intercropping with different vegetables was more productive and profitable than sole cropping, thanks to the complementary effects of intercrops.

In India, Chilli (*Capsicum annum* L.), sometimes referred to as the "king of spices," is widely grown. The largest producer, user, and exporter of chillies worldwide is India. Around 36% of the world's total production of chillies comes from India. It is eaten like a dry, green chilli. With a production of 34.10 lakh tonnes and a productivity of 12 MT/ha, green chilli is grown on 2.87 lakh hectares. 8.30 lakh hectares are used for dry chilli growing, yielding 18.7 lakh tonnes at a productivity of 2.25 MT/ha (*Horticultural Statistics 2016-17*). Red chillies are mostly sourced from India for the global market. 3.48 lakh tonnes and Rs. 3931.70 crores worth of chilli were exported from India in 2015–16, according to Spice India (*http://www.spiceindia.com*). Chilli is generally grown at a wider distance of 0.6 m × 0.45 m, which makes it suitable for intercropping.

Carrot (*Daucus carota* L.) are a domesticated form of the wild carrot, *Daucus carota*, native to Europe and southwestern Asia. The plant probably originated in Persia and was originally cultivated for its leaves and seeds. The most commonly eaten part of the plant is the taproot, although the greens are sometimes eaten as well. The carrot is a biennial plant in the umbellifer family Apiaceae. Carrots have also a unique combination of three flavonoids: kaempferol, quercetin and luteolin. They are also rich in other phenols,

including chlorogenic, caffeic and phydroxybenzoic acids along with numerous cinnamic acid derivates. Among hydroxycinnamic acid and its derivates, chlorogenic acid represents 42.2% to 61.8% of total phenolic compounds detected in different carrot tissues (Mangla *et. al*., 2021).

Radish (*Raphanus sativus* L.) is one of the most popular root vegetable crops, which is cultivated for its enlarged edible roots. It is a quick growing and short duration vegetable crop suitable for growing both in temperate and tropical climate. Though Western Asia was considered as original home of radish, the variability existing among the cultivated forms in morphology and ecology signifies the multicenter origin of this crop Radish root is a good source of vitamin-C (ascorbic acid) containing 15-40 mg per 100 g of edible portion and supplies a variety of minerals. Trace elements in radish include aluminum, barium, lithium, manganese, silicon, titanium, fluorine and iodine. Tender leaves which are used as greens are rich in vitamin-A and C. Roots are also rich in carbohydrate and protein. Pinked skinned radish is generally richer in ascorbic acid than the white skinned one. The characteristic pungent flavor of radish is due to the presence of volatile isothiocynates (Bose *et al.*, 2000). The juice of newly harvested leaves is beneficial in diuretic and laxative purpose. The average yield of chilli and maximum utilization of land can be increased through the intercropping of chilli with carrot and radish. It's thus important to estimate the performance and ease of the intercropping system among growers. The present study was conducted to estimate the performance of the intercropping system and to find out a suitable combination of chilli intercrop as well as to enhance the productivity and profitable return and to indicate that growing of chili as intercrops is more salutary than growing chilli alone in Prayagraj agro-climatic conditions.

2. MATERIALS AND METHODS

The experiment was conducted at Horticulture Research Farm, Department of Horticulture, Naini Agricultural Institute, Sam Higginbottom University of Agriculture, Technology & Sciences, Prayagraj (U.P.) during November 2021-March 2022. One cultivar of each crop was tried in Randomized Block Design (RBD) with three replications and eight treatment combinations viz. $\mathbf{T_1}$ Sole Chilli @100% RDF, $\mathbf{T_2}$ Sole Carrot @100% RDF, $\mathbf{T_3}$ Sole Radish @100% RDF, $\mathbf{T_4}$ Chilli @ 80% RDF + Carrot @20% RDF, $\mathbf{T_5}$ Chilli @ 80% RDF+ Radish @20% RDF, $\mathbf{T_6}$ Chilli @70% RDF + Carrot @30% RDF, $\mathbf{T_7}$ Chilli @ 70% RDF + Radish @ 30% RDF, $\mathbf{T_8}$ Chilli@60%RDF+Carrot@20%RDF+

Radish @20%RDF. Chilli cv. Suraimukhi, Carrot cv. Samson-196, Radish cv. White Queen these three varieties were used for the experiment. Farm Yard Manure 20 t/ha for chilli, 25 t/ha for carrot and 25 t/ha for radish were applied at the time of field preparation. Nitrogen was supplied through the application of urea and DAP; phosphorus was supplied only through DAP, and potassium was supplied through MOP at various stages of crop growth. In each plot fertilizers were applied as per above- mentioned treatment combination and thoroughly mixed in the soil with the help of khurpi. Thirty days old healthy seedlings of chilli having 4-5 leaves with a height of 15-18 cm were selected and transplanted at the experimental plot and given light irrigation. At each observation, three plants from each plot were randomly selected for chilli and tagged, and for carrot and radish, five plants of each plot were randomly selected at the time of harvesting. The observations were recorded from these plants. The data were subjected to analysis of variance and mean separation was assessed by critical difference (CD) at 5% probability. Data was analyzed using OPSTAT software.

3. RESULTS AND DISCUSSION

3.1 Effect of Intercrops on Green Chilli Yield and Quality on Application of Different level of RDF

It was clearly observed that the intercrops had significantly shown influence on growth and yield of chilli.

3.2 Growth, Yield and Quality Characters of Chilli

The growth, yield, and quality traits of chilli considerably varied depending on the treatment, as shown in Table 1. In terms of growth parameters, the maximum plant height of chilli (71.11 cm) was found in T1 (Sole Chilli @100% RDF) and the minimum plant height (60.21 cm) was recorded in T6 (Chilli @70% RDF + Carrot @30% RDF). Kaur and Sharma, [2] reported that increasing the nitrogen level helped in increasing the plant height. Similarly the highest number of branches plant^{-1} (15.22), maximum leaf area at the time of harvesting (41.56 cm2), lowest number of days taken for 50% flowering (28.67 days), minimum number of days taken to 1st harvest (47.99 days) was recorded in T1 (Sole chilli @ 100% RDF) while the lowest number of branches plant^{-1} (13.95), minimum leaf area at the time of harvesting (36.74 cm^2), highest number

of days taken for 50% flowering (35.33 days), maximum number of days taken to 1st harvest (56.47 days) was recorded in T8 (Chilli @ 60%RDF+Carrot@20%RDF +Radish @20%RDF). When it comes to yield parameters, the maximum fruit length (8.28 cm) was recorded in T1 (Sole Chilli @100% RDF) while the minimum fruit length (8.08 cm) was recorded in T8 (Chilli @ 60%RDF+Carrot@20%RDF +Radish @20%RDF). Correspondingly the maximum fruit girth (3.67 cm), the maximum average fruit weight (5.14 g), maximum number of fruit plant^{-1} (75.99), highest fruit yield plant^{-1} (396.54 g), maximum fruit yield hectare^{-1} (13.09 t) was recorded in T1 (Sole chilli @ 100% RDF) while the minimum fruit girth (3.48 cm), the minimum average fruit weight (4.94 g), minimum number of fruit plant^{-1} (64.24), lowest fruit yield plant^{-1} (316.27 g), minimum fruit yield hectare^{-1} (10.57 t) was recorded in T8 (Chilli @ 60%RDF+Carrot@20%RDF +Radish @20%RDF). Similarly, Tumbare and Niikam, 2004 reported impact of intercropping on main crop. Likewise, the maximum TSS value (8.18 ºBrix) was observed in T1 (Sole chilli @ 100% RDF) while the minimum TSS value (7.72 ºBrix) was observed in T8 (Chilli @ 60%RDF+Carrot@20%RDF +Radish @20%RDF). Intercrops significantly reduced the yield of main crop as compared to sole cropping.

3.3 Yield and Quality Characters of Carrot

Yield and quality characteristics of carrot were significantly differed in different treatments and are mentioned in Table 2. In terms of yield parameters, the maximum root length (12.71 cm) was recorded in T2 (Sole Carrot @100% RDF) and the minimum root length (11.21 cm) was recorded in T8 (Chilli @ 60% RDF + Carrot @ 20% RDF + Radish @ 20 % RDF). Uniformly the maximum root girth (24.09 cm), the maximum root weight without leaves (166.11 g), the maximum root weight with leaves (256.14 g), the maximum root yield without leaves hectare^{-1} (49.83 t) was recorded in T2 (Sole Carrot @100% RDF) while the minimum root girth (21.33 cm), the minimum root weight without leaves (155.34 g), the minimum root weight with leaves (236.90 g), the minimum root yield without leaves hectare^{-1} (37.78 t) was recorded in T8 (Chilli @ 60% RDF + Carrot @ 20% RDF + Radish @ 20 % RDF). Likewise,

the maximum TSS value (8.37 ºBrix) was observed in T2 (Sole Carrot @100% RDF) while the minimum TSS value (7.91 ºBrix) was observed in T8 (Chilli @ 60% RDF + Carrot @ 20% RDF + Radish @ 20 % RDF).For growth, yield and quality parameters, sole cropping pattern of each crop showed best result compared to intercropping combination but when it comes to overall yield, intercropping showed maximum result.

3.4 Yield and Quality Characters of Radish

Yield and quality characteristics of radish were significantly differed in different treatments and are mentioned in Table 3. In terms of yield parameters, the maximum root length (31.05 cm) was recorded in T3 (Sole radish @ 100% RDF) and the minimum root length (26.41 cm) was recorded in T_8 (Chilli @ 60 % RDF + Carrot @ 20 % RDF +Radish @20%RDF). Uniformly the maximum root girth (15.00 cm), the maximum root weight without leaves (226.81 g), the maximum root weight with leaves (342.52 g), the maximum root yield without leaves hectare^{-1} (128.61 t) was recorded in T3 (Sole radish @ 100% RDF) while the minimum root girth (13.58 cm), the minimum root weight without leaves (218.69 g), the minimum root weight with leaves (328.78 g), the minimum root yield without leaves hectare^{-1} (102.38 t) was recorded in T8 (Chilli @ 60 % RDF + Carrot @ 20 % RDF + Radish @ 20 % RDF) .Likewise, the maximum TSS value (6.15 ºBrix) was observed in T3 (Sole radish @ 100% RDF) while the minimum TSS value (4.57 ºBrix) was observed in T8 (Chilli @ 60 % RDF + Carrot @ 20 % RDF + Radish @ 20 % RDF). Similar findings were obtained by Ahamed, 2019). Similarly, Soniya *et al.*, observed that increasing the levels of recommended doses of fertilizers helps in increasing the growth and yield of radish intercropping combination.

3.5 COST BENEFIT ANALYSIS

Considering all the economics of different treatment and intercropping combination in chilli, the net return (Rs. 817969/ha) was maximum in T8 (Chilli @ 60 % RDF + Carrot @ 20 % RDF + Radish @ 20 % RDF). followed by (Rs. 799168/ha) was observed in T6 (Chilli @70% RDF + Carrot @30% RDF) while the minimum net return (Rs. 74626) was observed in T1 (Sole Chilli @ 100% RDF) (Table 4). Although the cost of cultivation of sole chilli, sole carrot

and sole radish was comparatively lower as compared to intercropping combinations but due to the additional yield of the intercropping vegetables the profitability of intercropping was increased over sole cropping. Ijoyah and Dzer [8] reported that the more the combined yields the more the economic return of the intercropping compared to sole cropping. Innazent et al., [9] reported that chilli + amaranth intercropping system provided maximum biological return. The highest benefit cost ratio (BCR) (3.88) was recorded in T8 (Chilli @ 60 % RDF + Carrot @ 20 % RDF + Radish @ 20 % RDF) followed by (3.82) was observed in T6 (Chilli @70 % RDF + Carrot @ 30% RDF) while the minimum benefit cost ratio (1.40) was observed in T1 (Sole Chilli @ 100% RDF). Similarly, Patil et al., [10] observed that turmeric and chilli intercropping combination increased the economics without affecting the growth and yield of main crop turmeric. Kadir et al., [11] observed that chilli and groundnut intercropping systems increased yield, economic and nutritional value. Besides this, many researchers also indicated that intercropping practice gets a higher economic return than the sole cropping practice (Suresha et al.,2007 ; Alom et al., 2008 ; Farhad et al., (2014); Begum et al., Khatun etal.,).

Table 1. Growth, yield and quality of chilli as influenced by chilli, carrot and radish intercropping

Treatments	Plant height (cm)	No. of branches plant^{-1}	Leaf area at harvest (cm^2)	Days taken for 50% flowering	Days taken to 1st harvest	Avg. fruit length (cm)	Avg. fruit girth (cm)	Avg. fruit weight (g)	Avg. no of fruit plant^{-1}	Avg. fruit yield plant^{-1} (g)	Avg. yield hectare^{-1} (t)	TSS (^{o}Brix)
T_1	71.11	15.14	41.56	28.67	47.99	8.28	3.67	5.14	75.99	396.54	13.09	8.18
T_4	66.53	15.05	37.48	30.00	53.07	8.21	3.56	5.11	72.64	368.35	12.3	7.90
T_5	62.25	14.36	37.11	32.67	55.23	8.15	3.55	5.04	68.13	340.99	11.37	7.87
T_6	60.21	15.04	38.00	29.33	52.47	8.29	3.58	5.12	73.85	378.23	12.68	8.07
T_7	67.81	14.22	37.26	32.00	54.77	8.18	3.59	5.10	69.15	350.55	11.67	7.88
T_8	63.71	13.95	36.74	35.33	56.47	8.08	3.48	4.94	64.24	316.27	10.57	7.72
SE(d)±	0.39	0.07	0.58	0.19	0.28	0.02	0.03	0.04	0.29	0.95	0.02	0.03
CD $_{0.05}$	0.94	0.54	1.66	0.55	0.81	0.07	0.1	0.11	0.86	2.74	0.05	0.11

T_1 Sole Chilli @100% RDF, **T_4** Chilli @ 80% RDF + Carrot @20% RDF, **T_5** Chilli @ 80% RDF+ Radish @20% RDF, **T_6** Chilli @70% RDF + Carrot @30% RDF, **T_7** Chilli @ 70% RDF + Radish @ 30% RDF, **T_8** Chilli @ 60%RDF+Carrot@20%RDF+Radish @20%RDF.

Table 2. Yield and quality of carrot as influenced by chilli, carrot and radish intercropping

Treatments	Root length (cm)	Root Girth (cm)	Root weight without leaves plant^{-1} (g)	Root weight with leaves plant^{-1} (g)	Root yield without leaves hectare^{-1} (t)	TSS (^{o}Brix)
T_2	12.74	24.09	166.11	256.14	49.83	8.37
T_4	11.91	22.44	159.94	245.37	39.10	7.92
T_6	12.51	23.25	162.42	252.10	39.77	7.99
T_8	11.21	21.33	155.34	236.90	37.78	7.91
SE(d)±	0.03	0.02	0.16	0.03	0.08	0.18
CD 0.05	0.39	0.06	0.49	0.1	0.26	0.39

T_2 Sole Carrot @100% RDF, **T_4** Chilli @ 80% RDF + Carrot @20% RDF, **T_6** Chilli @70% RDF + Carrot @30% RDF, **T_8** Chilli @ 60%RDF+Carrot@20%RDF+Radish @20%RDF.

Table 3. Yield and quality of radish as influenced by chilli, carrot and radish intercropping

Treatments	Root length (cm)	Root Girth (cm)	Root weight without leaves plant^{-1} (g)	Root weight with leaves plant^{-1} (g)	Root yield without leaves hectare^{-1} (t)	TSS (°Brix)
T_3	31.05	15.00	226.81	342.52	128.61	6.15
T_5	27.69	14.02	220.91	333.87	103.91	5.25
T_7	29.97	14.69	223.49	336.96	104.88	5.46
T_8	26.41	13.58	218.69	328.78	102.38	4.57
SE(d)±	0.56	0.02	0.09	0.11	0.08	0.32
CD 0.05	1.77	0.07	0.29	0.32	0.26	0.83

T_3 Sole Radish @100% RDF, **T_5** Chilli @ 80% RDF+ Radish @20% RDF, **T_7** Chilli @ 70% RDF + Radish @ 30% RDF, **T_8** Chilli @ 60%RDF+Carrot@20%RDF+Radish @20%RDF.

Table 4. Economics of intercropping of carrot and radish with chilli per hectare

Treatments	Gross return (Rs. /ha)	Cost of cultivation (Rs. /ha)	Net return (Rs. /ha)	B:C Ratio
T_1	261845	187219	74626	1.4
T_2	499080	188137	310943	2.65
T_3	641475	176467	465008	3.64
T_4	617193	240808	376386	2.56
T_5	764350	229949	534401	3.32
T_6	630202	241462	388740	2.61
T_7	776441	230398	546043	3.37
T_8	1101506	283537	817969	3.88

T_1 Sole Chilli @100% RDF, **T_2** Sole Carrot @100% RDF, **T_3** Sole Radish @100% RDF, **T_4** Chilli @ 80% RDF + Carrot @20% RDF, **T_5** Chilli @ 80% RDF+ Radish @20% RDF, **T_6** Chilli @70% RDF + Carrot @30% RDF, **T_7** Chilli @ 70% RDF + Radish @ 30% RDF, **T_8** Chilli @ 60%RDF+Carrot@20%RDF+Radish @20%RDF

4. CONCLUSION

From the study it was concluded that intercropping practices of carrot and radish with chilli at different nutrient levels showed morepotential than sole cropping for increasing theproductivity without hindering the yield of main crop chilli. Results showed that providing higher levels of nutrients helped in increasing the growth, yield and quality, which directly helped inincreasing the economics. The highest economicreturn and the best B:C ratio was obtained in T8 (Chilli @ 60 % RDF + Carrot @ 20 % RDF + Radish @ 20 % RDF) due to addition of yield of two different intercrops. Hence the treatment T8 (Chilli @ 60 % RDF + Carrot @ 20 % RDF + Radish @ 20 % RDF) is best suited for the farmers under Prayagraj agro-climatic Conditions in terms of land use efficiency, yield and net return.

5. REFERENCES

Alom MS, Paul NK, Quayyum M A. **(2008)** Performance of hybrid maize (*Zea mays* L.) under intercropping systems with mungbean in different planting methods. *SAARC J. Agric*.;6: 73-82.

Begum SA, Zaman MS, Khan ASMMR. (2015) Intercropping of root crops with chilli in charlands of Mymensingh. Progressive Agriculture.26:109-114.

Bose, T. K. Kabir, J. Das, P. and Joy, P. P. (2000), Tropical Horticulture, Volume-1 Naya Prokash, Calcuta. Pp. 145.

Farhad ISM, Chowdhury MMU, Bhowal SK, Choudhury AK, Khan AS. (2014) Chilli–garlic intercropping system in coastal saline area. App. Sci. Report. PSCI Publications. 2(2):47-50.

Ijoyah MO and Dzer DM. (2012) Yield performance of okra (Abelmoschus esculentus L. Moench) and maize (Zea mays L.) as affected by time of planting maize in Makurdi. Nigeria. ISRN Agron. 2012;7.

Innazent A, Anitha S, Thomas CG, Prameela KP, Beena (2018) VI. Biological efficiency of chilli + amaranth intercropping system under fertigation. Journal of Tropical Agriculture. 2018;56(2): 201-205

Kadir M, Rahman J, Riad MI, Alam MK (2021). Intercropping chilli with groundnut in char land. Tropical Agroecosystem (TAEC). 2021;2(2):79-81.

Khatun MF, Islam MS, Ali MA, Ali MO, Ahmed QM. (2020) Intercropping Garlic (*Allium sativum* L.) with Chilli (*Capsicum annum* L.) in the Haor area of Kishoreganj. Bangladesh *Agron. J.* 23(1):75- 81.

Mangla, N., S., Srivastava, R., and Yadav, Indranil (2021) Study of different varietis of carrot and its benefits for human health: A review , *Journal of Pharmacognosy and Phytochemistry* 10(1): 1293-1299.

Patil PM, Chougala DC, Adarsh HS. (2020) Turmeric + chilli Intercropping: Way towards doubling farmers income. International Journal of Science and Research. 2020;10(5):655-657.

Soniya T, Kamalakannan S, Maheswari TU, Sudhagar R. (2021) Effect of intercropping on growth and yield of tomato (*Solanum lycopersicum* L.). *Annals of Plant and Soil Research*. 23(1):36-41.

Suresha BA, Allolli TB, Patil MG, Desai BK, Hussain S A. (2007) Yield and economics of chilli based intercropping system. Karnataka J. Agric. Sci.;20(4):807- 809.