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Response of Fertilizer Levels and Safflower Varieties to Growth, Yield and Economics of Safflower under Irrigated Condition

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Abstract

Considering the nutrient use efficiency of fertilizers under irrigation condition, a field studies were conducted during rabi 2016 on a clay loam soil at the PGI farm, MPKV, Rahuri, to study the influence of fertilizer levels and different varieties of safflower. The fertilizer dose of 100% recommended dose of fertilizer with variety SSF 748 is beneficial for maximum seed yield (2766.46 kg ha^{-1}), net monetary returns (Rs. 45054.0 ha^{-1}) and benefit cost ratio (2.54) of safflower.

Key words :

Safflower (*Carthamus tinctorius* L.) is an herbaceous annual broad-leaved plant and a member of the Asteraceae family. It is native to parts of Asia, the Middle East and Africa. Safflower has been grown in India since ancient times not only for its orange red dye extracted from its florets but also for its seed oil. The dye was largely used for coloring purposes in food and textile industry. With the introduction and availability of cheaper synthetic dyes, use of safflower as a source of dye slowly diminished during twentieth century. The crop is now grown for its premium oil. Safflower produces oil rich in poly unsaturated fatty acids (PUFA) which play an important role in reducing blood cholesterol level and is considered as a healthy cooking medium. Safflower oil is also used in infant foods and liquid nutrition formulations. Safflower plant also makes an acceptable livestock forage in times of scarcity, if cut at or just after bloom stage. It can also be used after converting into silage. Safflower seed as a bird food ingredient has also gained growing acceptance in recent years. Hulls can be used in the manufacture of cellulose, insulations, abrasins, and hard boards and as fuel. Safflower leaves are rich in carotene, riboflavin and vitamin C and hence young seedlings, thinning's; pruning's used as green vegetable and as pot herb. The meal that remains after oil extraction is used as a protein supplement for livestock. The meal usually contains about 24 % protein and much fiber. Safflower oil can also be used as a diesel fuel substitute. The birdseed industry buys a small portion of the seed production. The high fat, protein and oil content of safflower makes it a valuable nutritional food source for wild birds and is widely known as the cardinal's favorite food of choice. The importance of safflower as oilseed crop has increased in recent years, especially with the increasing interest in the production of biofuels. India ranks first in area (41%) and production (29%) of the safflower grown across the world. In India, safflower is grown in 1.78 lakh ha and production is 1.44 lakh tons. In Maharashtra, safflower is grown in 1.07 lakh hectares with a production of about 61,000 tons, with a productivity of 570 kg ha^{-1} (Anon, 2015). This is 60.11 and 53.5 per cent of India's area and production.

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The safflower crop is usually grown in the *Rabi* or winter season generally as an intercrop with cereals such as wheat and sorghum. It is one of the most important crops for The relative importance of each yield component is affected by many factors, including genotype, environmental conditions and cultural practices. Nutrient management and variety are important parameters affecting yield and yield components in safflower. Nutrient management is one of the critical inputs in achieving high productivity of safflower.

One of the most important methods for increasing agricultural production in crop management practices is to increase the efficiency of fertilizer dose. With this aim in view, optimum fertilizer application ratios, fertilizer content, nutritional requirements of the plant during the growth season, and the amounts of nutrients present in the soil should be ascertained (Alivelu *et al*., 2006; Dong *et al.*, 2005). Nutrient management is one of the critical inputs in achieving high productivity of safflower. Nitrogen and phosphorus are two essential nutrients for growth and development of safflower which optimizing rates of them can strongly increase the seed yield and oil content in safflower. However, the amount of commercial fertilizer required for safflower production depends on the yield goal, the place of safflower in the crop rotation, and on the other crops included in the rotation cycle. Suggestions for fertilizers with nitrogen should be made to ensure a high-quality product, optimum yield, high profit and lesser environmental pollution risks (Belanger *et al*., 2000). Nitrogen compounds are important in plant chemical compounds such as protein, nucleic acid, and chlorophyll and enzymes structure. It has an important role in the tissues structure of plants (Herdrich, 2001). Therefore, the determination of the most suitable dose of nitrogen fertilizer will increase the seed yield of safflower. Present study was undertaken to find out marginal farmers. Traditionally it is grown as a rain-fed crop on residual soil moisture. Safflower is considered as a drought tolerant crop, able to extract water at soil moisture contents that are not available to the majority of crops (Majidi *et al*., 2011)). It is highly drought resistant crop due to its extended root system enabling access to water down to 2-3 m in the soil (Burgener *et al*., 2004). Irrigation is an important factor affecting plant growth (Moghadam and Rokhzadi, 2015) and yield especially in scarcity areas where, the agriculture is totally depends upon rain. Water stress is a very important limiting factor at the initial phase of plant growth and establishment. It was evident from previous research the positive effects of irrigation in safflower. The results indicated that under irrigated conditions it could be very productive (Ibrahim *et al*. 1991, Singh *et al.* 1995) and it has a significantly positive effect on yield attributes (Abbas and Mehdi, 2015) the optimum dose of fertilizer and suitable variety of Safflower and suitable combination of variety and fertilizer level to Safflower.

Material and methods

A field experiment conducted at Post Graduate Institute Farm, Mahatma Phule Krishi Vidyapeeth, Rahuri during *Rabi* 2016. The soil of experimental site was clayey in texture. The chemical composition according to criteria laid by Muhr *et al*. (1965) indicate that soil was low in available nitrogen (194.74 kg ha^{-1}), low in available phosphorus (14.38 kg ha^{-1}) and very high in potassium (358 kg ha^{-1}). The soil was slightly alkaline in reaction (pH 8.17) with electrical conductivity 0.32 dSm^{-1}. The experiment was laid out in Factorial Randomized Block Design during Rabi season with four fertilizer levels *viz*., F_1 - 0% of RDF (00:00:00 N, P_2O_5, K_2O kg ha^{-1}), F_2 - 75% of RDF (45:22.5:00 N, P_2O_5, K_2O kg ha^{-1}), F_3 - 100% RDF (60:30:00 N, P_2O_5, K_2O kg ha^{-1}), F_4 - 125% of RDF (75:37.5:00 N, P_2O_5, K_2O kg

ha^{-1}) and four varietal treatments *viz*., V_1 - SSF 658, V_2 - SSF 708, V_3 - SSF 733 and V_4 - SSF 748 on safflower and replicated three times. Thus, there were total sixteen treatment combinations. Each experimental unit was with gross plot size of 4.00 m x 3.15 m while net plot size was 3.60 m x 2.25 m.

Results and discussion

Growth studies

Effect of nutrient management : Application of 125% RDF (Table 1) was recorded significantly maximum plant height (139.12 cm), no. of branches $plant^{-1}$ (22.35), total dry matter $plant^{-1}$ (92.86 g), no. of leaves $plant^{-1}$ (48.2) and leaf area $plant^{-1}$ (311.2 cm2) of safflower at harvest, however, it was at par with 100% RDF at harvest .This results were similar with the findings of Naik *et al*. (2007), and Haghighati (2010), Eryigit *et al*. (2015).

Effect of varieties : The variety SSF 748 recorded significantly maximum plant height (141.40 cm) and leaf area $plant^{-1}$ (283.20 cm2) of safflower at harvest than the other varieties. Total dry matter $plant^{-1}$ (92.28 g) was recorded significantly maximum by variety SSF 733. However, no. of branches $plant^{-1}$ and no. of leaves $plant^{-1}$ was found non significant by different varieties (Table 1).

Effect of interaction : Interaction effects between varieties and different fertilizer levels practices were significant at harvest in respect of plant height of safflower (Table 1 a).

At harvest the variety SSF 748 with application of fertilizer level 125% RDF recorded significantly higher plant height (142.93 cm) than rest of treatments and it was at par with 100% RDF and with the variety SSF 658 with application of 125% RDF.

Yield studies

Seed yield (kg ha^{-1}) : The data pertaining to seed yield as influenced by different treatments are presented in Table 2. The mean seed yield was (2477.37 kg ha^{-1}).

Table 1. Growth parameters of safflower at harvest as influenced by different treatments

Treatment	Growth parameter				
	Plant height (cm)	No. of branches $plant^{-1}$	Total dry matter $plant^{-1}$ (g)	No. of leaves $plant^{-1}$	Leaf area $plant^{-1}$ (cm^2)
A) Fertilizer levels					
F_1 - 0% RDF	132.90	19.47	86.19	32.9	187.2
F_2 - 75% RDF	136.10	19.97	89.41	39.4	214.2
F_3 - 100% RDF	138.18	20.98	91.17	46.5	273.8
F_4 - 125% RDF	139.12	22.35	92.86	48.2	311.2
SEm±	0.41	0.21	0.56	2.2	7.3
CD at 5%	1.19	0.63	1.64	6.9	22.0
B) Varieties					
V_1 - SSF-658	138.60	20.57	88.10	47.4	271.9
V_2 - SSF-708	136.16	20.62	88.62	39.6	191.6
V_3 - SSF-733	130.15	20.89	92.28	38.2	239.7
V_4 - SSF-748	141.40	20.70	90.65	41.8	283.2
SEm±	0.41	0.21	0.56	3.7	11.2
CD at 5%	1.19	NS	1.64	NS	31.8
C) Interaction (A x B)					
SEm±	0.82	0.41	1.13	8.4	14
CD at 5%	2.39	NS	NS	NS	42.1
General Mean	136.58	20.69	89.91	41.8	246.6

Table 1a. Interaction effect between nutrient management and varieties on plant height of safflower at harvest

Treatment	Plant height (cm)			
Nutrient management/ Varietie	**F_1 0% RDF**	**F_2 75% RDF**	**F_3 100% RDF**	**F_4 125% RDF**
V_1 - SSF 658	135.33	138.13	139.40	141.53
V_2 - SSF 708	133.40	135.93	137.20	138.07
V_3 - SSF 733	123.93	130.00	132.73	133.93
V_4 - SSF 748	138.93	140.33	142.47	142.93
Source (A x B)	SEm± 0.82		C.D. at 5% 2.39	

Effect of fertilizer levels : Application of fertilizer dose of 125% RDF recorded maximum and significantly higher seed yield (2839.51 kg ha^{-1}) than other fertilizer levels. However, it is at par with 100% RDF (2766.46 kg ha^{-1}). Similar results were recorded by Naik *et al*. (2007), Bastia *et al*. (2003), and Morvarid *et al*. (2012).

Effect of varieties : The seed yield of safflower was differed significantly due to different varieties. The variety SSF 748 was recorded significantly higher seed yield (2665.64 kg ha^{-1}) than rest of the varieties

Effect of interaction : Interaction effects between varieties and different fertilizer levels were non-significant in respect of seed yield of safflower.

Straw yield (kg ha^{-1}) : The data regarding straw yield (kg ha^{-1}) as affected by various treatments are presented in Table 2. It could be seen from the data that the mean straw yield was 4691.87 kg ha^{-1}.

Effect of fertilizer levels : Different treatment of fertilizer levels showed significant effect on the straw yield. Maximum straw yield was obtained with the application of fertilizer dose of 125% RDF i.e. (4993.83 kg ha^{-1}) and at par with 100% RDF (4864.20 kg ha^{-1}). Similar results recorded by Bastia *et al*. (2003).

Effect of varieties : The straw yield of safflower was differed significantly due to different varieties. The variety SSF 733 was recorded significantly higher straw yield (4873.46 kg ha^{-1}) than rest of the varieties and SSF 748 (4815.84 kg ha^{-1}) is at par with SSF 733.

Effect of interaction : Interaction effects between varieties and different fertilizer levels were non-significant in respect of straw yield of safflower.

Biological yield (Kg ha^{-1}) : The data regarding biological yield (kg ha^{-1}) as affected by various treatments are presented in Table 2. It could be seen from the data that the mean biological yield was 7169.23 kg ha^{-1}.

Effect of fertilizer levels : Different treatment of fertilizer levels showed significant effect on the biological yield of safflower. The application of fertilizer dose of 125% RDF recorded maximum and significantly higher biological yield (7832.67 kg ha^{-1}) and it is at par with 100% RDF (7630.34 Kg ha^{-1}).

Effect of varieties : The biological yield of safflower was differed significantly due to different varieties. The variety SSF 748 was recorded significantly higher straw yield (7481.48 kg ha^{-1}) than other varieties and SSF 733 (7349.79 kg ha^{-1}) is at par with SSF 748.

Table 2. Yield of seeds, straw yield, biological yield and harvest index of safflower influenced by different treatments

Treatment	Seed yield (kg ha^{-1})	Straw yield (kg ha^{-1})	Biological yield (kg ha^{-1})	Harvest index (%)
A) Fertilizer levels				
F_1 - 0% RDF	2020.58	4272.63	6293.21	32.10
F_2 - 75% RDF	2282.92	4636.83	6919.75	32.99
F_3 - 100% RDF	2766.46	4864.20	7630.34	36.25
F_4 - 125% RDF	2839.51	4993.83	7630.66	37.21
SEm±	29.02	73.66	85.09	0.38
CD at 5%	83.82	212.76	245.70	1.10
B) Varieties				
V_1 - SSF-658	2246.91	4445.47	6692.38	33.57
V_2 - SSF-708	2520.58	4632.72	7153.30	35.23
V_3 - SSF-733	2476.34	4873.46	7349.79	33.69
V_4 - SSF-748	2665.64	4815.84	7481.48	35.63
SEm±	29.02	73.66	85.09	0.38
CD at 5%	83.82	212.76	245.7	1.10
C) Interaction (A x B)				
SEm±	58.04	147.33	170.18	0.76
CD at 5%	NS	NS	NS	NS
General Mean	2477.37	4691.87	7169.23	34.36

Effect of interaction : Interaction effects between varieties and different fertilizer levels were non-significant in respect of biological yield of safflower.

Harvest Index

Effect of fertilizer levels : Different treatment of fertilizer levels showed significant effect on the harvest index of safflower. The application of fertilizer dose of 125% RDF recorded maximum and significantly higher harvest index (37.21%) and it is at par with 100% RDF (36.25 %).

Effect of varieties : The harvest index of safflower was differed significantly due to different varieties. The variety SSF 748 was recorded significantly higher harvest index (35.63%) and it is at par with SSF 708 (35.23%)

Effect of interaction : Interaction effects between varieties and different fertilizer levels were non-significant in respect of harvest index of safflower.

Economics

Effect of fertilizer levels : Cost of cultivation (Rs. 30134 ha^{-1}), gross returns (Rs. 76324.06 ha^{-1}), net returns (Rs. 46190.0 ha^{-1}) and benefit cost ratio (2.54) was recorded maximum in fertilizer level 125 % RDF than other fertilizer levels. However, it was at par with it is at par with 100 % RDF (Table 3).

Effect of varieties : Cost of cultivation (Rs. 26873 ha^{-1}), gross returns (Rs. 71714.51 ha^{-1}), net returns (Rs. 44841.5 ha^{-1}) and benefit cost ratio (2.66) was recorded maximum in variety SSF 748 (Table 3).

Interaction effect : Interaction effects between fertilizer levels and varieties were non-significant during the crop growth in respect economics of safflower.

Table 3. Economics of safflower as influenced by different treatments

Treatment	Gross returns (Rs. ha^{-1})	Cost of cultivation (Rs. ha^{-1})	Net returns (Rs. ha^{-1})	B:C ratio
A) Fertilizer levels				
F_1 - 0% RDF	54671.30	25450	29221.3	2.14
F_2 - 75% RDF	61674.38	27758	33916.3	2.22
F_3 - 100% RDF	74360.08	29306	45054.0	2.53
F_4 - 125% RDF	76324.06	30134	46190.0	2.54
SEm±	763.77	-	763.77	0.026
CD at 5%	2205.94	-	2205.94	0.077
B) Varieties				
V_1 - SSF-658	60642.49	26370	34272.4	2.29
V_2 - SSF-708	67851.34	26699	41152.3	2.54
V_3 - SSF-733	66821.50	26646	40175.5	2.50
V_4 - SSF-748	71714.51	26873	44841.5	2.66
SEm±	763.77	-	763.77	0.026
CD at 5%	2205.94	-	2205.94	0.077
C) Interaction (A x B)				
SEm±	1527.55	-	1527.55	0.053
CD at 5%	NS	-	NS	NS
General Mean	66757.46	27404.5	39352.62	2.42

Conclusion

It could be concluded that, application of fertilizer dose of 100% recommended dose of fertilizer with variety SSF 748 is beneficial for maximum growth yield and net monetary returns of safflower.

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