“Effect of date of sowing and cultivars on germination, emergence and rosette termination of safflower”

Abstract

The present experiment was carried out 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 germination, emergence and rosette termination of safflower. The experiment was performed in split plot design using three sowing dates and three cultivars. The choice of location specific variety has advantages over other varieties since it well adopted and responded better to local environment/growing conditions and applied inputs leading to significant higher production. The safflower cultivar NARI-6 had maximum germination percentage (91.43%) and number of days for rosette termination (21.50 days) while the earliest emergence is noted under A-1 (10.92 days). In case of sowing dates, 1 November sowing took minimum days to emerge out (10.92 days), 15 November proved beneficial with respect to maximum germination percentage (88.60%) while 30 November took maximum number of days for rosette termination (22.08 days).

Comment [WU1]: Please, re-write the abstract by summarizing all parts of the study.

Keywords: Safflower, rosette termination, germination percentage, cultivar, dates of sowing

1. INTRODUCTION

Safflower [*Carthamus tinctorius* (L.) Moench] is one of the important rainfed and drought tolerant *rabi* oilseed crop. Generally, it is known as *kusum* or *kardi*. Safflower is a member of family compositae, cultivated mainly for its seeds, which yield 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 are 30-150 cm tall with globular flower heads (capitula) and commonly brilliant yellow, orange or red flowers. The plant has a strong taproot which enables it to thrive in dry climates.

Comment [WU2]: Please specify the local language that *kusum* or *kardi* referred from.

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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 production in the country during 2013-2014 ~~is~~ was 178 thousand ha with total production of 114 thousand tones with 640 kg/ha. 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 [1]. 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.

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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 variety 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].

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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 germination, emergence and rosette termination.

2. MATERIALS AND METHODS

2.1 Chemical analysis

The pH of soil was determined by using glass electrode pH meter using 1:2 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 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 in 1956 [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].

Comment [WU4]: This is the studied areas soil description. This is not your result of the research and not part of your objective. So please say it "description of the study area soil". You can also put the values without Table 1 and Table 2.

Table 1 Chemical analysis of the experimental soil

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

Comment [WU5]: Remove Table 1 and Table 2. You can narrate as the soil pH was 7.55, electrical conductivity was 0.43 dsm^{-1}, organic carbon 0.39%, available nitrogen 232 kg ha^{-1}, available phosphorus 12.2 kg ha^{-1} and available potash 496 kg ha^{-1}. The soil texture was Sand (9.56%), Silt (34.32%) and Clay (56.12%) as determined by Bouyoucos hydrometer method [12]

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) (dS/m) at 25 °C	EC meter [11]

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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%)	

2.2 Method of fertilizer application and sowing

In experimental plot furrows were opened with the help of small *kudali* at a distance of 45 cm from each other. ~~The calculated~~ Calculated ~~quantities~~ amount 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~~comprised of nitrogen, phosphorous and potash in the ratio of …(IFFCO) grade 12:32:16. 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~~ to 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. In order to get good tilth of soil for sowing, the experiment field was cultivated once with the tractor drawn cultivator and one harrowing by bullock drawn harrow followed by planking to level the field. 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. ~~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~~

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~~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 varieties of safflower experimented were Annigeri (A-1), NARI-6 and NARI-57.

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~~ is 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~~ is 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.

3. Result and discussion

3.1 Plant population (m^{-2})

~~The p~~Plant population is ~~a~~ the most important factor, which directly influence the yield of the crop. Initial plant population was recorded at 20 day after germination (DAG) and final plant population was recorded one day before harvest by counting the actual number of plants per square meter. It is obvious from the data presented in Table 3., that sowing dates did not show any significant difference. However, higher plant population of per metre^2 was received by 15th November sowing followed by 1st November sowing at 20 DAG and at harvest. Minimum plant population was obtained with 30th November sowing.

The data indicated in Table 3~~.~~, that safflower plant population was not affected significantly by safflower cultivars at 20 DAG and at harvest. However, higher plant population of metre^{-2} was received by safflower cultivar NARI-6

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followed by A-1 at 20 DAG and at harvest. Minimum plant population was obtained with NARI-57 cultivar. Interaction of sowing dates and cultivars of safflower did not show any significant difference in plant population.

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Table 3. Impact of sowing dates and cultivars on plant population (plants m^{-2}) at 20 days after germination and at harvest

Treatments		Plant population (plants m^{-2})	
		20 DAG	**At harvest**
Sowing dates	1 November	11.56	10.96
	15 November	12.01	10.97
	30 November	11.02	10.32
	SEm ±	**0.32**	**0.22**
	CD at 5 %	**NS**	**NS**
Cultivars	A-1	11.48	10.57
	NARI-6	11.72	11.19
	NARI-57	11.39	10.48
	SEm ±	**0.20**	**0.22**
	CD at 5 %	**NS**	**NS**

3.2. Number of days for emergence

The data presented in Table 4, that difference in number of days for germination of safflower was found significant by sowing dates. For variety **A-1, the** 1st November sowing was the earliest in germination followed by the 30th November~~.~~ and ~~T~~the maximum number of days for germination was received by 15th November sowing. Sowing date clearly influences the soil temperature and soil water availability experienced by germinating seeds and as a consequence, manipulating the sowing dates could be an efficient practice to help crops better escape abiotic or biotic stresses. However, the specific response to sowing date depends on the location and farming system [13]. Similar result also noted by Ballesta et al. [14].

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The data presented in Table 4 shows ~~,~~ that number of days for emergence of safflower was affected significantly by cultivars. Cultivar A-1 was the earlier in germination followed by NARI-6. The maximum number of days for germination was received by safflower cultivar NARI-57.

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~~The data presented in Table 4, indicated that~~Therefore, the effect of sowing dates and safflower cultivars combinations was found to be ~~the~~ significantly affecting the emergence.~~on this parameter~~. ~~However, the Cultivar A-1 was the earliest in number of days for germination (10.25 days) on 1st November sowing as compared to other treatment combinations.~~

Table 4 Interaction impact of sowing dates and cultivars on number of days for emergence

	Cultivars (V)		
Sowing dates (D)	**A-1**	**NARI-6**	**NARI-57**
1 November	10.25	11.50	11.00
15 November	11.50	11.75	12.50
30 November	11.00	11.25	12.75
	(D×V)1		**(D×V)2**
SEm ±	**0.29**		**0.40**
CD at 5 %	**1.01**		**0.87**

3.3 Germination percentage

~~The data presented in Table 4, indicated that~~The different sowing dates and safflower cultivars ~~registered~~ significantly influenced ~~on~~ germination per cent (Table???)~~%~~. The highest germination % was received by 15th November sowing followed by 1st November sowing and lowest germination % was obtained with 30th November sowing. The highest germination % was obtained by cultivar NARI-6 followed by A-1 and lowest germination % was obtained with NARI-57 cultivar. The variation in these growth parameters of the cultivars might be related to inherent differences. The results are in close conformity with the findings of Singh *et al*. [15].

~~The data presented in Table 4 indicated that different safflower cultivars was registered significant variation on germination %. The highest germination % was received by cultivar NARI-6 followed by A-1 and lowest germination % was obtained with NARI-57 cultivar. The variation in these growth parameters of the cultivars~~

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~~might be related to inherent differences and high vigour in these cultivars. The results are in close conformity with the findings of Singh *et al.* [15].~~

~~The data presented in Table 5 indicated that s~~Sowing dates and safflower cultivars combinations were found to be significantly affecting ~~in~~ germination per cent. ~~%. However,~~Out of those, ~~–~~the Cultivar NARI-6 ~~recorded~~ showed the maximum germination percentage (92.28%) on 15th November sowing as compared to other treatment combinations. Higher germination ~~with~~on 15th ~~–~~November sowing might be due to favourable climatic condition. Similar result ~~has been~~was reported by Yusuf et al. [16] and Bhayal el al. [17].

~~Higher germination with 15 November sowing might be due to favourable climatic condition. Similar result has been reported by Yusuf et al. [16] and Bhayal el al. [17].~~

3.4 Rosette termination

~~The data presented in Table 4, indicated that~~The different sowing dates and safflower cultivars ~~registered~~ significantly influenced the ~~on~~ number of days for rosette termination (Table 4). The minimum number of days was ~~received~~ obtained by the 1st ~~–~~November sowing followed by 15th November sowing and the maximum number of days was ~~received~~ obtained by 30th November sowing.

~~The data indicated in Table 5, those different safflower cultivars was registered significant variation on number of days for rosette termination.~~ The minimum number of days was ~~received~~ obtained by A-1 cultivar followed by NARI-57 and the maximum number of days was ~~received~~ obtained by NARI-6 cultivar. The differences in plant growth ~~attributes between~~ among cultivars might be attributed ~~due~~ to ~~the~~ genet~~ic~~al ~~modified~~ and/or ~~by~~ environmental factors ~~resulting in variations in leaf development~~ [5]. The results are in close conformity with the findings of Mohankumar and Chimmad [18]. Interaction of sowing dates and cultivars of safflower did not show any significant difference on number of days for rosette termination.(Table???)

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Table 5 Impact of sowing dates and cultivars on number of days for emergence, germination percentage and rosette termination

	Treatments	Number of days for emergence	Germination percentage	Number of days for rosette termination
Sowing dates	1 November	10.92	86.75	17.50
	15 November	11.92	88.60	20.17
	30 November	11.67	85.73	22.08
	SEm ±	**0.15**	**0.31**	**0.25**
	CD at 5 %	**0.54**	**1.09**	**0.90**
Cultivars	A-1	10.92	86.27	18.75
	NARI-6	11.50	91.43	21.50
	NARI-57	12.08	83.38	19.50
	SEm ±	**0.16**	**0.29**	**0.17**
	CD at 5 %	**0.58**	**0.86**	**0.52**

Table 6 Interaction effect of sowing dates and cultivars on Germination percentage

Sowing dates (D)	Cultivars (V)		
	A-1	**NARI-6**	**NARI-57**
1 November	85.90	90.85	83.50
15 November	88.80	92.28	84.73
30 November	84.10	91.18	81.90
	(D×V)1	**(D×V)2**	
SEm ±	**0.50**	**0.52**	
CD at 5 %	**1.49**	**1.62**	

Conclusion

The choice of location specific variety has advantages over other varieties since it well adopted and responded better to local environment/growing conditions and applied inputs leading to significant higher production. The safflower cultivar NARI-6 had maximum germination percentage (???) and number of days (???) for rosette termination while the earliest emergence was~~is~~ noted under A-1 (10.92 days). In case of

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sowing dates, 1 November sowing took minimum days to emerge out, 15 November proved beneficial with respect to maximum germination percentage while 30 November took maximum number of days for rosette termination. What is your recommendation?

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