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Study the impact of leafy vegetables as intercrop on productivity and profitability of safflower (*Carthamus tinctorius* L.)

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Abstract
A field experiment was conducted two consecutive *Rabi* season of 2016-17 and 2017-18 on silty clay loam soil at Research cum Instructional Farm, IGKV, Raipur (C.G) to assess the performance of leafy vegetables (Fenugreek and coriander) as intercrop in between rows of safflower for improving the profitability of safflower. Fenugreek and coriander were sown in between rows of safflower in the ratio of 1:1, broadcasted in the standing safflower and mixed sowing with safflower as per farmer's practice. Plant height, number of branches, dry matter production, yield attributes and yield of safflower were significantly higher under intercropping of safflower + fenugreek as leafy vegetable in the ratio of 1:1 but it was remained at par with safflower + coriander as leafy vegetable in 1:1 ratio, broadcasting of fenugreek or coriander in the line sown safflower and sole safflower. Intercropping of safflower + fenugreek as leafy vegetable in the ratio of 1:1 obtained 73% higher safflower equivalent yield and 66% net return over sole safflower.

Keywords: Safflower, intercropping, fenugreek, coriander, economics

Introduction

Safflower (*Carthamus tinctorius* L.) is mainly grown for edible seed oil in India during winter season. Kazakhstan ranks first in area with share of 31% of world safflower area and with 23% share in the world safflower production. The productivity of safflower (1541 kg/ha) in world is maximum in China (Sarda *et al*., 2015) [11]. Safflower growing other countries is Argentina, Australia, Ethiopia, Iran, Kyrgyzstan, Mexico, Tanzania, USA and Uzbekistan. In Chhattisgarh, major safflower growing districts are Bemetara, Rajnandgaon, Bilaspur, Raipur, Durg, Janjgir-Champa and Bastar.

Safflower is a unique crop and it has multipurpose uses. Flowers of safflower were used for colouring, flavouring of foods and making dyes before the advent of cheaper aniline dyes (Mukta, 2012) [9]. The medicinal property of safflower is being used by china. Safflower has two types of fatty acid i.e. monosaturated (oleic) and polyunsaturated (linoleic) fatty acid. Oil having monounsaturated fatty acid is preferred for frying due to its heat stability characteristics and it is also uses for manufacturing cosmetics, food coatings and infant food formation. Oil with high percentage of polyunsaturated fatty acids is used as oils and for making of margarines. High protein content (24%) and fiber in safflower cake can be used as supplement feed for livestock and poultry unit. Boland (2011) [2] also reported that safflower seeds are widely used in bird seed industries. Petals of safflower are collected after seed setting and it uses as herbal tea. More remunerative crop chickpea is main competent crop for safflower during *Rabi* season in Chhattisgarh. In spite of this, chickpea is also facing many problems like attack by monkeys during poding, theft and wilt disease. These factors are responsible for reducing the area and productivity of chickpea. In this context, farmers desires alternate crop for chickpea. Spiny nature of safflower provides an opportunity to avoid the attack from monkeys and also it is difficult for theft. Safflower can be considered most suitable alternative crop of chickpea. Sole cropping of safflower is comparatively not remunerative and it is difficult to sustain in the system therefore it is need to introduce intercrop for getting more profit. Intercropping of compatible crops can be of great value in achieving the improved productivity without requiring significant additional resources (Gawade. *et al*., 2002) [4]. The normal row spacing is maintained 45 cm which allow short duration crops to accommodate in between rows of safflower. Spines in safflower generally emerge 50-55 days after sowing (DAS) and after that it is difficult to enter in the field.

Hence, it is required to grow those types of crops which complete their life span before 50-55 days. Leafy vegetables may be an option to grow in between rows of safflower. Among leafy vegetables, fresh leaves of coriander and fenugreek are consumed as most popular leafy vegetables. Coriander and Fenugreek have slender, erect, hollow stem and shallow root system which help to uproot these crops at 25 DAS as leafy vegetables. Intercropping of vegetables is a recognized system for efficient use of fertilizers and increasing the productivity per unit area. This system usually gives higher combined yield than the sole crops (Mandal *et al*., 1986). Keeping this in view, present investigation was undertaken to evaluate the most appropriate leafy vegetable as intercrop for increasing the profitability of safflower.

Materials and Methods

The present study was carried out in Indira Gandhi Krishi Vishwavidayalaya (IGKV), Raipur, Chhattisgarh during the two consecutive years of *Rabi* 2016-17 and 2017-18. Raipur is intersected by 21°16´ N latitude and 81°36´ E longitude and located at an altitude of 298 m above the mean sea level. The soil of the experimental field for both the year was same and classified as *Alfisols*, texturally silty clay loam and locally known as "*Dorsa*". The soil of the study field was sampled at the depth of 0-20 cm to determine its physical and chemical characteristics. The nutrient status of the soil was low in available N (202 kg N/ha), medium in available P (17 kg P/ha) and high in available K (343 kg K/ha). The electrical conductivity and pH of the soil were 0.51 dS/m and 7.2, respectively.

The experiment was laid out in randomized block design with three replications. Treatments were Sole Safflower, Safflower + Coriander (1:1), Safflower + Fenugreek (1:1), Line sowing of safflower and broadcasting of coriander, Line sowing of safflower and broadcasting of fenugreek, Farmer's practice (Mixed sowing of safflower and coriander), Farmer's practice (Mixed sowing of safflower and fenugreek). The recommended dose of fertilizers (RDF) of safflower was applied @ 90:40:30 kg N:P_2O_5:K_2O/ha to each plot. Before sowing, the seeds of each crop were treated with bavistin @ 3 g/ha to prevent fungal diseases, then seeds were hand sown and come up irrigation was immediately applied to ensure the proper germination of the crop. Intercultivation was done at 25 and 45 DAS. Need based plant protection measures were followed for controlling aphids.

Plant height at maturity was measured from the base of the plant to the tip of the plant. Number of branches was recorded from five tagged plants. Five plants were uprooted for determination of dry matter accumulation. Plants were washed and the dry weight was taken after oven drying at 60°C for 48 hours at harvest of crop. Fresh weight of leafy vegetables i.e. fenugreek and coriander were measured from 25 square metre area at 25 days after sowing. Number of capitula per plant and number of seeds per capitula were determined based on ten randomly selected plants from the central three rows of each plot at maturity stage. Five randomly 100 seeds samples from harvest area were used for recording the 100 seed weight (seed index). Seed yield was determined by harvesting the net plot area of each plot. All data were subjected to analysis of variance (ANOVA) and differences among treatments were tested by procedures of Gomez and Gomez (1984) [6].

Results and Discussion

Crop growth

Sowing techniques of safflower and leafy vegetables (coriander and fenugreek) significantly influenced the plant height of safflower (Table 1). The highest plant height (114.6 cm) was recorded when safflower was sown as sole crop. This treatment was found comparable with the treatments where coriander and fenugreek was sown with safflower in the ratio of 1:1. Significantly reduction in plant height was noticed when coriander and fenugreek were either mixed sown with safflower or broadcasted in line sown safflower. Competition among the crops might be the reason for reduction in increasing the cell division and its multiplication which ultimately reduced the plant height of safflower. The findings are in accordance with Patel and Patel (1993) [10].

Sowing of safflower as sole crop and coriander or fenugreek sown as intercrop with safflower in the ratio of 1:1 or broadcasting of coriander or fenugreek in line sown safflower produced similar number of primary and secondary branches and found superior over mixed sowing of coriander or fenugreek with safflower. Number of tertiary branches was found maximum when safflower was sown as sole crop. However, it was significantly reduced under mixed sowing of coriander or fenugreek with safflower and it was also at par with broadcasting of coriander in line sown safflower.

Sole safflower, leafy vegetables (fenugreek and coriander) sown in between rows of safflower and broadcasting of leafy vegetables in line sown safflower were comparable to each other and found significantly superior over mixed sowing of leafy vegetables with safflower for dry matter production. More vegetative growth leads to increased dry matter production by accumulating photosynthates. Khapre *et al*. (1993) [7] also reported that photosynthetic accumulation plays an important role in determining the total biomass production. Irrespective of sowing technique, fresh weight of fenugreek was found higher than that of coriander. Leafy vegetables produced more fresh weight when sown with safflower in the ratio of 1:1 as compared to broadcasting in line sown safflower or mixed sown with safflower.

Yield attributes and Yield

Yield attributes i.e. number of capitula, number of seeds, seed index and seed and biological yield were significantly affected due to sowing techniques of leafy vegetables with safflower (Table 2). Sowing of sole safflower and leafy vegetables (fenugreek and coriander) sown either in the ratio of 1:1 or broadcasted in the line sown safflower were comparable and produced higher yield attributes, seed and biological yield of safflower as compared to mixed sowing of safflower and leafy vegetables. The introduction of leafy vegetables with safflower did not affect the yield of safflower rather it gave additional yield advantages of leafy vegetables. Optimum plant population and competition free environment for light, nutrient and space might be resulted in higher growth, yield attributes and yield of safflower. Similar of the results have also been reported by Gobade *et al*. (2013) [5].

Seed yield of safflower was reduced to an extent of 29 and 30 percent under mixed cropping of safflower with coriander and fenugreek as compared to sole safflower. The reduction in yield was mainly because of variation in density of plant population. Similar results were also reported by Gangadhar *et al*. (2018) [3].

Safflower equivalent yield

Crop equivalent yield is an important index for assessing the performance of different crops under a given circumstance. Safflower equivalent yield (SEY) significantly differs due to sowing technique of safflower and leafy vegetables. The SEY was significantly increased under safflower + fenugreek as leafy vegetable in 1:1 ratio (2903 kg/ha). Intercropping of safflower and fenugreek in the ratio of 1:1 obtained 73% higher safflower equivalent yield as compared to sole safflower. Higher safflower as well as fenugreek yield and higher market price of fenugreek might have increased the SEY. These results are in conformity with the findings of Aladkatti *et al*. (2011).

Oil content and oil yield

The difference in oil content was not found discernible due to sowing techniques of safflower and leafy vegetables (coriander and fenugreek) (Table 3). Sowing of sole safflower, leafy vegetables with safflower in the ratio of 1:1 and broadcasting of leafy vegetables with safflower were found comparable and obtained significantly higher oil yield over mixed sowing of safflower and leafy vegetables. Less competitive environment helps to improved the growth which turns in increased the dry matter production and its accumulation in reproductive parts per plant at later stages of crop growth resultant in increased the seed yield ultimately increased the oil yield because oil yield is a combination of seed yield and oil content. Similar of the findings have also been reported by Sharma *et al*. (1992) [12].

Economics

The maximum gross return, net return and B:C ratio was obtained under intercropping of safflower + fenugreek in ratio of 1:1 (Table 3). This is due to the fact that less input cost and higher economical yield resultant in increased the B: C ratio. Intercropping of safflower + coriander (1:1) and broadcasting of fenugreek in line sown safflower found to be next best treatment combination with respect to gross return, net return and B:C ratio. Although the minimum gross and net return was received under sole safflower but B:C ratio was lowest under mixed sowing of coriander with safflower because of higher input cost.

It is concluded that intercropping of safflower + fenugreek as leafy vegetable in the ratio of 1:1 proved to be best for higher safflower equivalent yield and greater profit from safflower. Intercropping of safflower + coriander as leafy vegetable (1:1) and broadcasting of fenugreek in line sown safflower found to be next remunerative combination as compared to sole safflower.

Table 1: Effect of sowing techniques of leafy vegetables as intercrop on growth parameters of safflower (pooled mean of 2016 and 2017)

Treatments	Plant height (cm)	No. of primary branches/plant	No. of secondary branches/plant	No. of tertiary branches/plant	Dry matter production (g/plant)	Fresh wt. of leafy vegetables (kg/plot)
Safflower	114.6	7.0	20.9	2.8	70.0	-
Safflower + Coriander (1:1)	113.7	6.3	19.3	1.8	61.4	18.3
Safflower + Fenugreek (1:1)	112.6	6.9	21.1	2.4	69.6	20.6
Line sowing of safflower and broadcasting of coriander	108.2	6.4	19.5	1.5	59.5	14.9
Line sowing of safflower and broadcasting of fenugreek	108.0	6.5	19.7	1.8	62.9	18.1
Mixed sowing of safflower and coriander	106.5	4.7	13.0	1.3	47.2	13.4
Mixed sowing of safflower and fenugreek	105.3	4.8	13.1	1.4	44.5	13.4
SEm (±)	1.4	0.3	0.6	0.1	3.6	-
CD (P=0.05)	4.2	0.8	1.9	0.4	10.9	-

Table 2: Effect of sowing techniques of leafy vegetables as intercrop on yield attributes and yield of safflower (pooled mean of 2016 and 2017)

Treatments	No. of capitula/ plant	No. of seeds/ capitula	Seed index (g)	Seed yield (kg/ha)	Biological yield (kg/ha)	Safflower equivalent yield (kg/ha)
Safflower	24	25	5.7	1679	6287	1679
Safflower + Coriander (1:1)	23	24	5.4	1634	6108	2680
Safflower + Fenugreek (1:1)	24	25	5.6	1729	6247	2903
Line sowing of safflower and broadcasting of coriander	22	23	5.4	1606	6087	2457
Line sowing of safflower and broadcasting of fenugreek	24	24	5.6	1644	6224	2676
Mixed sowing of safflower and coriander	17	18	5.1	1308	4884	2074
Mixed sowing of safflower and fenugreek	17	19	5.1	1305	4897	2182
SEm (±)	1.0	1.0	0.05	67	237	67
CD (P=0.05)	3.0	3.0	0.2	206	732	206

Table 3: Effect of sowing techniques of leafy vegetables as intercrop on oil content, oil yield and economics of safflower (pooled mean of 2016 and 2017)

Treatments	Oil content (%)	Oil yield (kg/ha)	Gross return (Rs/ha)	Cost of cultivation (Rs/ha)	Net returns (Rs/ha)	B: C ratio
Safflower	31.1	522	58767	22192	36575	2.6
Safflower + Coriander (1:1)	30.9	505	85458	31342	54116	2.7
Safflower + Fenugreek (1:1)	30.6	533	92556	31842	60715	2.9
Line sowing of safflower and broadcasting of coriander	30.9	495	79222	30892	48331	2.6
Line sowing of safflower and broadcasting of fenugreek	30.7	504	85411	31392	54020	2.7
Mixed sowing of safflower and coriander	30.7	401	66462	29492	36971	2.2
Mixed sowing of safflower and fenugreek	30.7	400	69368	29992	39376	2.3
SEm (±)	0.2	22	-	-	-	-
CD (P=0.05)	NS	68	-	-	-	-

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