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Original Research Article

Effect of *In-Situ* Green Manuring and Organic Manures on Growth and Yield of Organic Safflower under Rainfed Condition

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A B S T R A C T

A field experiments were conducted to study Effect of leguminous green manures on growth and yield of organic safflower crop at Agricultural Research Station, Annigeri, University of Agricultural Sciences, Dharwad during 2011-12 and 2012-13. The experiments was laid out in split plot design which comprised of four green manures assigned to main plots (sunnhemp, greengram, cowpea and fallow) and five organic manures assigned to sub-plots in second experiment (No fertilizer, 100% N through FYM, 100% N through vermicompost, 50% N through FYM + 50% N through vermicompost (VC) and RDF (40:40:12 kg N, P_2O_5, K_2O ha^{-1})). The significantly higher safflower seed yield (10.08 q ha^{-1}) was recorded in RDF without green manuring compared to fallow with no fertilizer/manure. Further the seed yield of safflower increased with incorporation of cowpea and sunnhemp with the application of RDF to safflower (13.54 and 12.91 q ha^{-1}, respectively) than other combinations except cowpea and sunnhemp coupled with 50 % N through FYM + 50 % N through VC (12.41 and 12.31 q ha^{-1}, respectively). Maximum net returns per ha was recorded with cowpea coupled with RDF (Rs. 21,851) or cowpea applied with 50 % N through FYM + 50 % N through VC (Rs. 19,934) or sunnhemp green manure applied with RDF (Rs. 19,658). This clearly indicates the possibility of growing safflower organically without affecting its productivity and profitability.

Keywords

Safflower, Sunhemp, Cowpea, Organic manures, Seed yield and green manures

Introduction

The safflower oil is one of the direct consuming edible oil in Karnataka. Now a day due to health awareness, there is a growing awareness among the consumers about organic products which give more scope for organic safflower production. The mental awareness about organic agriculture and concern has been increasing among the general population. Premium prices for products and in some cases government policy support has been attracting many farmers towards organic farming. The farmers in developing world have been converting themselves for ecological and economic reasons (Paul, 2007). Under arable production system organic manures suffers from the drawback of slow release of nutrients at initial stages, may result in slow initial growth and reduced crop yield and income. This can be overcome by judicious

combination of organic manures by encashing the positive aspects of green manures, crop residues, compost, vermicompost and other organic manures. The combined application of organic manures mainly FYM, vermicompost and *in-situ* green manure in groundnut, soybean, chilli and maize based cropping system has increased the soil available nutrients and enhanced the productivity of crops on *Vertic Inceptisols* of Dharwad (Anon., 2011). A more synchronized nutrient supply system through green manuring can be achieved to maintain long-term soil fertility and sustain higher productivity of crops. However, the available information on organic safflower production is meager. This gives a scope to conduct present investigation because in safflower growing belt of Northern Dry Zone (Zone-3) of Karnataka farmers leave their land fallow during *kharif season* and cultivate safflower during *rabi season* under residual soil moisture. Since the land is left fallow during *kharif season* which gives an opportunity to grow green manures as catch crop. Green manures known to produce 15-22 tonnes of green matter (Nooli *et al.,* 2001). When such a green manure was incorporated in the soil, it know to improve productivity of soil and subsequent crop by improving soil physico-chemical and biological properties of soil and also by supplying all nutrients (Macro and micro) required by safflower. The nutritional requirement of crop during growth period can be be met through well decomposed organic fertilizers which contain innumerable microorganism and growth promoting substances in addition to nutrients which help in improving plant growth, metabolic activity and resistance to pest and diseases.

Materials and Methods

The field study was conducted during *kharif* and *rabi* seasons of 2011-12 and 2012-13 at Agricultural Research Station, Annigeri. The experiment was laid out in split plot design which comprised of four green manures assigned to main plots (GM_1: sunnhemp, GM_2: greengram, GM_3: cowpea and GM_4: fallow) and five organic manures on N equivalent basis assigned to sub-plots (OM_1 – No fertilizer, OM_2 – 100 per cent N through FYM, OM_3 – 100 per cent N through Vermicompost, OM_4 – 50 per cent N through FYM + 50 per cent N through Vermicompost, OM_5 – RDF (40:40:12 kg N, P_2O_5, K_2O ha^{-1}). Sunnhemp, cowpea and greengram green manures were line sown on 03/06/2011 in first year and 20/07/2012 in second year with the row spacing of 30 cm by using seed rate of 25 kg ha^{-1} and harvested at 55 days after sowing and incorporated immediately. The quantity of biomass harvested and incorporated by green manures, and nutrients (NPK) added by them on pooled basis is presented in table 1.

During *rabi season*, the safflower was sown on 21/10/2011 in first year and 12/11/2012 in second year with the spacing 45 cm x 30 cm. The organic nutrients on N equivalent basis were applied according to treatments. The safflower was harvested at 130 days after sowing. The soil enzyme activity was assayed at 60 DAS sowing of the crop. The mean values were subjected to Duncan' multiple range test (DMRT) using the corresponding error mean sum of squares and degrees of freedom values.

Results and Discussion

Effect of *in-situ* leguminous green manures on growth, yield, nutrient uptake (N and P) and economics of organic safflower

In the present study, green manuring of cowpea and sunnhemp recorded significantly higher seed yield compared to greengram and fallow while fallow recorded lowest seed yield (Table 3). On pooled basis,

incorporation of cowpea and sunnhemp in preceding season recorded significantly higher safflower seed yield of 11.60 and 10.57 q ha^{-1}, respectively which was 41.80 and 29.22 % higher compared to fallow-safflower system (8.18 q ha^{-1}). Similar increase in seed yield of safflower due to green manuring of cowpea and sunnhemp during *kharif* have been reported by many research workers (Dasaraddi, 1998; Nooli, 2001; Karle *et al.*, 2007 and Biradar, 2008). The improvement in seed yield of safflower in cowpea and sunnhemp green manuring was due to increase in yield attributes viz., number of capsules per plant (20.85 and 20.15, respectively), seed weight per plant (25.71 and 23.39 g, respectively) and test weight (58.25 and 58.15 g, respectively) (Table 3). All these yield components recorded significantly higher values with cowpea and sunnhemp incorporation than greengram incorporation and fallow. Similar increases in yield attributes with incorporation of green manure species were reported in safflower by Dasaraddi (1998), Nooli (2001), Karle *et al.,* (2007) and Biradar (2008).

The differences in yield components of safflower could be traced back to the favourable improvement in growth characters which conformed further with better growth attribute such as TDMP. Cowpea and sunnhemp green manured treatments recorded significantly higher TDMP (107.05 and 104.13 g, respectively) which was 10.71 and 7.69 per cent higher compared to fallow (Table 2). This higher TDMP was the cumulative effect of higher growth characters of safflower such as plant height (73.95 and 72.00 cm, respectively), LAI (2.96 and 2.74, respectively) and total number of branches (28.88 and 28.38, respectively) on pooled basis and also this must be the consequence of the influence of higher phosphorous and nitrogen added through biomass of cowpea and sunnhemp. These results corroborate with the findings of Rao and Patil (1990), Dasaraddi (1998), Nooli (2001) and Biradar (2008).

Significantly higher net returns (Rs. 15679 and 13137 ha^{-1}, respectively) and B:C ratio (2.08 and 1.90, respectively) of safflower were observed under cowpea and sunnhemp incorporated treatments compared to greengram GM and fallow treatment on pooled basis (Table 3). The higher net returns and B:C ratio of safflower was mainly due to higher seed yield of safflower. Similar increases in economics of safflower with incorporation of different green manures were reported by Franke *et al.,* (2004) and Rajshekhar *et al.,* (2004).

Effect of different organic manures on performance of safflower

Seed yield of safflower was substantially influenced by incorporation of different organic manures during 2011-12, 2012-13 and on pooled basis (Table 3). Application of recommended dose of fertilizer (RDF) and 50 % N through FYM + 50 % N through VC to safflower produced significantly higher seed yield compared to other organic manure treatments. The treatment receiving no fertilizer/manure recorded the lowest seed yield. Application of RDF (OM_5) and 50 % N through FYM + 50 % N through VC (OM_4) recorded significantly higher safflower seed yield of 12.11 and 11.62 q ha^{-1}, respectively which was 65.89 and 59.18 per cent higher compared to no fertilizer/manure. In other words, yield improvement in RDF treatment was primarily due to balanced supply of all major nutrients whereas yield improvement in 50 % N through FYM + 50 % N through VC treatment was due to balanced and continuous supply macro and micro nutrients throughout the crop growth period. These results are in conformity with the findings of

Naik *et al.,* (2008). The improvement in seed yield with recommended dose of fertilizer (OM_5) and 50 % N through FYM + 50 % N through VC (OM_4) to safflower was due to increase in yield attributes such as number of capsules per plant (22.55 and 21.86, respectively), seed weight per plant (28.37 and 26.34 g, respectively) and test weight (58.20 and 58.12 g, respectively) (Table 3). All these yield components recorded significantly higher values with RDF (OM_5) and 50 % N through FYM + 50 % N through VC (OM_4) than other organic manures and no fertilizer/manure (OM_1). Similar increases in yield attributes with different organic manures were reported in safflower by Raghwendra and Kedar (2008), Naik *et al.,* (2008) and Malligawad (2010).

The differences in yield components of safflower could be traced back to the differences in various growth parameters such as TDMP, plant height and number of branches. Significantly higher TDMP (107.98 and 107.44 g plant^{-1}, respectively) was recorded with the application RDF (OM_5) and 50 % N through FYM + 50 % N through VC (OM_4) treatments which was 19.78 and 19.18 per cent, respectively higher than no fertilizer/manure. This could be attributed to the cumulative effect of higher growth characters of safflower like plant height (76.64 and 73.71 cm, respectively), LAI (3.04 and 2.68, respectively) and total number of branches (29.95 and 27.82, respectively) on pooled basis besides the influence of balanced application of nutrients and also supply of nutrients throughout the cropping period with slow releasing organic manures. These results corroborate with the findings of Kubsad *et al.,* (2007).

Application of recommended dose fertilizers (40:40:12 kg $N:P_2O_5:K_2O$ ha^{-1}) recorded significantly higher net returns (Rs. 18120 ha^{-1}) and B:C ratio (2.35) compared to other organic manure treatments on pooled basis followed by treatment receiving 50 % N through FYM + 50 % N through VC (Table 3). The higher net returns and B:C ratio of safflower was due to higher seed yield of safflower. These results are in line with the findings of Singh and Prasad (2008).

Table.1 Phytomass, biomass and nutrients (NPK) accumulation of different *in-situ* leguminous green manures (pooled data of two years)

	Phytomass (t/ha)	Biomass (t/ha)	N added (kg/ha)	P added (kg/ha)	K added (kg/ha)
Sunnhemp	11.43	2.08	43.27	10.50	39.10
Greengram	9.25	1.64	20.78	9.12	20.01
Cowpea	12.54	2.05	36.41	17.23	31.78
SEm±	**0.40**	**0.09**	**1.68**	**0.24**	**0.79**
CD 5 %	**1.56**	**0.35**	**6.58**	**0.93**	**3.11**

Table.2 Effect of in-situ green manuring and levels of organic manures on growth and yield attributes of succeeding safflower (pooled data of two years)

Treatment	Plant height (cm)	LAI	TDMP (g plant^{-1})	Total no of branches plant^{-1}	Number of capsule plant^{-1}
Green manures (GM)					
GM_1 : Sunnhemp	72.00ab	2.96a	104.13ab	28.38a	20.15a
GM_2 : Green gram	70.51bc	2.34c	100.94b	25.42b	17.27b
GM_3 : Cowpea	73.95a	2.74b	107.05a	28.88a	20.85a
GM_4 : Fallow	68.92c	2.02d	96.69c	22.91c	15.03c
SEm±	**0.66**	**0.05**	**1.05**	**0.39**	**0.58**
Organic manure (OM)					
OM_1: No fertilizer	64.30d	1.98e	90.15d	19.78e	11.70d
OM_2: 100% N through FYM	70.25c	2.36d	100.32c	23.84d	16.23c
OM_3: 100% N through VC	71.82bc	2.51c	105.11b	26.86c	19.30b
OM_4: 50% N through FYM + 50% N through VC	73.71b	2.68b	107.44a	29.43b	21.86a
OM_5: RDF (40:40:12 kg N, P_2O_5, K_2O ha^{-1})	76.64a	3.04a	107.99a	32.09a	22.55a
SEm±	**0.85**	**0.03**	**0.57**	**0.20**	**0.42**
Green manure x organic manure (GM x OM)					
GM_1OM_1	64.84h-j	2.37gh	90.80j	21.32e	13.03hi
GM_1OM_2	70.60d-g	2.75de	100.67fg	26.03d	18.20ef
GM_1OM_3	72.37b-g	2.97c	108.96cd	29.10c	21.13cd
GM_1OM_4	74.51a-e	3.17e	109.82c	31.42b	23.90ab
GM_1OM_5	77.66ab	3.53a	110.40bc	34.05a	24.50ab
GM_2OM_1	63.88ij	1.87k	89.89jk	18.85h	10.63ij
GM_2OM_2	69.47e-h	2.20hi	101.16fg	22.50e	14.90gh
GM_2OM_3	70.93c-g	2.33gh	101.86fg	25.63d	18.17ef
GM_2OM_4	72.30b-g	2.46fg	105.52de	28.53c	20.77c-e
GM_2OM_5	75.98a-d	2.82cd	106.27de	31.57b	21.90bc
GM_3OM_1	67.53g-i	2.12ij	93.20ij	22.60c	14.43gh
GM_3OM_2	72.40b-g	2.60ef	103.38ef	26.73d	19.03de
GM_3OM_3	74.43a-c	2.77de	111.12a-c	29.17c	21.83bc
GM_3OM_4	76.35a-c	2.93cd	113.43ab	31.83b	24.23ab
GM_3OM_5	79.03a	3.29b	114.10a	34.07a	24.70a
GM_4OM_1	60.96g	1.57i	86.69k	16.33i	8.68j
GM_4OM_2	68.51f-i	1.89k	96.06hi	20.08g	12.80hi
GM_4OM_3	69.56e-h	1.99jk	98.51gh	23.53c	16.07fg
GM_4OM_4	71.70c-g	2.14ij	100.99fg	25.93d	18.53d-f
GM_4OM_5	73.90a-f	2.50fg	101.17fg	28.67c	19.09b-e
SEm±	**1.69**	**0.07**	**1.14**	**0.39**	**0.84**

Means followed by the same lower case letter/s in a column do not differ significantly by DMRT (P = 0.05)

Table.3 Effect of in-situ green manuring and levels of organic manures on yield, yield attributes and economics of succeeding safflower (pooled data of two years)

Treatment	Seed weight plant^{-1} (g)	Seed yield (q ha^{-1})	Gross returns (Rs. Ha^{-1})	Net returns (Rs. Ha^{-1})	B : C ratio
Green Manures (GM)					
GM_1:Sunnhemp	23.39a	10.57ab	27721ab	13137ab	1.90ab
GM_2:Green gram	20.24b	9.70b	25211b	10708bc	1.74bc
GM_3:Cowpea	25.71a	11.60a	30160a	15677a	2.08a
GM_4:Fallow	16.84c	8.18c	21264c	8706c	1.69c
SEm±	**0.77**	**0.40**	**1035**	**1035**	**0.07**
Organic manure (OM)					
OM_1: No fertilizer	13.01d	7.30d	19095d	6796e	1.55d
OM_2: 100% N through FYM	17.92c	8.78c	23002c	8304d	1.56d
OM_3: 100% N through VC	22.08b	10.25b	26641b	11676c	1.77c
OM_4: 50% N through FYM + 50% N through VC	26.34a	11.62a	30221a	15389b	2.03b
OM_5: RDF (40:40:12 kg N, P_2O_5, K_2O ha^{-1})	28.37a	12.11a	31486a	18120a	2.35a
SEm±	**0.80**	**0.21**	546	546	0.04
Green manure x organic manure (GM x OM)					
GM_1OM_1	14.56i	7.71i-k	20549i-k	7699i-k	1.60f-h
GM_1OM_2	20.05f-h	9.00f-i	24085f-h	8835f-h	1.58f-h
GM_1OM_3	23.92c-f	10.92de	28394de	12877de	1.83ef
GM_1OM_4	28.05a-c	12.31bc	32001bc	16618bc	2.08cd
GM_1OM_5	30.35ab	12.91a-c	33575a-c	19658a-c	2.41ab
GM_2OM_1	11.99ij	7.04kl	18291kl	5521kl	1.43h
GM_2OM_2	16.47hi	8.68g-j	22570g-j	7400g-j	1.49gh
GM_2OM_3	20.94f-i	9.41f-h	24470f-h	9034f-h	1.59f-h
GM_2OM_4	24.90c-f	11.62cd	30222cd	14919cd	1.97de
GM_2OM_5	26.88b-d	11.73cd	30502cd	16665cd	2.20b-d
GM_3OM_1	16.49hi	8.46h-j	21983h-j	9233h-j	1.72e-g
GM_3OM_2	21.92d-g	9.87e-g	25656e-g	10506e-g	1.69f-h
GM_3OM_3	26.30b-e	12.41bc	32277a-c	16860a-c	2.09cd
GM_3OM_4	31.12ab	13.54ab	35217ab	19934ab	2.30bc
GM_3OM_5	32.73a	13.72a	35668a	21851a	2.58a
GM_4OM_1	9.00j	5.98l	15557l	4732l	1.44h
GM_4OM_2	13.24ij	7.58jk	19698jk	6473jk	1.49gh
GM_4OM_3	17.16g-i	8.24h-k	21424h-k	7932h-k	1.59f-h
GM_4OM_4	21.27e-h	9.02f-i	23443f-i	10085f-i	1.76e-g
GM_4OM_5	23.50c-f	10.08ef	26199ef	14307ef	2.20b-d
SEm±	**1.61**	**0.40**	**1093**	**1093**	**0.08**

Means followed by the same lower case letter/s in a column do not differ significantly by DMRT (P = 0.05)

Interaction effect of *in-situ* green manures and organic manures on performance of safflower

The interaction effect of incorporation of leguminous green manures and organic manures showed significant variations in seed yield of safflower (Table 3). Among the various treatment combinations, significantly higher safflower seed yield (10.08 q ha^{-1}) was recorded in RDF without green manuring compared to fallow with no fertilizer/manure. Further the seed yield of safflower increased to 12.91 and 13.54 q per ha with incorporation of sunnhemp and cowpea, respectively along with the application of RDF to safflower when compared to all other combinations except cowpea and sunnhemp combined with 50 % N through FYM + 50 % N through VC on pooled basis. The per cent increase in seed yield of safflower in cowpea and sunnhemp GM treatments receiving RDF were 34.33 and 28.08 per cent incremental seed yield in comparison to fallow-safflower sequence applied with 100 % RDF (GM_4OM_5) and 126 and 115 per cent over absolute control (fallow with no fertilizers/manures) on pooled basis.

Similarly, the per cent increase in seed yield of safflower in cowpea and sunnhemp GM plots (12.41 and 12.31 q ha^{-1}, respectively) receiving 50 % N through FYM + 50 % N through VC were 23.12 and 22.12 per cent incremental seed yield in comparison to fallow-safflower sequence applied with 100 % RDF (GM_4OM_5) and 107 and 105 per cent over absolute control.

Thus, the study clearly revealed that incorporation of green manures could further improve the productivity of safflower or could be grown organically without affecting the productivity of safflower when compared to fallow with RDF. The differential response of safflower to different green manures and organic manures could be related to their differential response in terms of growth and yield contributing characters. These results are in line with the findings of Karle *et al.*, (2007).

The improvement in seed yield with cowpea and sunnhemp applied with RDF and 50 % N through FYM + 50 % N through VC was due to increase in yield attributes such as number of capsules per plant (24.70, 24.50 and 24.23, 23.90, respectively) and seed weight per plant (32.73, 30.35 and 31.12, 28.05 g, respectively) on pooled basis (Table 3). These results are line with the findings of Ali and Mahmoud (2012).

The differences in the yield components in cowpea and sunnhemp plots applied RDF and 50 % N through FYM + 50 % N through VC could be traced back to the differences in growth attributing characters such as plant height (79.03, 77.66 and 76.35, 74.51 cm, respectively), LAI (3.29, 3.53 and 2.93, 3.17, respectively) and TDMP (114.10, 110.40 and 113.43, 109.82 g, respectively). These results corroborate with the findings of Singh and Prasad (2008) and Raghwendra and Kedar (2008).

Cowpea and sunnhemp green manured plots applied with recommended dose of fertilizers and 50 % N through FYM + 50 % N through VC recorded significantly higher net returns (Rs. 21851, 19658 and 19934, 16618 ha^{-1}, respectively) and B:C ratio (2.58, 2.41 and 2.30, 2.08, respectively) compared to other treatment combinations on pooled basis (Table 3). The higher net returns and B: C ratio of safflower was due to higher seed yield of safflower. The results are line with the findings of Patil (2011).

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