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Research Paper

Impact of cumin (*Cuminum cyminum* L.) based intercropping system and its residual influence on summer greengram (*Vigna radiata* L. Wilczek)

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ABSTRACT

The cumin (*Cuminum cyminum* L.) based intercropping system and its residual impact was studied on summer-greengram (*Vigna radiata* L. Wilczek) over the years in split-plot design. n pooled results application of FYM @ 5 t/ha + 75% RDF to cumin recorded significantly higher seeds, stover yield, cumin equivalent yield, number of umbels/plant, number of umbellate/ umbel and number of seeds/umbellate, while, in intercropping most of all yield attributing parameters were significantly higher with cumin + leafy fenugreek (2:1) intercropping. The highest gross return, net return and BCR were obtained with application of FYM @ 5 t/ha + 75% RDF and intercropping of cumin with leafy fenugreek (2:1) in a paired row of cumin at 20 cm. In summer greengram, the residual effect of fertilizers applied to cumin and intercropping of leafy fenugreek (2:1) was found significant on plant height, number of branches/plant, pods/plant, seeds/pod, seed yield, stover yield and quality attributes. The maximum system productivity, gross return, net return and BCR were achieved with the treatment combination of FYM @ 5 t/ha + 75% RDF with intercropping of cumin + leafy fenugreek (2:1) in paired row of cumin and 75% RDF with *Rhizobium* to following greengram.

Key words: Cumin, Equivalent yield, Intercropping, Leafy coriander, Leafy fenugreek, System Productivity

INTRODUCTION

Cumin is extensively cultivated in India, Iran, Turkey, Egypt, Syria, China and Pakistan. In India, during 2016-17, the area and production of cumin were 7.60 lakh hectares and 4.86 lakh tonnes, respectively, with an average productivity of 640 kg/ha, which was the highest in the world (DASD, 2017). Gujarat, Rajasthan, Uttar Pradesh, and Punjab are the leading states for growing cumin in India. During 2016-17, the area and production of spices in Gujarat were 5.02 lakh hectares and 8.68 lakh tonnes, respectively. Whereas, the area under cumin cultivation was reported to be 2.78 lakh hectares and production 2.84 lakh tonnes with an average productivity of 1022 kg/ha (DOA 2017). Fenugreek leaves and seeds are consumed for different purposes, such as medicinal uses, making food, roasted grain as a coffee substitute and coriander, also known for their medicinal properties and are considered carminative, diuretic tonic, stomachicant bilious, refrigerant and aphrodisiac. Green gram (*Vigna radiata L.* Wilczek) is one of the major pulse crops in India, which is cultivated in arid and semi-arid regions. In the present circumstance, it is not possible to increase production without bringing additional area under cultivation. Therefore, there is an urgent need to enhance the productivity of the system. The system productivity can be increased by using available area through vertical expansion of enterprises or intensification of the cropping system. The intercropping system is a very important avenue in this direction, which aims at increasing productivity per unit area per unit time and insurance against total crop failure under aberrant weather conditions (Mullick *et al.* 1993). Wide spacing and slow-growing nature during the initial growth period of cumin, with leafy coriander and leafy fenugreek make it possible to raise short-duration intercrops in between the rows. Leafy fenugreek as an intercrop has been reported to enhance the productivity and profitability per unit area in winter maize (*Zea mays* L.) as compared to its sole cropping (Singh and Kumar 2002). The emerging scenario necessitates the need for the adoption of practices that maintain soil health, make the production system more sustainable and provide quality food for meeting the nutritional

requirements. Keeping in this view of facts, the present investigation was carried out to find out the feasibility of leafy coriander and leafy fenugreek as intercrop in cumin with nutrient management and its residual effect on succeeding greengram.

MATERIAL AND METHODS

The field experiment was laid out during the *Rabi* and summer seasons of 2019-20 and 2020-21 at Agronomy Instructional Farm, Chimanbhai Patel College of Agriculture, Sardarkrushinagar Dantiwada Agricultural University, Sardarkrushinagar, District: Banaskantha (Gujarat). The soil was loamy sand in texture, neutral in soil reaction (7.15 pH), with low organic carbon (0.14) and available nitrogen (142 kg/ha), medium in available phosphorus (35 kg/ha) and potash (240 kg/ha). There were 21 treatment combinations during *rabi* consisting of three levels of nutrient management (Main plot), *i.e.,* (F_1: FYM @ 10 t/ha, F_2: Only RDF of crop and F_3: FYM @ 5 t/ha + 75% RDF) and seven intercropping treatments (Sub-plot) (C_1: Cumin sole, C_2: Coriander sole (leafy vegetable), C_3: Fenugreek sole (leafy vegetable), C_4: Cumin + leafy coriander (1:1), C_5: Cumin + leafy fenugreek (1:1), C_6: Cumin + leafy coriander (2:1) in paired row of cumin at 20 cm, C_7: Cumin + leafy fenugreek (2:1) in paired row of cumin at 20 cm were tried in split plot design with three replications. During summer seasons, again the subplot was divided into two equal plots and the two levels of nutrient management were tested with F_1:100 per cent RDF + *biofertilizer* and F_2: 75 percent RDF + *biofertilizer* to study the residual effect of nutrient management of previous cumin and leafy coriander and leafy fenugreek intercrops. Biofertilizers used in greengram enhance nitrogen fixation naturally, improve soil fertility and structure, increase crop yield and reduce dependence on chemical fertilizers. It is used by seed treatment with biofertilizers (*Rhizobium*) in greengram (*Rhizobium* @ 10 ml per kg seed). The data were analyzed in a double split design. The seeds of the variety *cv.* Gujarat Cumin 4, GDLC 1 and GM 2 during *rabi* and greengram in summer season were sown manually as per treatments with seed rate of 12, 15, 15 and 18 kg/ha, respectively for cumin, leafy coriander, leafy fenugreek and greengram (Intercropping spacing cumin 30 cm in replacement series and 20 cm paired row of cumin in additive series) The cutting of leafy coriander and leafy fenugreek crop was done at 45 and 60 DAS. All the cultural operations were carried out as per the needs of crops and as per the recommendations of both the season's crops. Observations on growth attributes, yield components, and yield were recorded for cumin, leafy coriander, leafy fenugreek and greengram at harvest. The data have been analyzed for individual years as well as pooled as per standard procedure. The cumin equivalent yield was calculated by the following equation for respective treatments for both years.

$$CEY\ (kg/ha) = (Yc \times Pc) + (Ycs \times Pcs) + (Yc/f \times Pc/f) / Pc$$

Where, CEY = Cumin equivalent yield, Yc = Yield of cumin, Pc = Price of cumin, Ycs = Yield of cumin stover, Pcs = Price of cumin stover,Yc/f = Yield of coriander or fenugreek as an intercrop, and Pc/f = Price of coriander or fenugreek.

Statistical analysis of the data generated during the course of investigation was carried out through software on a computer following the procedure described by Cochran and Cox (1967). The variances of different sources of variation in ANOVA were tested by the F-test and compared with the value of Table 'F' at 5% level of significance. The pooled analysis of the two years' data was carried out as per the procedure suggested by Cochran and Cox (1967) a fixed site and the same randomization of the treatments for both years.

RESULTS AND DISCUSSION

The cumin growth metrics benefited from the application of nutrition management. The plant height (27.7 cm) and number of branches/plant (7.36) were considerably higher when FYM @ 5 t/ha + 75% RDF was applied. The treatment of FYM @ 5 t/ha + 75% RDF also resulted in a significant increase in cumin yield parameters, including number of umbels/plant (25.47), number of umbellets/umbel (3.73), number of seeds/umbel (5.06) and seed yield (517 kg/ha) (Table 1). The per cent increase in seed yield with the application of FYM @ 5 t/ha + 75% RDF was to the tune of 7.3 per cent over FYM @ 10 t/ha in pooled results. In the case of intercropping, results showed that all the growth and yield attributing parameters of cumin were influenced significantly by different intercropping systems (Table 1). Intercropping of cumin + leafy fenugreek (2:1) (paired row of cumin at 20 cm) recorded significantly higher number of branches per plant (7.69), number of umbels per plant (25.85), number of umbellates per umbel (3.88) and number of seeds per umbellate of cumin (5.16), which were at par with all other treatments, expect cumin sole. Significantly higher per cent increase in

seed yield under cumin + leafy fenugreek (2:1) with a paired row of cumin at 20 cm was to the tune of 2.5 per cent over sole cumin. The increase in plant height due to nutrient management may be due to the synergistic effect of inorganic and organic nutrient management may be ascribed to the greater uptake of nutrients by the plants, favoring better cell division, elongation, amino acid and protein synthesis. The improvement in morphological as well as photosynthetic parameters was due to nutrient (RDF) application, as it could have resulted in better light interception and utilization of radiant energy. A similar finding was reported by Choudhary *et al.* (2006) in cumin and Tripathi *et al*. (2019) in pigeonpea for growth parameters. The increase in seed yield under integrated nutrient management might be due to FYM had increased the soil organic matter and improved the soil structure, water holding capacity and biological activity of the soil. These findings are in accordance with the findings of Mehta *et al*. (2012) in fenugreek and Bedse *et al*. (2013) in cumin. Significantly higher number of branches per plant of cumin was recorded with cumin + leafy fenugreek (2:1) under paired row cropping system (7.69) in pooled. Intercropping of cumin + leafy fenugreek (2:1) (paired row of cumin at 20 cm) recorded significantly higher number of umbels per plant (25.85), number of umbellates per umbel (3.88) and number of seeds per umbellate of cumin (5.16) in the pooled. Significantly higher seed yield (614 kg/ha), which was at par with cumin + leafy coriander (2:1) (paired row of cumin at 20 cm) (606 kg/ha) and cumin sole (599 kg/ha) in pooled analysis. The per cent increase in seed yield under cumin + leafy fenugreek (2:1) (paired row of cumin at 20 cm) was to the tune of 2.5 per cent over sole cumin in pooled results. The higher yield attributes under cumin + leafy fenugreek (2:1) might be due to more space available to cumin in a 2:1 row ratio (additive series) and nutrients available for growth and development of cumin, which led to higher photosynthesis owing to greater exposure of the cumin crop to sunlight. It might also be due to a conducive environment created by intercrop (fenugreek) as it fixed atmospheric nitrogen and increased its availability in soil, which might have also been utilized partly by the cumin crop for better growth and development and ultimately increased the growth and yield attributes. Similar results were also reported by Awasthi *et al.* (2011) in the intercropping of fennel with chickpea.

In case of intercrops yield, application of FYM @ 5 t/ha + 75% RDF to crops recorded the highest fresh weight and dry weight of 2439 and 439 kg/ha at 45 DAS, 1201 and 224 kg/ha at 60 DAS and 3640 and 550 kg/ha total fresh and dry weight, respectively for leafy coriander (Table 2). The same treatment also recorded significantly higher fresh fenugreek leaves weight (2788, 1434 and 4221 kg/ha) at 45 DAS at 60 DAS, and total fresh weight, respectively, while 503, 271 and 774 kg/ha dry weight at 45 DAS at 60 DAS and total dry weight, respectively. Similar observations were also made earlier in fenugreek (Godara *et al.* 2014, Sahu *et al.* 2020) and coriander (Jhankar *et al.* 2017. The fresh and dry weight at 45, 60 DAS and total weight did not exert its significant effect among the intercropping of leafy coriander and leafy fenugreek with cumin in different row ratios. The reduction in the yield parameters under 1:1 and 2:1 row ratios might be due to competition between the component crops for nutrients, light and water, which might have affected the growth of leafy coriander and leafy fenugreek. The results confirmed those reported by Tripathi and Dwivedi (2009), and Boori *et al.* (2017) in fennel and Padanad (2018) in intercropping of vegetables with seed spices.

Residual effect on succeeding greengram

Application of fertilizer FYM @ 5 t/ha + 75% RDF recorded significantly higher seed yield (701 kg/ha) and stover yield (1104 kg/ha) during the second year (Table 3). The residual effect of intercropping of cumin with leafy coriander or leafy fenugreek with different row ratios in replacement series or in additive series was found to be non-significant to seed yield and stover yield of succeeding greengram in pooled results. Application of different levels of RDF to greengram had no significant effect on seed yield and stover yield of succeeding greengram. Significantly higher yield in the second year may be due to the residual and cumulative effects of organic and inorganic sources applied to the cumin crop in the two seasons. The nitrogen, phosphorus and other nutrients released from organic sources, which built up their available status and effects its may have increased vegetative growth of greengram (Khan and Khalil 2014). Application of 100 % RDF with biofertilizer to summer greengram recorded numerically higher branches per plant (5.03), pods per plant (22.63), seed per pod (7.34), seed yield (732 kg/ha) and stover yield (1121 kg/ha) in pooled results over 75% RDF. Significantly higher crop growth and yield attributes and yield in the second year may be due to the residual and cumulative effects of organic and inorganic sources

Table 1. Growth, yield and yield attributes of cumin as influenced by nutrient management and intercropping (Pooled data)

Treatment	Plant height (cm)	No. of branches/plant	No. of umbels/ plant	No. of umbellates/ umbel	No. of seeds/ umbellate	Seed yield (kg/ ha)
(a) Nutrient management (F)						
F_1 : Only FYM @ 10 t/ha	26.23	6.60	24.12	3.34	4.61	483
F_2 : Only RDF of crop	26.99	7.47	24.05	3.29	4.56	469
F_3 : FYM @ 5 t/ha + 75% RDF	27.70	7.36	25.47	3.73	5.06	517
SEm± (R)	0.39	0.13	0.36	0.07	0.09	8.63
CD at 5% (R)	1.27	0.43	1.16	0.24	0.28	28
CV (%)	7.93	9.94	7.92	11.50	9.85	9.66
(b) Intercropping (C)						
C_1 : Cumin sole	26.09	6.67	22.58	2.92	4.33	599
C_4 : Cumin + Coriander (1:1)	26.88	7.07	24.32	3.37	4.43	308
C_5 : Cumin + Fenugreek (1:1)	27.31	7.44	25.36	3.61	4.98	320
C_6 : Cumin + Coriander (2:1) (Paired row of cumin at 20 cm)	27.04	7.29	24.63	3.48	4.81	606
C_7 : Cumin + Fenugreek (2:1) (Paired row of cumin at 20 cm)	27.54	7.69	25.85	3.88	5.16	614
SEm±	0.50	0.13	0.45	0.07	0.09	8.68
CD at 5%	NS	0.38	1.28	0.20	0.26	25
Interaction F × C	NS	NS	NS	NS	NS	NS
SEm±	0.86	0.23	0.78	0.12	0.16	15.03
CV (%)	7.82	7.91	7.79	8.81	8.32	7.52

Table 2. Fresh weight and dry weight of leafy fenugreek as influenced by nutrient management and cumin based intercropping (Pooled data)

Treatment	Leafy coriander						Leafy fenugreek					
	Fresh weight of plant (kg/ha)			Dry weight of plant (kg/ha)			Fresh weight of plant (kg/ha)			Dry weight of plant (kg/ha)		
	45 DAS	60 DAS	Total	45 DAS	60 DAS	Total	45 DAS	60 DAS	Total	45 DAS	60 DAS	Total
(a) Nutrient management (F)												
F_1 : Only FYM @ 10 t/ha	2218	1091	3309	381	194	494	2483	1279	3762	444	239	684
F_2 : Only RDF of crop	2358	1155	3513	355	181	518	2631	1365	3995	485	260	745
F_3 : FYM @ 5 t/ha + 75% RDF	2439	1201	3640	439	224	550	2788	1434	4221	503	271	774
SEm± (R)	48.44	23.67	72.02	11.51	6.08	10.10	80.45	41.22	122	13.45	7.32	20.76
CD at 5% (R)	158	77	235	38	20	33	262	134	397	43.87	23.88	67.70
CV (%)	8.79	8.74	8.76	12.46	12.92	8.23	12.96	12.87	12.93	11.95	12.11	12.00
(b) Intercropping (C)												
C_2 : Coriander (Leafy vegetable)-Sole	3913	1923	5836	642	328	843	4425	2283	6708	801	430	1232
C_4 : Cumin + Coriander (1:1)	1431	703	2134	255	130	341	1657	854	2511	297	160	457
C_6 : Cumin + Coriander (2:1) (Paired row of cumin at 20 cm)	1671	821	2492	277	141	378	1819	940	2759	334	180	514
SEm±	45.92	22.39	68.29	10.27	5.43	9.68	68.21	34.66	102.91	11.60	6.33	17.91
CD at 5%	134	65	199	30	16	28	199	101	300	33.85	18.47	52.29
Interaction F × C	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
CV (%)	8.33	8.27	8.31	11.13	11.53	7.89	10.99	10.82	10.93	10.30	10.46	10.35

applied to the cumin crop in the two seasons. The residual effect of these inputs on the succeeding greengram crop will be more pronounced compared to a monoculture system or fertilizer application alone. The organic matter from FYM, coupled with the nitrogen fixation from intercropped legumes, helps maintain nutrient levels in the soil, ensuring that greengram has access to adequate nutrients, particularly nitrogen, for its growth. The additive series intercropping likely provides the most favorable conditions for greengram's growth, as both crops contribute to overall soil health and fertility. The nitrogen, phosphorus and other nutrients released from organic sources, which built up their available status and effects its may have increased vegetative growth of greengram (Khan and Khalil 2014).

Cumin equivalent yield

Different treatments significantly influenced the cumin equivalent yield during the period of investigation and on a pooled basis also (Table 4). Significantly highest cumin equivalent yield during the first year was recorded with application of only RDF to the crop (710 kg/ha), while it was significantly highest in the second year and pooled results by application of FYM @ 5 t/ha + 75% RDF (609 and 630 kg/ha, respectively). The increase in cumin equivalent yield with treatment of FYM @ 5 t/ha + 75% RDF supply could be explained on the basis of the beneficial effects of FYM and RDF application on the yield contributing characters of cumin, like umbels per plant, umbellate per umbel and seeds per umbel of crops. The combination of FYM and RDF works synergistically. While FYM enhances soil organic matter and microbial activity, RDF provides a more immediate, targeted nutrient supply. This combination ensures that the plant receives both long-term soil fertility benefits (from FYM) and short-term nutrient availability (from RDF).

Similar results were also reported by Bedse *et al.* (2013) in cumin. Intercropping systems brought significant differences in the cumin equivalent yield. Cumin equivalent yield in intercropping systems having an additive series was higher than their respective sole crop yields, as well as intercropping with replacement series. Among the different intercropping systems, cumin intercropping with fenugreek (2:1) having paired row of cumin recorded significantly highest CEY (934 and 830 kg/ha) in first year and in pooled results, while significantly higher (727 kg/ha) during the second year, which was at par with Cumin + Coriander (2:1) (Paired row of cumin at 20 cm) (709 kg/ha). The higher CEY in the intercropping system was on account of the additional yield of the component crop without much reduction in the yield of the base crop, resulting in a higher cumin equivalent yield. The higher CEY observed in intercropping systems is a result of the efficient use of resources, reduced competition between crops, improved pest and disease management and enhanced soil health. By integrating different crops that complement each other's growth, the system improves the overall productivity of the land without causing significant yield loss in the base crop (cumin). This leads to higher total yields per unit area, making intercropping an attractive farming practice that combines both ecological sustainability and economic profitability. Similarly, Mehta *et al.* (2015) reported higher fennel equivalent yield in intercropping as compared to sole crops.

System productivity

Application of FYM @ 5 t/ha + 75% RDF recorded the significantly highest system productivity of 1347 and 1418 kg/ha during 2020-21 and in pooled results, which is consistent with findings that suggest organic amendments like FYM combined with reduced chemical fertilizers can improve soil health, nutrient availability, and crop yields (Bhattacharyya 2015). The significantly lower system productivity was recorded with the application of RDF to the crop in preceding cumin, likely due to nutrient imbalances or limited organic matter (Table 5), which can affect soil microbial health and nutrient availability (Singh 2020). In case of intercropping of cumin with leafy coriander or leafy fenugreek, intercropping of cumin with coriander (2:1) in paired row of cumin at 20 cm (C_6) recorded significantly higher system productivity (1718 kg/ha), which was at par with cumin + fenugreek (2:1) in paired row of cumin at 20 cm (1707 kg/ha) during first year. During second year and in pooled results the intercropping of cumin with leafy fenugreek (2:1) under paired row of cumin recorded significantly higher system equivalent yield (1452 and 1580 kg/ha) showing that intercropping enhances overall productivity due to complementary resource use (e.g., nitrogen fixation by legumes) and increased biodiversity, which optimizes light, water and nutrient availability (Willey 1979), which was at par with C_6 (1435 and 1576 kg/ha, respectively) in which intercropping of cumin with coriander (2:1) under paired row of cumin was taken. The per

Table 3. Seed yield and stover yield of succeeding greengram as influenced by nutrient management and residual effect of cumin based intercropping

Treatment			Seed yield (kg/ha)			Stover yield (kg/ha)		
			2019-20	2020-21	Pooled	2019-20	2020-21	Pooled
(a)	**Nutrient management (F)**							
F_1	:	Only FYM @ 10 t/ha	767	676	722	1156	1049	1102
F_2	:	Onl yRDF of crop	788	654	721	1171	1031	1101
F_3	:	FYM @ 5 t/ha+75% RDF	777	701	739	1167	1104	1135
SEm±			10.89	10.57	3.87	20.08	18.02	13.55
CD at 5%			NS	41.48	NS	NS	70.76	NS
CV (%)			9.08	10.12	9.06	11.17	11.01	7.89
(b)	**Intercropping (C)**							
C_1	:	Cumin Sole	780	681	730	1179	1073	1126
C_2	:	Coriander (Leafy vegetable)-Sole	771	668	720	1130	1038	1084
C_3	:	Fenugreek (Leafy vegetable)-Sole	768	663	715	1096	1004	1050
C_4	:	Cumin+Coriander (1:1)	780	677	729	1169	1051	1110
C_5	:	Cumin+Fenugreek (1:1)	774	673	724	1154	1053	1104
C_6	:	Cumin+Coriander (2:1) (Paired row of cuminat 20cm)	785	689	737	1213	1097	1155
C_7	:	Cumin + Fenugreek (2:1) (Paired row of cumin at 20cm)	784	688	736	1213	1112	1163
SEm± (R)			15.67	14.22	9.84	28.28	25.30	16.89
CD at 5% (R)			NS	NS	NS	NS	NS	NS
CV (%)			8.55	8.91	5.74	10.30	10.12	6.44
(c)	**Greengram(R)**							
R_1	:	100% RDF+ Biofertilizer	783	681	732	1172	1071	1121
R_2	:	75% RDF+ Biofertilizer	772	673	722	1158	1051	1104
SEm± (R)			6.59	7.73	5.09	13.19	12.14	8.43
CD at 5% (R)			NS	NS	NS	NS	NS	NS
Interaction: F×C, F×R, C× R, F×C×R			NS	NS	NS	NS	NS	NS
CV (%)			6.73	9.06	5.56	8.99	9.08	6.01

Table 4. Cumin equivalent yield as influenced by different treatments of the cumin based intercropping

Treatment			Cumin equivalent yield (kg/ha)		
			2019-20	2020-21	Pooled
(a)	**Nutrient management (F)**				
F_1	:	Only FYM @ 10 t/ha	613	547	580
F_2	:	Only RDF of crop	710	459	585
F_3	:	FYM @ 5 t/ha + 75% RDF	652	609	630
SEm± (R)			11.54	13.68	8.95
CD at 5% (R)			45	54	29
CV (%)			8.03	11.64	9.69
(b)	**Intercropping (C)**				
C_1	:	Cumin sole	681	523	602
C_2	:	Coriander (Leafy vegetable)-Sole	469	429	449
C_3	:	Fenugreek (Leafy vegetable)-Sole	535	497	516
C_4	:	Cumin + Coriander (1:1)	523	426	474
C_5	:	Cumin + Fenugreek (1:1)	574	457	516
C_6	:	Cumin + Coriander (2:1) (Paired row of cumin at 20 cm)	893	709	801
C_7	:	Cumin + Fenugreek (2:1) (Paired row of cumin at 20 cm)	934	727	830
SEm±			13.74	13.12	9.50
CD at 5 %			39	38	27
Interaction F × C			NS	NS	NS
SEm±			23.81	22.73	16.46
CV (%)			6.26	7.32	6.74

Table 5. Effect of nutrient management and cumin based intercropping system on system productivity

Treatment			Cumine quivalent yield of system (kg/ha)		
			2019-20	2020-21	Pooled
(a)	**Nutrient management (F)**				
	F_1	: Only FYM @ 10 t/ha	1419	1258	1338
	F_2	: Only RDF of crop	1515	1147	1331
	F_3	: FYM @ 5 t/ha+75% RDF	1490	1347	1418
SEm± (R)			18.70	18.78	4.55
CD at 5% (R)			73	74	19
CV (%)			8.22	9.73	2.17
(b)	**Intercropping (C)**				
	C_1	: Cumin Sole	1551	1240	1395
	C_2	: Coriander (Leafy vegetable)-Sole	1278	1131	1205
	C_3	: Fenugreek (Leafy vegetable)-Sole	1340	1193	1266
	C_4	: Cumin+Coriander (1:1)	1342	1138	1240
	C_5	: Cumin+Fenugreek (1:1)	1387	1165	1276
	C_6	: Cumin+Coriander (2:1) (Paired row of cumin at 20cm)	1718	1435	1576
	C_7	: Cumin + Fenugreek (2:1) (Paired row of cumin at 20cm)	1707	1452	1580
SEm± (R)			18.05	18.67	11.62
CD at 5% (R)			52	54	33
CV (%)			5.19	6.33	3.62
(c)	**Greengram (R)**				
	R_1	: 100% RDF+ Biofertilizer	1495	1255	1375
	R_2	: 75% RDF+ Biofertilizer	1454	1246	1350
SEm± (R)			6.59	7.66	5.08
CD at 5% (R)			19	NS	15
Interaction: F×C, F×R, C× R, F×C×R			NS	NS	NS
CV (%)			3.55	4.86	2.96

Table 6. Effect of nutrient management and cumin based intercropping on economics of crop sequence

Treatment			Gross return (₹/ha)	Cost of cultivation (₹/ha)	Net profit (₹/ha)	BCR
(a)	**Nutrient management (F)**					
	F_1	:Only FYM @ 10 t/ha	120423	77105	43318	1.56
	F_2	:Only RDF of crop	121185	73047	48138	1.66
	F_3	:FYM @ 5 t/ha + 75% RDF	128282	75562	50720	1.70
(b)	**Intercropping (C)**					
	C_1	:Cumin Sole	123808	74833	48976	1.65
	C_2	:Coriander (Leafy vegetable)-Sole	103700	69397	34303	1.49
	C_3	:Fenugreek (Leafy vegetable)-Sole	112109	68588	43522	1.63
	C_4	:Cumin+Coriander (1:1)	107254	78106	29149	1.37
	C_5	:Cumin+Fenugreek (1:1)	112289	77701	34589	1.45
	C_6	: Cumin+Coriander (2:1) (Paired row of cumin at 20cm)	150081	79224	70858	1.89
	C_7	: Cumin + Fenugreek (2:1) (Paired row of cumin at 20cm)	153831	78819	75013	1.95
(c)	**Greengram (R)**					
	R_1	:100% RDF + Biofertilizer	123014	75617	47997	1.63
	R_2	:75% RDF + Biofertilizer	123579	74960	48620	1.65

cent increase in system equivalent yield under C_7 to the tune of 13.3 % over sole cropping of cumin and 23.8% over intercropping of cumin with leafy fenugreek (2:1) in pooled result, Showing the synergistic benefits of intercropping, particularly in nutrient cycling and pest suppression, which are known to lead to improved yield stability and higher total production in mixed cropping systems (Natarajan 2020). Application of 100% RDF + biofertilizer (R_1) to succeeding summer greengram recorded significantly the highest system equivalent yield (1495 and 1375 kg/ha, respectively) during the first year and in pooled results supporting the idea that biofertilizers enhance nutrient uptake and improve soil microbial activity, leading to higher yields (Ghosh 2019).

Economics

Application of FYM @ 5 t/ha + 75% RDF (F_3) recorded the highest gross return (₹ 1,28,282/ha) and net return (₹ 50,720/ha), while intercropping of cumin + leafy fenugreek (2:1) in paired row of cumin at 20 cm registered highest gross return (₹ 1,53,831/ha) and net return (₹ 75,013/ha) and these were closely followed by intercropping of cumin + leafy coriander (2:1) in paired row of cumin at 20 cm. While application of 75% RDF + biofertilizer in summer green gram recorded the highest gross (₹ 1,23,579/ha) and net profit (₹ 48,620/ha) (Table 6)

CONCLUSION

Based on two-year experimentation, it can be concluded that for achieving higher cumin equivalent yield, net return and better land utilization, cumin should be intercropped with leafy fenugreek (2:1) in a paired row system (20-40-20 cm) of cumin and fertilized with FYM @ 5 t/ha + 75% RDF (30-11.25-00, N-P_2O_5-K_2O kg/ha). For achieving higher system productivity, net return and better residual effect of cumin intercropping with leafy fenugreek (2:1) in paired row of cumin, *rabi* crops should be fertilized with FYM @ 5 t/ha + 75% RDF (30-11.25-00, N-P_2O_5-K_2O kg/ha) and summer greengram should be fertilized with 75% RDF (15-30-00, N-P_2O_5-K_2O kg/ha) alongwith seed treatment of *Rhizobium* @ 10 ml per kg seeds.

REFERENCES

Awasthi UD, Tripathi AK, Dubey SD and Kumar S. 2011. Effect of row ratio and fertility levels on growth, productivity, competition and economics in chickpea + fennel intercropping system under scarce moisture condition. Journal of Food Legumes **24**: 211-214.

Bedse RD, Amin AU, Raval CH and Vaghela SJ. 2013. Effect of rate and time of nitrogen application on growth, yield and economics of cumin (*Cuminum cyminum* L.) under loamy sand soil. An Asian Journal of Soil Science **8**(1): 45-47.

Bhattacharyya R. 2015. Effect of organic amendments on soil quality and crop productivity. Agricultural Systems **135:** 135-146.

Boori PK, Shivran AC, Meena S and Giana GK. 2017. Growth and productivity of fennel (*Foeniculum vulgare* Mill.) as influenced by intercropping with fenugreek (*Trigonella Foenum-graecum L.*) and sulphur fertilization. Agricultural Science Digest **37**(1): 32-36.

Choudhary GR, Jain NK and Jat NL. 2006. Response of cumin (*Cuminum cyminum L.*) to inorganic nitrogen, farmyard manure and biofertilizer. Indian Journal of Agronomy **51**(4): 334-336.

Cochran WG and Cox GM. 1967. Experimental Designs, John Willey and Sons Incorporation, New York. Pp. 546-568.

Ghosh P. 2019. The role of biofertilizers in sustainable agriculture. Indian Journal of Agricultural Sciences **89**(1): 1-9.

Godara AS, Gupta US, Lal G and Singh R. 2014. Influence of organic and inorganic source of fertilizers on growth, yield and economics of coriander (*Coriandrum sativum* L.). International Journal of Seed Spices **4**(2): 77-80.

Jhankar P, Panda CM and Sethi D. 2017. Effect of INM practices on yield, yield attributes and economics of coriander (*Coriandrum sativum* L.). International Journal of Current Microbiology and Applied Sciences **6**(5): 1306-1312.

Khan S and Khalil SK. 2014. Integrated use of organic and inorganic fertilizers in wheat and their residual effect on subsequent mung bean. International Journal of Farming and Allied Sciences **3**(8): 835-844.

Mehta RS, Anwer MM and Malhotra SK. 2012. Influence of sheep manure, vermicompost and biofertilizer on growth, yield and profitability of cumin (*Cuminum cyminum* L.) production. Journal of Spices and Aromatic Crops **21**(1): 16-19.

Mehta RS, Singh B, Meena SS, Lal G, Singh R and Aishwath OP. 2015. Fennel (*Foeniculum vulgare* Mill.) based intercropping for higher system productivity. International Journal of Seed Spices **5**(1): 56-62

Mullick SP, More SM, Despandey SS and Patil JD. 1993. Intercropping for better stability in dryland water sheds. Indian Journal of Agronomy **38**(4): 527-530.

Natarajan S. 2020. Intercropping in sustainable agricultural systems. Sustainable Agriculture Reviews **41:** 119-148

Padanad LA, Yashvanta kumar KH, Arun Kumar B, Naik KR, Shreedhar D and Patil S. 2018. Effect of intercropping of vegetable with seed spices on yield and economics under northern Karnataka region.

International Journal of Chemical Studies **6**(5): 2533-2536.

Sahu PK, Naruka IS, Haldar A, Chundawat RS and Kumar H. 2020. Study the effect of integrated nutrient management on vegetative growth of fenugreek (*Trigonella Foenum-graecum* L.). Journal of Pharmacognosy and Phytochemistry **9**(3): 1389-1394.

Singh, M. 2020. "Soil health and fertility management for sustainable crop production." Soil Science and Plant Nutrition **66**(5): 297-311.

Singh SN and Kumar A. 2002. Production potential and economics of winter maize based intercropping systems. Annals of Agricultural Research **23**(4): 532-534.

Tripathi AK, Kushwaha HS, Dipali Singh and Praharaj CS. 2019. Nutrient management in pigeonpea [*Cajanus cajan* (L.) Millsp.]+ cereal intercropping system under rainfed environment of Bundelkhand region of India. Journal of Food Legumes **32**(3): 161-169.

Tripathi SM and Dwivedi AK. 2009. Economic of intercropping fennels with cauliflower. Annals of Horticulture **2**(1): 103-105.

Willey RW. 1979. Intercropping: Its importance and research needs. Part 1.Competition and yield advantages. Field Crops Abstracts **32**(1): 1-10.