Effect of different sowing time and cultivars on oil content, yield attributes and yield of safflower

Abstract

The present experiment was conducted at All India Coordinated Research Project on safflower, College of Agriculture, Indore, (M.P.) during *rabi* season 2015-16 to study the effect of date of sowing and cultivars on number of capitula plant^{-1}, total seed weight, 100 seed weight, seed yield, biological yield, straw yield, harvest index, oil content and oil yield. The experiment was performed in split plot design using three sowing dates and three cultivars. The maximum capitula (31.26 plant^{-1}) and total seed weight (25.11 g plant^{-1}) were recorded with 1st November sown crop. The cultivar A-1 registered the highest 100 seed weight (5.42 g) which was significantly superior over cultivar NARI-6 and NARI-57. The highest seed yield (1565.42 kg ha^{-1}), straw yield (7771 kg ha^{-1}) and biological yield (9336.42 kg ha^{-1}) were obtained under 1st November of sowing. The maximum oil content (35.36 %) was received with NARI-57 followed by NARI-6 and A-1. The highest oil yield (509.35 kg ha^{-1}) was observed with 1st November sown crop. Based on the findings it is concluded that for obtaining maximum yield of safflower, use of A-1 cultivar and sowing done at 1st November is recommended.

Keywords: Safflower, capitula, harvest index, yield and oil content

1. INTRODUCTION

Safflower [*Carthamus tinctorius* (L.) Moench] is one of the important rainfed and drought tolerant *rabi* oilseed crop. It is commonly referred to as *kusum* or *kardi*. Safflower is a plant of the Compositae family that is grown primarily for its seeds, which contain edible oil. It is a highly branched, thistle-like annual or winter annual herb, usually with many long sharp spines on the leaves and stems. Plants grow to be 30-150

cm tall, with globular flower heads (capitula) and bright yellow, orange, or red blooms. The plant has a robust taproot that allows it to survive in dry climates.

"In India, safflower is grown only as rainfed, winter crop on residual soil moisture. Also generally it is intercropped with cereals such as wheat and sorghum. The safflower area in the country during 2020 is 51.79 thousand ha with total production of 43.67 thousand tones" [1]. "In Madhya Pradesh safflower crop is grown mainly in *rabi* season and covers an area of 0.18 thousand ha with total production of 0.13 thousand tones. Its cultivation is becoming popular in Madhya Pradesh due to its high yield potential particularly under limited moisture conditions" [2]. The average production of safflower in India and Madhya Pradesh is too low. Among various factors which contributes to increase the safflower yield in per unit area, the most economical and possible set of practices a farmer can adopt, is the use of most suitable variety, planted at proper time, together with other cultural practices.

In the recent past, extensive research on climate change predicts marked increase in temperature. India's average temperature has inched up by around 0.7°C during 1901–2018 [3] and considered as one of the important factors responsible for low yield in wheat. The low production of safflower in Madhya Pradesh is due to shorter favourable growing period, high temperature with low humidity and short cool spell during growing season with more fluctuation in temperature. "The optimum sowing date depends on rainfall and temperature to maintain high grain yields. Under timely sown condition, safflower crop revived prolonged favourable growth environment and resulted in higher accumulation of carbon photosynthates which ultimately enhanced higher values of yield attributes including grain yield" [4]. Therefore, the optimization of sowing time is an important parameter to attain maximum yield and efficient conversion of biological yield into economic yield.

"Selection of location specific variety is one of the most essential agronomic activities" [5]. Variety change has played a key role in improving productivity, according to Chen et al. [6] with the contribution of cultivar to yield rising from 21.0% to 44.3% during the last 50 years. "Currently, many varieties have been evolved and each needs specific management practices and climatic requirements on which it reaches its full

genetic potential" [5]. "Therefore, a comparison of varieties for growth and yield characteristics under various sowing regimes is necessary" [7].

By considering the above facts, the experiment was carried out with the objective to test different safflower varieties under different sowing time for achieving better oil content, yield attributes and yield of safflower.

2. MATERIALS AND METHODS

2.1 Climatic and weather condition

The climate of the study region was semi-arid having mild winter and summer with uncertain winter rains. The rainfall occurs mostly from last week of June to middle of September with an average rainfall of 941 mm. South-west monsoon was responsible for major part of precipitation with occasional showers in winter. The mean values of meteorological parameters regarding the temperature minimum (7.7°C), maximum (40°C), relative humidity minimum (60.4%), relative humidity maximum (85.28%) and wind velocity (2.45Km ha^{-1}) were recorded during the cropping season.

2.2 Chemical analysis

The pH of soil was determined by using glass electrode pH meter using 1:2.5 soil water suspensions at 25°C. The supernated liquid of the soil suspension formerly used for pH determination was also used for the determination of electrical conductivity by conductivity meter in 1:2.5 soil water suspensions at 25°C and expressed as dSm^{-1}. Organic carbon was estimated by wet digestion method as explained by Walkley-Black [8] method. In this method organic matter in the soil is oxidized with a mixture of potassium dichromate ($K_2Cr_2O_7$) and concentrated H_2SO_4 utilizing the heat of dilution of H_2SO_4. Unused $K_2Cr_2O_7$ is back titrated with ferrous ammonium sulphate. The available nitrogen in soil was determined by alkaline permanganate method as explained by Subbian and Asija [9]. The estimation of available P_2O_5 was done by using Olsen's extract (0.5 m sodium bicarbonate solution of pH 8.5) as described by Olsen *et al*. [10]. The available amount of potassium was determined by using N neutral ammonium acetate as mentioned by Jackson [11].

Table 1 Chemical analysis of the experimental soil

Analysis	Values
Soil pH	7.55
Electrical conductivity (dSm^{-1})	0.43
Organic Carbon (%)	0.39
Available Nitrogen ($kg\ ha^{-1}$)	232
Available phosphorus ($kg\ ha^{-1}$)	12.2
Available potash ($kg\ ha^{-1}$)	496

Table 2 Different soil properties and methods employed for analysis

Sr. No.	Soil property	Method followed
1.	Soil pH (1:2.5)	pH meter
2.	EC (1:2.5) (dSm^{-1}) at 25°C	EC meter [11]
3.	Organic carbon (%)	Walkley and Black's method [8]
4.	Available N ($kg\ ha^{-1}$)	Alkaline $KMnO_4$ method [9]
5.	Available P_2O_5 ($kg\ ha^{-1}$)	Olsen's method [10]
6.	Available K_2O ($kg\ ha^{-1}$)	Flame photometric method [11]
	Mechanical analysis	
7.	Sand (9.56%)	Bouyoucos hydrometer method [12]
8.	Silt (34.32%)	
9.	Clay (56.12%)	

2.3 Sowing and method of fertilizer application

In experimental plot furrows were opened with the help of small *kudali*at a distance of 45 cm from each other. The calculated quantities of fertilizer as per treatment were applied plot wise. The amount of nutrient was given through complex fertilizer (IFFCO grade 12**:**32**:**16) was used for supplying nitrogen, phosphorous and potash. The remaining amount of nitrogen was applied through urea. The recommended dose of fertilizer (60 N + 40 P_2O_5 + 20 K_2O $kg\ ha^{-1}$) was applied in safflower. Full dose of P_2O_5, K_2O and half dose of N were applied at the time of sowing in the furrow below the seed. Remaining half dose of N was applied at stage of crop at 45 DAS. The required quantity of seed was placed in furrows manually and covered with soil immediately. For ensuring

good germination, healthy and good quality seeds were used with 20 kg ha^{-1}. The seed of safflower was treated before sowing with Thiram @ 2.5 g kg^{-1} seed.

Annigeri (A-1): The average seed yield of this variety is 1600-1700 kg ha^{-1}. Oil content of this variety is 24-29 % and oil yield is 600-725 kg ha^{-1}. This variety matures in 120-140 days. It has moderately tolerant to aphid. This variety is mainly grown in regions of Karnataka, Bihar, Orissa and Rajasthan.

NARI-6: The average yield of this variety is 1000-1100 kg ha^{-1}. Oil content of this variety is 26-32 % and oil yield is 550-650 kg ha^{-1}. This variety matures in 135-145 days. It has tolerant to foliar and wilt disease such as Alternaria and cercospora. NARI-6 is non spiny variety grown in regions of all over India. Flowers are dark red and flowers yield 70-80 kg ha^{-1}.

NARI-57: The average yield of this variety is 1300-1400 kg ha^{-1}. Oil content of this variety is 28-35 % and oil yield is 530-650 kg ha^{-1}. This variety matures in 130-140 days. NARI-57 is spiny variety grown in regions of all over India.

2.4 Oil extraction

Safflower is a versatile and drought-tolerant crop used for various purposes, including oil production. Oil in the seeds was extracted by petroleum ether in soxhlet's apparatus.

2.5 Statistical analysis

The data was analyzed by the method of "Analysis of variance". The null hypothesis was tested by the 'F' test, which revealed the significance of treatment effect. The critical difference (C.D.) of 5 % was worked out to judge the significant difference between the two treatment means.

3. Results and discussion

3.1 Number of capitula $plant^{-1}$

Number of capitula per plant is important yield contributing character to judge the grain yield of safflower crop. The data on average number of capitula $plant^{-1}$ were analyzed statistically. Data presented in Table 3, revealed that sowing dates showed a

significant variation on number of capitula plant^{-1}. The maximum capitula (31.26 plant^{-1}) was recorded with 1st November sown crop, which was significantly superior over 15th Novemberand 15th November sowing also gave significantly higher number of capitula plant^{-1} as compared to 30th November sown crop. The data presented in Table 3, indicated that cultivars caused significant variation on capitula plant^{-1}. The maximum capitula (22.84 plant^{-1}) was recorded incultivar A-1 followed by NARI-57 (21.26 capitula plant^{-1}) and minimum capitula recorded in cultivar NARI-6 (17.44 capitula plant^{-1}).

The yield attributing characters *viz.* number of capitula plant^{-1} and total seed weight g plant^{-1} were significantly influenced by different sowing dates, cultivars and their interaction. The sowing of crop on 1st November gave the highest number of capitula plant^{-1} and total seed weight g plant^{-1}. Delay in sowing results generally decrease in the yield attributes. Increase in different yield attributing characters in 1st November sowing might be due to more availability of favorable environmental condition at the vegetative and reproductive phase of the crop and might be due to better uptake of nutrients and translocation of photosynthates during the reproductive phase of the crop, thus increasing the size and weight of seeds. The results are close conformity with the findings of Ddasi*et al* (13), Nikpporand Koocheki (14), Emami *et al.* (15)**.** Data showed that the yield attributing characters was affected significantly by cultivars. Higher number of capitula plant^{-1}, total seed weight plant-1 and 100 seed weight was obtained by cultivar A-1. The variation in these growth parameters of the cultivars might be related to inherent differences and high vigour of these cultivars.

3.2 Total seed weight

The data in Table 3, showed that the total seed weight was affected significantly by different sowing dates. Maximum total seed weight (25.11 g plant^{-1}) was observed in the 1st November sown crop and minimum total seed weight (7.66 g plant^{-1}) was found at 30th November crop. A perusal of data as evident from Table 3, indicated that the maximum total seed weight (19.04 g plant^{-1}) was recorded by A-1. Minimum total seed weight (12.86 g plant^{-1}) was found with safflower cultivar NARI-6.

3.3 100 Seed weight (g)

The Table 3 showed that the 100 seed weight was not affected significantly by the different sowing dates. However, maximum 100 seed weight (4.56 g) was obtained under the 1st November date of sowing followed by 15th November sowing date. The data presented in Table 3 also indicated that cultivar caused significant impact on 100 seed weight. The cultivar A-1 registered the highest 100 seed weight (5.42 g) which was significantly superior over cultivar NARI-6 and NARI-57. Aakash et al. [5] also reported that yield attributes may vary depending on the genotype special ability for some traits.

Table 3. Impact of sowing dates and cultivars on number of yield attributes

Treatment		Number of capitula plant^{-1}	Total seed weight (g plant^{-1})	100 seed weight (g)
Sowing dates	1 November	31.26	25.17	4.56
	15 November	19.99	14.00	4.23
	30 November	10.30	7.66	4.04
	SEm±	**1.30**	**0.78**	**0.13**
	CD at 5 %	**4.51**	**2.72**	**NS**
Cultivars	A-1	22.84	19.04	5.42
	NARI-6	17.44	12.86	3.42
	NARI-57	21.26	14.93	4.00
	SEm±	**0.68**	**1.50**	**0.11**
	CD at 5 %	**2.02**	**4.48**	**0.33**

3.4 Seed yield (kg ha^{-1})

Seed yield is the most economical character for evaluating the superiority of the treatment over the other. The activeness of any treatment could be judged by the magnitude of changes in the productivity potential of a crop responded to different treatments in the experiment.

The data presented in Table 4 (A) indicated that sowing dates brought about significant variation in seed yield. The highest seed yield (1565.42 kg ha^{-1}) was obtained under 1**st** November sown crop, which was significantly higher over 15th November and 15th November sown crop also gave significantly superior seed yield as compared to 30th November sown crop. A perusal of data as evident from Table 4(A)**,** indicates that the maximum seed yield (1385.58 kg ha^{-1}) recorded with A-1 which was significantly higher over NARI-57. NARI-57 also recoded significantly highest seed yield as compared to NARI-6 cultivar. The differences in genotypic yield attributes due to higher growth parameters was also observed by [5]. Such close association of seed yield with

different yield components was also observed by Muralidharudu *et al.* (16), Kumar and Chimmad (17).

Table 4 (A) Impact of sowing dates and cultivars on seed yield, biological yield and straw yield (kg ha^{-1})

Treatment		Seed yield (kg ha^{-1})	Biological yield (kg ha^{-1})	Straw yield (kg ha^{-1})
Sowing dates	1 November	1565.42	9336.42	7771
	15 November	1215.08	7031.92	5816.83
	30 November	707.42	3400.33	2692.92
	SEm±	**66.90**	**342.20**	**286.06**
	CD at 5 %	**231.53**	**1184.21**	**989.93**
Cultivars	A-1	1385.58	7638.92	6253.33
	NARI-6	914.83	5776.83	4862
	NARI-57	1187.50	6352.92	5165.42
	SEm±	**37.74**	**120.86**	**105.34**
	CD at 5 %	**112.15**	**359.11**	**313.00**

Among interaction of different sowing dates and different cultivars of safflower, the data presented Table 4 (B) indicated that the cultivar A-1 recorded the highest seed yield (1833.00 kg ha^{-1}) with 1st November sown crop, which was followed by cultivar NARI-57 sown on 1st November (1665.25 kg ha^{-1}). All the cultivars performed significantly poorer seed yield on 30th November sowing over both the early dates.

Table 4 (B) Interaction impact of sowing dates and cultivars on seed yield

	Cultivars (V)		
Sowing dates (D)	**A-1**	**NARI-6**	**NARI-57**
1 November	1833.75	1197.25	1665.25
15 November	1455.00	911.50	1278.75
30 November	868.00	635.75	618.50
	(D×V)1	**(D×V)2**	
SEm±	**65.37**	**85.59**	
CD at 5 %	**194.24**	**278.35**	

3.5 Biological yield (kg ha^{-1})

The data showed that the safflower biological yield was influenced significantly by the different date of sowing, different cultivars of safflower and their interaction. The data presented in Table 4(A) indicated that the highest biological yield (9336.42 kg ha^{-1}) was obtained under 1st November sown crop which was superior over 15th November

and 15th November sown crop also gave significantly highest biological yield over 30th November sown crop. The data presented in Table 4 (A), showed that cultivar A-1 registered significantly higher biological yield (7638.42 kg ha^{-1}) over NARI-57 and NARI-57 also gave significantly highest biological yield over NARI-6 during the investigation. The results revealed significantly higher seed yield of safflower recorded by sowing on 1st November.

It was also observed that straw and biological yield were significantly higher by sowing at 1st November. The positive impact of date of sowing on straw yield and biological yield may be due to the pronounced growth during early stages of crop. It resulted in higher plant height and dry matter accumulation and ultimately tended in realization of higher straw and biological yields. The findings are in close results with Kzl (18).

Among interaction of different sowing dates and cultivar of safflower, the data presented Table 4 (C) indicated that cultivar A-1 recorded the highest biological yield (10046.25 kg ha^{-1}) with 1st November sown crop, which was followed by NARI-57 sown on 1st November (9321 kg ha^{-1}). All the cultivars performed significantly poorer biological yield on 30th November sowing over both the early dates.

Table 4 (C) Interaction impact of sowing dates and cultivars on biological yield

Sowing dates (D)	Cultivars (V)		
	A-1	NARI-6	NARI-57
1 November	10046.25	8642.00	9321.00
15 November	7963.00	6095.75	7037.00
30 November	4907.50	2592.75	2700.00
	(D×V)1	(D×V)2	
SEm±	209.34	382.51	
CD at 5 %	622	1282.7	

3.6 Straw yield

The data showed that the safflower straw yield was influenced significantly by the different sowing dates, different cultivars of safflower and their interaction. The data presented in Table 4 (A) indicated that the highest straw yield (7771 kg ha^{-1}) was

obtained under 1st November sown crop which was superior over 15th November, and 30th November sown crop. The data presented in Table 4 (A), showed that cultivar A-1 registered significantly highest straw yield (6253.33 kg ha^{-1}) over NARI-57 and NARI-6 during the investigation. The data presented in Table 4, showed that cultivar A-1 registered significantly highest straw yield (6253.33 kg ha^{-1}) over NARI-57 and NARI-6 during the investigation

In case of straw yield and biological yield the cultivar A-1 was found superior over other cultivars due to taller plant. Such close association of seed yield with different yield components was also observed by Muralidharudu *et al.* (16) and Kumar and Chimmad (17).

Among interaction of different sowing dates and cultivar of safflower, the data presented Table in 4 (D), indicated that cultivar A-1 recorded the highest straw yield (8212.50 kg ha^{-1}) under 1st November sown crop, which was followed by cultivar NARI-57sown on 1st November (7655.00 kg ha^{-1}). On 30th November date of sowing all the cultivar performed significantly poorer over both the early dates.

Table 4 (D) Interaction impact of sowing dates and cultivars on straw yield

Sowing dates (D)	Cultivars (V)		
	A-1	**NARI-6**	**NARI-57**
1 November	8212.50	7444.75	7655.75
15 November	6508.00	5184.25	5758.25
30 November	4039.50	1957	2082.25
	(D×V)1		**(D×V)2**
SEm±	**182.45**		**322.52**
CD at 5 %	**542.12**		**1079.19**

3.7 Harvest index HI (%)

Harvest index (HI) is the measure of economic yield in relation to total biological yield. Depending on the economic product, harvest index varies widely which is expressed in term of percentage. The analysis of variance showed that harvest index was significantly influenced by the different sowing dates, safflower cultivars and their interaction. The data presented in Table 5 (A), indicated that the maximum harvest

index (21.78%) was recorded with 30th November sown crop followed by 15th November sown crop (17.18%). Data presented in Table 5 (A), showed that cultivar NARI-57 registered significantly higher harvest index (19.74%) followed by A-1 (18.06%), NARI-6 (17.81%) respectively.

Table 5 (A) Impact of sowing dates and cultivars on harvest index, oil content and oil yield

Treatment		Harvest index	Oil content (%)	Oil yield (kg ha^{-1})
Sowing dates	1 November	16.66	32.55	509.35
	15 November	17.18	31.64	381.71
	30 November	21.78	29.51	210.23
	SEm±	**0.63**	**0.62**	**26.55**
	CD at 5 %	**2.20**	**2.16**	**91.89**
Cultivars	A-1	18.06	27.55	383.50
	NARI-6	17.81	31.21	287.56
	NARI-57	19.74	35.36	430.23
	SEm±	**0.53**	**0.45**	**13.05**
	CD at 5 %	**1.58**	**1.35**	**38.78**

Among interaction of different sowing dates and different cultivars of safflower, the data presented in Table 5 (B), indicated that cultivar NARI-6 recorded the maximum harvest index (24.55%) under 30th November sown crop which was followed by cultivar, NARI-57, sown during 30th November (23.13%).

Table 5 (B) Interaction impact of sowing dates and cultivars on harvest index

Sowing dates (D)	Cultivars (V)		
	A-1	**NARI-6**	**NARI-57**
1 November	18.25	13.81	17.91
15 November	18.28	15.08	18.17
30 November	17.66	24.55	23.13
	(D×V)1	**(D×V)2**	
SEm±	**0.92**	**0.98**	
CD at 5 %	**2.74**	**3.10**	

4 Oil content and oil yield

4.1 Oil content (%)

The data indicated in Table 5 (A), that oil content of safflower was significantly influenced by different sowing dates. The maximum oil content (32.55 %) was observed with 1st Novembersown crop followed by 15th November and 30th November sowing. A perusal of data Table 5 (A) indicated that different cultivar registered a significant variation in oil content of safflower. The maximum oil content (35.36 %) was received with NARI-57 followed by NARI-6 and A-1. It was observed maximum oil content was obtained in combination of cultivar NARI-57 with 1st November sowing. Such close association of oil content with different sowing date and cultivars components was also observed by Belgin *et al.* (19).

The data presented in Table 6, revealed that sowing dates and safflower cultivars combinations were found the significantly impact on oil content. Safflower Cultivar NARI-57 was given the maximum oil content **(**37.21%) on 1st November sowing as compared to other treatment combinations.

Table 6 Interaction impact of sowing dates and cultivars on oil content

Sowing dates (D)	**Cultivars (V)**		
	A-1	**NARI-6**	**NARI-57**
1 November	28.71	32.08	37.21
15 November	26.22	31.51	36.86
30 November	27.73	30.06	32.02
	(D×V)1	**(D×V)2**	
SEm±	**0.78**	**0.89**	
CD at 5 %	**2.34**	**2.85**	

4.2 Oil yield

The data indicated in Table 5 (A), that oil yield of safflower was significantly influenced by different sowing dates. The highest oil yield (509.35kg ha^{-1}) was observed with 1st Novembersown crop followed by 15th November and 30th November sowing. A perusal of datatable5(A) indicated that different cultivar registered a significant variation in oil yield of safflower. The highest oil yield (430.24 kg ha^{-1}) was received with NARI-57followed by A-1 and NARI-6. The data presented in table 7, revealed that sowing dates and safflower cultivars combinations were found the significantly impact on oil

yield. Safflower Cultivar NARI-57 was given the maximum oil yield (617.05 kg ha^{-1}) in 1st November sowing as compared to other treatment combinations.

Table 7 Interaction impact of sowing dates and cultivars on oil yield

Sowing dates (D)	Cultivars (V)		
	A-1	**NARI-6**	**NARI-57**
1 November	527.63	383.39	617.05
15 November	381.81	287.40	475.92
30 November	241.07	191.90	197.73
	(D×V)1	**(D×V)2**	
SEm±	**22.60**	**32.33**	
CD at 5 %	**67.17**	**106.26**	

Conclusion

In conclusion, the research conducted at the All India Coordinated Research Project on safflower, College of Agriculture, Indore, during the *rabi* season of 2015-16, has provided valuable insights into the impact of date of sowing and cultivar selection on various important parameters of safflower production. The results clearly demonstrate that the choice of sowing date and cultivar can significantly influence the number of capitula per plant, total seed weight, 100 seed weight, seed yield, biological yield, straw yield, harvest index, oil content, and oil yield. The findings highlight the remarkable performance of the 1st November sowing date, which resulted in the highest capitula per plant, total seed weight, seed yield, and oil yield. Additionally, cultivar A-1 exhibited exceptional 100 seed weight, further emphasizing its potential in safflower cultivation. These insights collectively recommend the utilization of the A-1 cultivar and the strategic choice of the 1st November sowing date to maximize safflower yield. This research contributes to the ongoing efforts to optimize safflower cultivation practices and enhance agricultural productivity in the region.

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