

Fennel (*Foeniculum vulgare* Mill.) based intercropping for higher system productivity

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Abstract

A field experiment on effect of different intercropping ratios on growth, yield and system productivity was conducted at NRCSS, Ajmer (Raj.) during rabi season of 2004-05, 2005-06 and 2006-07. The experiment comprising of thirteen treatment viz., sole fennel, sole onion, sole garlic, sole carrot, fennel+ garlic (1:1), fennel+ garlic (1:2), fennel+ garlic (2:2), fennel+ carrot (1:1), fennel+ carrot (1:2), fennel+ carrot (2:2), fennel + onion(1:1), fennel+ onion (1:2) and fennel + onion (2:2) was laid in randomized block design with three replications. The yield of sole crops viz., fennel, carrot, onion and garlic gave the highest economic yield over that obtained with different intercropping ratio. Fennel with all inter crops in 1:1 ratio found superior in respect to, growth, yield attributes and yield of fennel over other ratios under study. Fennel + carrot with all intercropping ratios proved superior over onion. Besides sole cropping, the economic yield of carrot, onion and garlic was recorded higher in intercropping ratio of 1:2 as compared to 1:1 and 2:2. The highest equivalent yield, net return and BCR was obtained in inter cropping of fennel + carrot with 1:1 ratio followed by 2:2 ratio. Fennel and carrot at all the ratios resulted higher equivalent yield, net return, BCR and LER over fennel intercropped by onion and garlic. Thus, it is inferred that intercropping of fennel and carrot in 1:1 ratio is better for realizing higher system productivity, net return and BCR.

Key words: Equivalent yield, fennel, Inter cropping, LER, temporal resource

Introduction

India has been recognized as a land of spices and at present it is the world's largest producer, consumer and exporter of the spices. Among the seed spices fennel commonly known, as Saunf is major seed spice crop belonging to Apeaceae family. Burgeoning population all over the world specially in Asian countries is putting pressure on existing natural resources for meeting the increasing demand for food fodder, shelter and fuel production. The per capita availability of land is declining year after year. Thus, the possibility of horizontal expansion of agricultural enterprises is very limited. Only scope lies in vertical expansion of agriculture which is only possible through increase in productivity of resources per unit area per unit time. The system productivity can be increased by using available area through vertical expansion of enterprises. The intercropping system is a very important avenue in this direction which aimed at increasing productivity per unit area per unit time and insurance against total crop failure under aberrant weather conditions (Mullick *et al.* 5). Therefore, integration of suitable vegetable crops with wide spaced seed spice crop is necessary. Among seed spices, fennel is a wide space crop best suited for intercropping with vegetable crops (Mehta *et al.*

4). Therefore, the present investigation on performance of fennel based intercropping system was undertaken with an object to find out best intercropping ratio for realizing higher system productivity, net return and BCR.

Materials and methods

The field experiment on growth and yield of fennel and system productivity as influenced by different intercropping ratios was conducted at NRCSS, Ajmer (Raj) during three consecutive rabi season of 2004-05, 2005-06 and 2006-07. The soil of the experimental site was sandy loam with a pH of 8.92 having 0.21 percent organic carbon and 76.0, 33.4, and 234.1 kg per ha available N, P₂O₅ and K₂O respectively. The experiment comprising of thirteen treatment viz., sole fennel, sole onion, sole garlic, sole carrot, fennel+ garlic (1:1), fennel + garlic(1:2), fennel+ garlic (2:2) fennel+ carrot (1:1), fennel+ carrot (1:2), fennel+ carrot (2:2), fennel + onion(1:1), fennel + onion (1:2) and fennel + onion(2:2) was laid in randomized block design with three replications. Ajmer fennel-1 was sown using 10 kg seed at row to row spacing of 60 cm in 1:1 and 1:2 inter cropping ratio of fennel + carrot or onion or garlic but in 2:2 ratio fennel was sown in pair of 40/80 cm. The onion (N-53), carrot (Pusa Kesar) and garlic (G-41) were

accommodated in fixed ratio as per treatment keeping population of fennel (base crop) as constant. The N and P was applied as per recommendation for respective crops in sole crops but in intercropping system the N and P was applied in proportion to the area occupied by each crop. In sole fennel, onion, garlic and carrot 90 kg N, 50 kg P₂O₅ and 40 kg K₂O per ha and in inter cropping 135 kg N, 75 kg P₂O₅ and 60 kg K₂O per ha were applied. 1/3rd N and full dose of P and K was applied as basal dose at the time of sowing and remaining 2/3rd N was applied in two equal split at 30 and 60 DAS. The standard agronomic practices were followed for raising healthy crop of fennel as well as carrot, onion and garlic. Irrigation was applied as per requirement of fennel, which met the demand of intercrops also. The observation on growth parameters and yield attributes of fennel and intercrops were recorded. Harvesting of fennel was done in stages keeping in view the maturity of umbels. The yield of fennel, carrot, onion and garlic was converted into fennel equivalent yield as per prevailing rates in market and treatment evaluation was done accordingly. Economic analysis of the different treatment was done for drawing conclusion

Results and discussion

Growth parameters of fennel

The plant height and dry matter accumulation per plant at all the growth stages and number of branches per plant at maturity of fennel were recorded higher in sole fennel (Table 1). Inter cropping of fennel with vegetables crops like carrot, onion and garlic significantly influenced the growth parameters of fennel and higher plant height and dry matter accumulation and number of branches per plant of fennel were recorded with carrot in 1:1, 1:2 and 2:2 ratio over onion and garlic in respective ratios. The growth parameters of fennel were recorded higher in 1:1 intercropping ratio with carrot/onion and garlic being at par with 2:2 ratio. The higher plant height and DMA of fennel in 1:1 ratio with intercrops was due to less competition between fennel and intercrops as compared to other ratio. The lower plant height, DMA at all the growth stages and branches /plant with garlic in all intercropping ratio was low on account of higher nutrient requirement by garlic resulting in competition with fennel leading to lower growth parameters in fennel. Tiwari et al. (9) reported depressing effect on growth and performance of fennel when intercropped with vegetable crop. Similarly Nandekar et al. (6) reported decrease in growth parameters of base crop with intercropping.

Yield attributes and yields of fennel

Significantly the higher umbels /plant, umbellate /umbel, seeds /umbellate, diameter of umbel, seed yield per plant and 1000 seed weight and economic yield of fennel was obtained in sole fennel over all intercropping ratios (Table 2). Among different intercropping ratios of fennel with carrot, onion and garlic, the higher yield attributes and yield of fennel was recorded in 1:1 ratio being at par with 2:2 ratio. Inter cropping of fennel + carrot with all ratio resulted higher yield and yield attributes of fennel over inter cropping with onion and garlic. In sole fennel the higher yield attributes and yield of fennel was obtained due to no competition for resources with any other crop except fennel leading to better absorption of nutrient and water by fennel. The higher yield attributes and yield in 1:1 ratio with all component crops was recorded due to higher growth parameters leading to higher translocation of photosynthates from source to sink as compared to other ratio. Tiwari et al. (7) reported depressing effect on growth and performance of fennel when intercropped with vegetable crop. Similarly Nandekar et al. (6) reported decrease in yield of base crop with intercropping.

Yield attributes and yields of intercrops

Yield attributes and yield of intercrops viz. onion, garlic and carrot was recorded higher in respective sole intercrops as compared to intercropping with fennel. Further, perusal of data in Table 3 revealed that among different inter cropping ratios, the higher yield of intercrops was exhibited in 1:2 ratio over 1:1 and 2:2 ratio but yield attributes of all the intercrops was recorded in 1:1 intercropping ratio followed by with 2:2 ratio. Inter cropping of fennel + carrot with all ratios resulted higher economic yield of carrot as compared to onion and garlic. The higher yield attributes and yield of intercrops in sole cropping was on account of less competition for space, sunlight, water and nutrient with other crops resulting better availability of nutrient, water and space to facilitate growth and development of these crops independently. The higher yield all the intercrops crops in 1:2 ratio was on account of higher plant population due to accommodation of more number of rows in between interspaces as compared to 1:1 and 2:2 ratio.

System productivity

The critical examination of data in Table 4 reveals that significantly higher fennel equivalent yield and land equivalent ratio of the system was recorded in different intercropping system as compared to sole cropping of respective crops. Fennel + carrot in all intercropping ratio

Table 1: Effect of intercropping system on plant height, dry matter accumulation and branches per plant of fennel (Pooled data of 2004-05, 2005-06 and 2006-07.)

Treatments	Plant height (cm)			Dry matter accumulation per plant (g)				Number of branches /plant	
	40 DAS	80 DAS	120 DAS	At harvest	40 DAS	80 DAS	120 DAS		At harvest
Inter cropping system									
Sole fennel	25.5	78.5	135.6	175.6	2.42	15.25	64.80	94.25	21.25
Sole Onion	-	-	-	-	-	-	-	-	-
Sole carrot	-	-	-	-	-	-	-	-	-
Sole garlic	-	-	-	-	-	-	-	-	-
Fennel + Onion (1:1)	19.3	74.6	129.9	162.2	1.94	13.15	56.42	81.90	18.32
Fennel + Onion(1:2)	16.4	72.6	126.1	155.6	1.82	10.87	53.39	76.20	16.38
Fennel + Onion (2:2)	18.4	73.4	128.9	158.8	1.92	12.25	54.52	78.90	17.42
Fennel + Carrot (1:1)	21.2	76.5	131.9	173.7	2.12	13.55	58.39	85.59	20.45
Fennel + Carrot (1:2)	18.2	73.7	129.0	167.6	2.03	12.15	55.39	79.88	18.54
Fennel + Carrot (2:2)	20.3	75.4	130.1	169.5	2.08	12.85	57.52	82.00	19.42
Fennel + Garlic (1:1)	18.3	73.62	128.5	161.3	1.91	12.25	55.35	80.25	17.52
Fennel + Garlic (1:2)	15.4	70.4	125.2	154.7	1.76	10.77	51.58	75.35	15.25
Fennel + Garlic (2:2)	17.4	71.8	127.4	157.6	1.88	11.5	53.52	77.240	16.38
S.Em ±	0.70	2.71	5.51	5.97	0.07	0.46	2.72	2.96	0.66
CD (P=0.05)	2.07	8.06	16.36	17.73	0.21	1.36	8.09	8.81	1.97

Table 2 : Effect of different intercropping on yield attributes of fennel (Pooled data of 2004-05,2005-06 and 2006-07)

Treatments	Number of umbel /plant	Number of umbellate /umbel	Umbel diameter (cm)	Number of seeds/umbellate	1000 seed weight (g)	Seed yield /plant (g)
Inter cropping system						
Sole fennel	31.12	38.25	16.85	29.25	7.80	40.25
Sole Onion	-	-	-	-	-	-
Sole carrot	-	-	-	-	-	-
Sole garlic	-	-	-	-	-	-
Fennel + Onion (1:1)	28.45	34.25	15.25	25.29	7.64	37.56
Fennel + Onion(1:2)	25.26	31.28	14.85	23.36	6.80	34.45
Fennel + Onion (2:2)	27.35	33.26	15.14	24.24	7.12	36.13
Fennel + Carrot (1:1)	29.40	37.24	15.76	26.31	7.70	38.98
Fennel + Carrot (1:2)	26.60	33.25	15.08	24.24	7.20	35.74
Fennel + Carrot (2:2)	28.65	35.28	15.65	25.31	7.48	37.64
Fennel + Garlic (1:1)	27.12	33.25	14.78	24.15	7.56	36.46
Fennel + Garlic (1:2)	24.23	30.28	14.26	22.18	6.75	33.35
Fennel + Garlic (2:2)	25.25	32.26	14.65	23.24	7.25	35.23
S.Em±	1.01	1.24	0.65	1.05	0.27	1.35
CD (P=0.05)	2.99	3.70	1.92	3.12	0.80	4.00

Table 3. Effect of different intercropping on growth and yield attributes of intercrops (Pooled data of 2004-05, 2005-06 and 2006-07)

Treatments	Individual root/bulb weight (g)	Length of root (cm)	Diameter of root (cm)	Equatorial diameter of bulb(cm)	Polar diameter of bulb(cm)	Cloves /bulb
Sole fennel	-	-	-	-	-	-
Sole Onion	41.35	-	-	4.17	3.85	-
Sole carrot	55.72	12.18	4.4	-	-	-
Sole garlic	17.28	-	-	3.65	3.02	12.12
Fennel + Onion (1:1)	27.28	-	-	3.84	3.71	-
Fennel + Onion (1:2)	19.45	-	-	3.72	3.47	-
Fennel + Onion (2:2)	25.68	-	-	3.86	3.61	-
Fennel + Carrot (1:1)	33.24	11.24	4.1	-	-	-
Fennel + Carrot (1:2)	26.84	10.82	3.4	-	-	-
Fennel + Carrot (2:2)	31.84	10.86	3.6	-	-	-
Fennel + Garlic (1:1)	12.34	-	-	3.35	2.91	8.26
Fennel + Garlic (1:2)	8.92	-	-	3.30	2.84	6.82
Fennel + Garlic (2:2)	11.31	-	-	3.31	2.86	7.24

Table 4. Effect of different intercropping system on yield of fennel, component crops fennel equivalent, return, BCR and LER (Pooled data of 2004-05,2005-06 and 2006-07.)

Treatments	Fennel yield q/ha	Carrot/ onion/garlic yield (q/ha)	EY yield of onion /carrot/garlic	Total EY of system (q/ha)	Cost of cultivation (Rs/ha)	Gross return (Rs. ha)	Net return (Rs/ha)	B: C ratio	LER
Inter cropping system									
Sole fennel	17.25	0	0	17.25	26750	69000	42250	1.58	1.00
Sole Onion	0	185.26	9.26	9.26	18950	37040	18090	0.95	1.00
Sole carrot	0	225.45	11.27	11.27	22840	45080	22240	0.97	1.00
Sole garlic	0	60.25	15.06	15.06	45250	60240	14990	0.33	1.00
Fennel + Onion (1:1)	15.25	123.45	6.17	21.42	28238	85680	57442	2.03	1.55
Fennel + Onion (1:2)	13.06	140.65	7.03	20.09	29532	80360	50828	1.72	1.52
Fennel + Onion (2:2)	14.86	108.38	5.42	20.28	27436	81120	53684	1.96	1.45
Fennel + Carrot (1:1)	16.85	138.27	6.91	23.76	27435	95040	67605	2.46	1.59
Fennel + Carrot (1:2)	13.69	142.45	7.12	20.81	28240	83240	55000	1.95	1.43
Fennel + Carrot (2:2)	15.25	121.28	6.06	21.31	27250	85240	57990	2.13	1.42
Fennel + Garlic(1:1)	14.25	28.25	7.06	21.31	34850	85240	50390	1.45	1.29
Fennel + Garlic (1:2)	12.06	23.24	5.81	17.87	38250	71480	33230	0.87	1.08
Fennel + Garlic (2:2)	13.86	26.24	6.56	20.42	34150	81680	47530	1.39	1.24
S.E.m±	0.55	4.67	0.30	0.65	-	-	-	-	-
CD (P=0.05)	1.62	13.69	0.87	1.91

Selling price of fennel Rs 40 /kg, Carrot Rs 2.0 /kg and onion Rs 2.0 /kg and Garlic Rs. 10

EY=Equivalent yield, LER= Land equivalent ratio

resulted higher fennel equivalent yield as compared to onion and garlic over respective inter cropping ratio. Further analysis of data presented in Table 4 reveals that 1:1 inter cropping ratio with all component crop proved superior and resulting higher fennel equivalent yield. The higher fennel equivalent yield in intercropping system was on account of additional yield of components crop without not much reduction in yield of base crop resulting in higher fennel equivalent yield. The highest fennel equivalent yield in 1:1 ratio with carrot, onion and garlic was due to proportionately less reduction in yield of fennel as compared with 1:2 ratio along with resulting better yield of component crop leading to higher fennel equivalent yield. Bhati (2) reported higher fennel equivalent yield in intercropping as compared to sole crops. Similarly, Ahlawat and Gangaiah (1) also reported higher system productivity in chickpea intercropped with linseed over sole chickpea.

Intercropping of fennel with carrot/ onion/ garlic in 1:1 ratio resulted higher land equivalent ratio over 1:2 and 2:2 ratio and all the intercropping systems exhibited higher land equivalent ratio over respective sole cropping. Significantly the highest LER (1.59) was exhibited in fennel and carrot in 1:1 intercropping ratio followed by fennel and onion in 1:1 (1.55) ratio. The higher LER with all intercropping system is on account of better spatial and temporal resource utilization resulting in higher combined economical yield of base and intercrop. Fennel intercropped with carrot resulted higher LER at all ratio over respective intercropping ratio with onion and garlic Thomas *et al.* (8) in a study of mustard and chickpea intercropping found that highest land equivalent ratio of 1.41 in mustard and chickpea intercropping over sole crops.

Economic analysis

Intercropping of fennel+ carrot in 1:1, 1:2 and 2:2 ratio exhibited significantly higher gross return, net return and BCR as compared to onion and garlic in all the three ratios. Intercropping of fennel +carrot or onion or garlic in 1:1 ratio proved superior over 1:2 and 2:2 ratio The highest gross return, net return and BCR was recorded with fennel and carrot in 1:1 ratio. Yadav *et al.* (10) reported that intercropping of fenugreek with mustard resulted higher net return and BCR over sole cropping. Similarly, Khurana, and Bhatia (3) found that intercropping with fennel increased net returns. Intercropping of fennel and carrot in 1:1 ratio is better for realizing higher growth yield and profit in fennel based intercropping system. Higher net return in chickpea intercropped with linseed over sole cropping was observed by Ahlawat and Gangaiah (1).

Thus, it is inferred that intercropping of fennel and carrot in 1:1 ratio is better for realizing higher system productivity, net return and BCR.

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