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An Agronomic Evaluation of Promising Safflower (*Carthamus tinctorius* L.) Genotypes for Seed and Oil Yields under Rainfed Conditions

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A B S T R A C T

Now a day's interest of agro-industrial research and development towards oilseed crops as projects has increased in recent years. Private company shows potential interest in Safflower crop mainly due to fatty acid content and variability in the seed oil. The aim of this study was to assess the agronomic performance of 5 new safflower accessions together with safflower variety A-1 & PBNS-12, used as a check, in a rainfed environment. The research was carried out at Research Farm of AICRP on Safflower, VNMKV, Parbhani during *rabi* season of 2019-20. The experiment included 3 replications with 21 treatments and 63 experimental units, and it included the main plots were assigned to fertilizer levels and sub plots to safflower genotypes. The experimental results revealed that application of fertilizer levels F_3 (90:60:00 kg NPK ha^{-1}) and F_2 (60:40:00 kg NPK ha^{-1}) recorded significantly higher seed yield, straw yield, biological yield and oil yield than application of fertilizer level F_1 (30:20:00 kg NPK ha^{-1}). Among various safflower genotypes, genotype PBNS-12 (G_7) recorded highest seed yield however, it was found at par with genotype ANG-17-102 (G_5) and SSF-16-02 (G_2) and found significantly superior over rest of the genotypes. Interaction effect of fertilizer levels and safflower genotypes in respect of above parameters was not found significant. This study confirms response of safflower for fertilizer applications, offering increase in seed yield, oil yield in rainfed regions.

Introduction

Safflower (*Carthamus tinctorius* L.) is an important *rabi* oilseed crop. Safflower has a wide adaptability to scanty moisture conditions. It has been under cultivation in India for it's colored florets and much valued oil. Safflower oil is rich in polyunsaturated fatty acids (Linoleic acid 78%), which plays an important role in reducing the blood cholesterol level. Today's need to increased productivity of safflower crop as this may help as cash crop of small and marginal holding farmers. There is urgent demand to develop suitable management practices and genotypes to make safflower cultivation a successful proposition under Marathwada region of vertisols. Physiological traits of safflower crop like growth, seed quality and oil content are controlled by variety, different for instance plant density, and chemical fertilizer application (Weiss, 2000). But, the productivity of safflower is very low as the crop is cultivated under nutrient stress environment conditions. This necessitates rational application of

these elements as they have become limiting factor for obtaining higher yields in safflower.

During the last few years, the domestic consumption of edible oils has increased substantially and has touched the level of 26 million tonnes in 2017-18 and is likely to increase further. With per capita consumption of vegetable oils at the rate of 19.5 kg/year/person for a projected population of 1.36 billion, the total vegetable oils demand is likely to touch 34 million tonnes by 2030 (Anonymous, 2018). This seems to be tremendous demand for edible oils which are turning into effective demand with increasing purchasing power. In this context, safflower is a species of potential interest for agriculture and industry due to its high adaptability to soil and climate conditions and fatty acid variability in the seed oil.

There is an urgent need to step up oilseed production on sustainable basis to meet the needs of increasing population and expanding demands. However, with chances on area expansion being limited, increase in oilseeds production have to come primarily from land saving technologies, highlighting a combination of high yielding plant types, standard agronomic practices and balance plant nutrition attained through integrated supply system (Hegde, 1999).

Therefore, the aim of this study was to "An Agronomic Evaluation of Promising Safflower (*Carthamus tinctorius* L.) Germplasm for Seed and Oil Yields under rainfed Conditions".

Materials and Methods

Site Characterization and Main Cultivation Practices

Geographically, Parbhani is situated at 409 m mean sea level altitude, 19°16‟ North latitude and 76° 47‟ East longitude and has a subtropical climate. Weather indicated that maximum temperature ranged between 27.0^{o}C to 40.4^{o}C and minimum temperature ranged from 12.3^{o}C to 23.4^{o}C during the crop growth period. The mean relative humidity ranged from 54 to 83 percent and from 17 to 52 percent during morning and evening hours respectively. There was about 84.6 mm rainfall received during the crop growth period.

Generally, weather conditions were quite favorable for the growth of the safflower crop. The soil in the experimental plot was clayey in texture, low in available nitrogen, low in available phosphorus, very high in potassium and slightly alkaline in reaction.

Treatment Details

The present experiment was laid out in split plot design with three replications. Twenty one treatments were formed by combination of three fertilizer levels as main plot and seven genotypes as sub plot. The three fertilizer levels were F_1:- 50% RDF (30:20:00 NPK kg ha^{-1}), F_2:- 100% RDF (60:40:00 NPK kg ha^{-1}) and F_3:- 150% RDF (90:60:00 NPK kg ha^{-1}) and seven genotypes comprised of G_1:- SSF-15-65, G_2:- SSF-16-02, G_3:- ISF-112-15, G_4:- RSS-2016-03, G_5:- ANG-17-102, G_6:- A-1 and G_7:- PBNS-12.

Main plot: Fertilizer levels (3)

F_1 = 50% RDF (30:20:00 NPK kg ha^{-1})
F_2 = 100% RDF (60:40:00 NPK kg ha^{-1})
F_3 = 150% RDF (90:60:00 NPK kg ha^{-1})

Sub plot: Genotypes (7)

G_1 = SSF-15-65
G_2 = SSF-16-02
G_3 = ISF-112-15
G_4 = RSS-2016-03
G_5 = ANG-17-102
G_6 = A-1
G_7 = PBNS-12

Safflower was sown on 16th Nov in 2019. The seed rate 10 kg/ha was used and row spacing was 45 cm and plant to plant 20cm. Intercultural such as hoeing

by hand hoe at 20 DAS and hand weeding at 30 DAS were carried out to keep the weeds under control and to lose the soil for aeration.

In order to control the aphids and capsule borer, two spray of Dimethoate 30 EC @ 10 ml in 10 liters of water were done. At maturity, the crop plant in each net plot was cut at ground level with help of a sickle. The plot wise harvested on 12.04.2020 plants were collected and sun dried for 3-4 days. Then threshing and cleaning was done on 16.04.2020.

Agronomic and Chemical Parameters

Seed yield (kg ha^{-1}) and Straw yield (kg ha^{-1})

The plants from each net plot were threshed and seeds were cleaned and after removing seed whatever remain measured as straw. The seeds and straw obtained in each net plot were weighted after sufficient sun drying and converted into hectare basis by multiplying with hectare factor.

Biological yield (kg ha^{-1})

Biological yield was calculated by summation of straw yield and seed yield plot^{-1} and expressed as kg ha^{-1}.

Oil content (%) in seed

The 25 g clean seeds from each net plot were taken and oil content in percent was calculated at IIOR Research Lab (Hyderabad) and the inferences were subjected to f-test. Oil yield the oil yield was calculated by using oil content (%) multiplied with total seed yield (kg ha^{-1}).

Results and Discussion

Effect of fertilizer levels on yield

Seed Yield

The data presented in Table 1 revealed that the effect of fertilizer levels on seed yield, straw yield, biological yield and harvest index (%) was found significant. Application of fertilizer level F_3 (90:60:00 kg NPK ha^{-1}) recorded highest seed yield (1346 kg ha^{-1}) which was found at par with fertilizer level F_2 (60:40:00 kg NPK ha^{-1}) (1282 kg ha^{-1}) and both fertilizer levels were found significantly superior over fertilizer level F_1 (30:20:00 kg NPK ha^{-1}) (876 kg ha^{-1}).

Among Genotype PBNS-12 recorded highest seed yield (1375 kg ha^{-1}) which was at par with genotype ANG-17-102 (1324 kg ha^{-1}), SSF-16-02 (1273 kg ha^{-1}) and ISF-112-15 (1222 kg ha^{-1}) and found significantly superior over genotypes RSS-2016-03, A-1 and SSF-15-65. Genotype SSF-15-65 recorded lowest seed yield (935 kg ha^{-1}).

Straw yield

Fertilizer level F_3 (90:60:00 kg NPK ha^{-1}) recorded highest straw yield (3497 kg ha^{-1}) which was at par with fertilizer level F_2 (60:40:00 kg NPK ha^{-1}) (3448 kg ha^{-1}) and both fertilizer levels were found significantly superior over fertilizer level F_1 (30:20:00 kg NPK ha^{-1}) (2581 kg ha^{-1}).

Genotype PBNS-12 (G_7) recorded highest straw yield (3463 kg ha^{-1}) which was at par with genotypes ANG-17-102 (G_5), SSF-16-02 (G_2) and ISF-112-15 (G_3) and found significantly superior over genotypes RSS-2016-03 (G_4), A-1 (G_6) and SSF-15-65 (G_1). Genotype SSF-15-65 (G_1) recorded lowest straw yield (2853 kg ha^{-1}).

Biological yield (kg ha^{-1})

From Table No 1 found that fertilizer levels F_2 (60:40:00 kg NPK ha^{-1}) and F_3 (90:60:00 kg NPK ha^{-1}) produced at par biological yield of safflower. The significantly lowest production of biological yield was observed with application of fertilizer level F_1 (30:20:00 kg NPK ha^{-1}).

The biological yield recorded by genotype PBNS-12 (G_7) was the highest and significantly superior over other genotypes, however it was at par with genotype ANG-17-102 (G_5), SSF-16-02(G_2) and ISF-112-15(G_3). Among all the genotypes, the lowest biological yield was recorded by Genotype SSF-15-65 (G_1).

Harvest Index

The data presented in Table 1 revealed that the mean harvest index was found to be 26.76%. The application of 150% RDF recorded highest harvest index whereas safflower genotype PBNS-12 noted highest harvest index

Interaction

The interaction effect of fertilizer levels and genotypes on seed yield, straw yield and biological yield was not found significant

Effect of Fertilizer levels on Oil content in seed (%)

The treatment differences due to various fertilizer levels was found non-significant in influencing the seed oil content of safflower. Numerically, genotype PBNS-12 (G_7) recorded highest seed oil content. This could be due to genetic makeup of genotype.

Effect of Fertilizer levels Oil yield (kg ha^{-1})

The effect of fertilizer levels on oil yield was found significant. F_3 (90:60:00 kg NPK ha^{-1}) and F_2 (60:40:00 kg NPK ha^{-1}) levels of fertilizer application produced at par oil yield and found significantly superior over fertilizer level F_1 (30:20:00 kg NPK ha^{-1}). The effect of genotypes on oil yield was found significant. Genotype PBNS-12 (G_7) recorded highest oil yield (416.09 kg ha^{-1}) which was significantly superior over other genotypes, however it was at par with genotype ANG-17-102 (397.61 kg ha^{-1}) and SSF-16-02 (379.62 kg ha^{-1}). Genotype SSF-15-65 (G_1) produced the lowest oil yield (261.72 kg ha^{-1}).This might be due to the highest seed yield recorded in genotype PBNS-12 (G_7).

Table.1 Effect of Different Fertilizer Levels on Seed yield (kg ha^{-1}), straw yield (kg ha^{-1}), biological yield (kg ha^{-1}) and harvest index (%) of Different Safflower Genotypes

Treatments	Seed yield (kg ha^{-1})	Straw yield (kg ha^{-1})	Biological yield (kg ha^{-1})	Harvest index (%)
Fertilizer levels (kg ha^{-1})				
F_1-50% RDF	876	2581	3458	25.33
F_2-100% RDF	1282	3448	4731	27.09
F_3-150% RDF	1346	3497	4843	27.79
SE(m) ±	11.16	85.79	124.90	-
CD at 5%	30.90	237.44	345.65	-
Safflower genotypes				
G_1-SSF-15-65	935	2853	3788	24.68
G_2-SSF-16-02	1273	3341	4614	27.58
G_3-ISF-112-15	1222	3279	4501	27.14
G_4-RSS-2016-03	1033	2975	4009	25.76
G_5-ANG-17-102	1324	3403	4727	28.00
G_6-A-1	1016	2914	3930	25.85
G_7-PBNS-12	1375	3463	4838	28.42
SE(m) ±	49.77	131.98	200.28	-
CD at 5%	137.76	365.26	554.28	-
Interaction (F x G)				
SE ±	86.22	228.60	346.89	-
CD at 5%	NS	NS	NS	-
General mean	**1168**	**3175**	**4344**	**26.76**

Table.2 Effect of Different Fertilizer Levels on mean oil content (%) and oil yield (kg ha^{-1}) of Different Safflower Genotypes

Treatments	Oil content (%)	Oil yield (kg ha^{-1})
Fertilizer levels (kg ha^{-1})		
F_1-50% RDF	28.64	250.90
F_2-100% RDF	29.29	375.51
F_3-150% RDF	29.61	398.57
SE(m) ±	0.78	7.32
CD at 5%	NS	20.28
Safflower genotypes		
G_1-SSF-15-65	27.99	261.72
G_2-SSF-16-02	29.82	379.62
G_3-ISF-112-15	29.59	361.60
G_4-RSS-2016-03	28.41	293.49
G_5-ANG-17-102	30.03	397.61
G_6-A-1	28.19	286.43
G_7-PBNS-12	30.26	416.09
SE (m)±	0.95	15.97
CD at 5%	NS	44.19
Interaction (F x G)		
SE(m) ±	1.65	27.66
CD at 5%	NS	NS
General mean	**29.18**	**342.15**

Interaction

The interaction effect of fertilizer levels and genotypes on seed oil content and oil yield was not found evident.

Effect of Fertilizer levels on Seed, straw and biological yield

Results of this study indicated that the safflower crop gives response to application of higher dose fertilizer level. This might be due to favorable effect of increased fertilizer levels on yield attributing characters which finally resulted in higher seed yield. This result was in conformity with findings of Mane *et al.,* (1990); Kawale (2010) and Shinde (2017). In-case of genotype from study found that some genotype gives wider response to increasing dose of fertilizer. This might be due to higher yield attributing characters were recorded by genotype PBNS-12 than rest of the genotypes which finally resulted in higher seed yield. This result was similar with findings of Kawale (2010); Abd (2012) and Shinde (2017).

Application of fertilizer increase straw yield and biological yield of safflower. This might be due to luxurious growth and higher growth attributes recorded in fertilizer grade F_3 (90:60:00 kg NPK ha^{-1}) than rest of the fertilizer grades. Similar results were quoted by Shinde (2017). Genotype PBNS-12 (G_7) recorded highest straw yield. This might be due to the growing habit of genotype. These results are similar with the findings of Kawale (2010).

Effect of Fertilizer levels on Oil content in seed (%)

Application of fertilizer not directly affect on oil content of safflower. This may be a genotypic

character of genotypes and did not affected by fertilizer levels. Similar findings were reported by Singh and Singh (1980).

Effect of Fertilizer levels Oil yield (kg ha^{-1})

From study recorded that higher seed yield higher will be the oil yield. This might be due to the highest seed yield obtained with the application of maximum amount of fertilizer than control. The above results are in conformity with Kawale (2010); Girase *et al.*, (1980) and Abd (2012). The application of Fertilizer level *i.e.* 60:40:00 kg NPK ha^{-1} was found superior in yield and oil yield over its lower fertilizer level *i.e.* 30:20:00 kg NPK ha^{-1}.

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