Effect of date of sowing and cultivars on growth and yield attributes 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 with the objective to test the effect of different sowing dates and cultivars on growth and yield attributes of safflower. The results showed that the cultivar A-1 accumulated maximum dry matter at 30 DAS, 60 DAS, 90 DAS and at harvest as well as took minimum number of days (86.58) for flower initiation, for 50% flowering (93.17) and for 100% flowering (99.67) as compared to other cultivars. While maximum plant height (125.54 cm), number of primary branches (10.33 $plant^{-1}$) were recorded in safflower cultivar NARI-6 followed by NARI-57 at harvest. It was observed that majority of secondary branches (18.84) emerged under 1st November sowing followed by 15th November sowing. The maximum CGR and RGR received by A-1 which was significantly superior to other cultivars at up to 30 DAS, 30-60 DAS 60-90 DAS and 90 DAS-at harvest compared to other cultivar. It is concluded that cultivar A-1 and NARI-6, and 1st November sowing performed better in terms of above parameters and recommended for cultivation.

Keyword: Date of sowing, Plant height, Dry matter, Flower initiation, Primary and Secondary Branches, CGR, RGR, Chlorophyll

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 typically vivid yellow, orange, or red flowers. The plant has a robust taproot that allows it to survive in dry climates.

In India, safflower is exclusively grown as a rainfed winter crop on residual soil moisture. It is also commonly intercropped with grains like wheat and sorghum. During 2013-2014, the country's safflower production was 178 thousand ha, with a total production of 114 thousand tones at 640 kg/ha. Safflower is mostly grown in Madhya Pradesh during the rabi season and covers an area of 0.18 thousand ha with a 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.

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].

By considering the above facts, the experiment was carried out with the objective to test different safflower cultivars under different date of sowing for achieving better growth and yield attributes.

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].

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%)	

2.2 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 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. 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 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.

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.

3. Result and discussion

3.1 Plant height (cm)

The periodical height of the plant was measured on 30 DAS, 60 DAS, 90 DAS and at harvest. The increases in height due to different treatments have been given in Table 3 (A). Data revealed that the plant height was progressively increased with advancement of crop till harvest.

The data in Table 3 (A), showed significant differences found by date of sowing in the periodical plant height of safflower at all growth stage. Significantly more plant height of safflower was observed in 1st November sowing as compared to 15th November sowing which gave significantly more plant height as compared to 30th November sowing at growth stages and at harvest. The early dates were significantly superior over 30th November sown crop in this aspect.

Study of the data on plant height revealed that the plant height progressively increased with an increase in age of crop till harvest. The rate of increase in plant height was higher up to harvest in all the sowing dates and cultivars. Such impacts may be ascribed to the fact that the actual time and cultivar is the source of plant growth and is mainly responsible for increasing the growth of the plant. Significantly taller plants of safflower were recorded with 1st November sowing in safflower as compared to other different sowing dates in all successive growth stages and at harvest. The results are in close conformity with the findings of Odivi *et al* [13] and Tomar [14].

The data presented in Table 3 (A) indicated that different cultivars showed significant variation on plant height of safflower at all growth stages. Significantly more plant height of safflower was observed with cultivar of A-1 at 30 DAS and 60 DAS as compared to other cultivars. The cultivar NARI-6 registered significantly higher plant height (125.54 cm) at 90 DAS and at harvest as compared to other cultivars. [5] also noted significant differences in plant height due to the effect of cultivars. The results are in close conformity with the findings of Mohankumar and Chimmad [16]. Cultivar NARI-6 registered significantly higher plant height at 90 DAS and at harvest. The results are in close conformity with the findings of Singh *et al*. [15]. The variation in these growth parameters of the cultivars might be related to inherent differences and high vigour in these cultivars.

The data presented in Table 3 (B), indicated that sowing dates and safflower cultivars combinations were found significant in plant height at 30 DAS, 60 DAS, 90 DAS and at harvest. However, the Cultivar A-1 recorded maximum height (8.56 cm.) at 30 DAS and (74.50 cm.) at harvest and cultivar NARI-6 recorded maximum height (68.08 cm.) at 60 DAS and (137.23 cm) at harvest under 1st November sowing as compared to other treatment combinations. The Cultivar A-1 was given the maximum height under 1st November sowing at 30 DAS, 60 DAS and 90 DAS as compared to other treatment combinations. The cultivar NARI -6 was given the maximum plant height under 1st November sowing at harvest.

Table 3 (A) Impact of sowing dates and cultivars on plant height (cm) 30, 60, 90 DAS and at harvest

Treatments		Plant height (cm)			
		30 DAS	**60 DAS**	**90 DAS**	**At harvest**
Sowing dates	1 November	7.56	68.64	116.91	125.58
	15 November	6.72	61.27	112.85	124.66
	30 November	5.05	56.44	87.58	96.52
	SEm ±	**0.21**	**1.12**	**0.61**	**1.95**
	CD at 5 %	**0.75**	**3.90**	**2.13**	**6.76**
Cultivars	A-1	7.22	67.32	100.99	108.98
	NARI-6	5.48	60.56	112.11	125.54
	NARI-57	6.63	58.47	104.23	112.23
	SEm ±	**0.15**	**0.51**	**0.57**	**1.21**
	CD at 5 %	**0.45**	**1.53**	**1.71**	**3.61**

Table 3 (B) Interaction impact of sowing dates and cultivars on plant height (cm) 30, 60, 90 DAS and at harvest

Sowing dates (D)	**Cultivars (V)**											
	A-1				**NARI-6**				**NARI-57**			
	30 DAS	**60 DAS**	**90 DAS**	**At harvest**	**30 DAS**	**60 DAS**	**90 DAS**	**At harvest**	**30 DAS**	**60 DAS**	**90 DAS**	**At harvest**
1 November	8.56	74.50	115.38	119.10	6.19	68.0 8	125.80	137.23	7.93	63.33	116.65	120.58
15 November	7.25	64.96	105.38	118.25	5.40	60.17	118.70	137.05	7.50	58.67	107.38	118.50
30 November	5.84	62.50	82.23	89.60	4.84	53.42	91.84	102.35	5.94	53.42	88.68	97.60

	(D×V)1				**(D×V)2**			
	30 DAS	**60 DAS**	**90 DAS**	**At harvest**	**30 DAS**	**60 DAS**	**90 DAS**	**At harvest**
SEm ±	0.26	0.89	0.99	2.10	0.30	1.34	1.02	2.60
CD at 5 %	0.78	2.65	2.96	6.25	0.97	4.42	3.18	8.39

3.2 Dry matter (g plant^{-1})

Dry matter accumulation is directly related with the growth pattern of the crop, which influence the biological yield linearly. Total dry matter per plant was computed at all successive stages of plant growth i.e. 30 DAS, 60 DAS, 90 DAS and at harvest. The data indicated that dry matter plant^{-1} increased up to harvesting. Result presented in Table 4 (A), showed that the date of sowing registered a significant impact on dry matter accumulation plant^{-1}. The crop sown on 1st November noted maximum dry matter at all growth stages as compared to other sowing dates at all the stages of crop growth i.e. 30 DAS, 60 DAS, 90 DAS and at harvest. Study of the data on dry matter accumulation at 30 DAS, 60 DAS and at harvest revealed that the dry matter progressively increased up to the harvest.

Dry matter accumulation plant^{-1} was significantly influenced by sowing dates and cultivars of safflower at all growth stages. 1st November sowing produced the highest dry matter. Further delay significantly decreased total dry matter. This could be attributed to overall improvement in crop growth as reflected by increase in dry matter accumulation under 1st November crop. The results are in close association with findings of Emami *et al.* [17], Rajput *et al*. [19] and Soleymani *et al.* [18]

Thus, it is evident that the crop sown on the most favourable environment factors may attain higher rate of photosynthetic efficiency. This is evidenced from the fact that dry matter accumulation at successive growth stages were observed to be higher in early sown crop in comparison to delayed sown crops. The results are in close conformity with the results of Patel *et al.* [20], Nikppor and Kolchak [21].

The data presented in Table 4 (A), indicated that the safflower cultivars significantly influenced the DMA. Cultivar A-1 accumulated maximum dry matter (2.58 g plant^{-1}) at 30 DAS**,** (16.02 g plant^{-1}) at 60 DAS (28.16 g plant^{-1}) at 90 DAS and (39.98 g plant^{-1}) at harvest which was significantly superior over other cultivars. Cultivar A-1 accumulated maximum dry matter at 30 DAS, 60 DAS, 90 DAS and at harvest. The results are in close conformity with the findings of Mohankumar and Chimmad [16]. The differential behavior of these cultivars could also be explained solely by the variation in their genetic makeup.

The data indicated that sowing dates and safflower cultivars combinations recorded significant impact on dry matter accumulation plant^{-1} at 60 DAS, 90 DAS and at harvest. Maximum dry matter accumulation was given by cultivar A-1 in 1st November sowing at 30 DAS, 60 DAS,90 DAS and at harvest in 1st November sowing **(**22.65 g plant^{-1}) at 60 DAS and **(**52.10 g plant^{-1}) at harvest compared to other treatment combinations. That data indicated in Table 4(B) Maximum dry matter accumulation was given by cultivar A-1 at 30 DAS, 60 DAS, 90 DAS and at harvest compared to other treatment combinations.

Table 4 (A) Impact of sowing dates and cultivars on dry matter

Treatments		**Dry matter (g plant^{-1})**			
		30 DAS	**60 DAS**	**90 DAS**	**At harvest**
Sowing dates	1 November	2.56	18.50	34.68	45.58
	15 November	2.23	14.43	23.36	37.68
	30 November	1.88	8.57	13.59	17.67
	SEm ±	**0.04**	**0.15**	0.29	**0.61**
	CD at 5 %	**0.14**	**0.54**	1.01	**2.14**
Cultivars	A-1	2.58	16.02	28.16	39.98
	NARI-6	1.84	11.63	19.57	28.53
	NARI-57	2.25	13.85	23.89	32.42
	SEm ±	**0.08**	**0.12**	0.25	**0.31**
	CD at 5 %	**025**	**0.37**	0.75	**0.94**

Table 4 (B) Interaction impact of sowing dates and cultivars on dry matter

Sowing dates (D)	**Cultivars (V)**											
	A-1				**NARI-6**				**NARI-57**			
	30 DAS	**60 DAS**	**90 DAS**	**At harvest**	**30 DAS**	**60 DAS**	**90 DAS**	**At harvest**	**30 DAS**	**60 DAS**	**90 DAS**	**At harvest**
1November	3.04	21.55	41.76	54.10	2.07	15.93	30.18	39.55	2.58	18.03	32.10	43.10
15 November	2.39	15.43	27.11	45.41	1.91	13.02	18.14	31.48	2.38	14.84	24.83	36.16
30 November	2.32	11.08	15.61	20.43	1.55	5.95	10.40	14.58	1.78	8.68	14.76	18.00

	(D×V)1				**(D×V)2**			
	30 DAS	**60 DAS**	**90 DAS**	**At harvest**	**30 DAS**	**60 DAS**	**90 DAS**	**At harvest**
SEm ±	0.14	0.21	0.4	0.54	0.12	0.23	0.46	0.76
CD at 5 %	NS	0.63	1.30	1.62	NS	0.74	1.44	2.50

3.3 Number of days to flower initiation, 50% flowering and 100% flowering.

The data indicated that sowing dates and cultivars were found the significant impact on flower initiation, 50% flowering and 100% flowering. It is presented in Table 5 **(**A). The crop sown on 30th November noted minimum number of days for flower initiation, 50% flowering and 100% flowering as compared to other sowing dates.

The data presented in Table 5 (A), indicated that the safflower cultivars was significantly influenced the flower initiation, 50% flowering and 100% flowering. Cultivar

A-1 received minimum number of days (i.e. 86.58 days) for flower initiation, 93.17 days for 50% flowering and 99.67 days for 100% flowering as compared to other cultivars.

The data indicated that sowing dates and safflower cultivars combinations were found the significant impact on flower initiation, 50% flowering and 100% flowering. Minimum number of days (84.75) received by A-1 in 30th November sowing for flower initiation, 89.50 days for 50% flowering and 94.50 days for 100% flowering compared to other treatment combinations as shown in Table 5 (B). Number of days for flower initiation, 50% flowering and 100% flowering was significantly influenced by sowing dates. The data indicate that the minimum number of days for flower initiation, 50% flowering, and 100% flowering received by the 30th November sowing. The results are close conformity with the findings of Omidi and Sharifmogadas [22]. The data indicated that the minimum number of days for flower initiation for 50% flowering and 100% flowering was received by cultivar A-1. The results are close conformity with the findings of Firouzabadi *et al*. [23]. The minimum number of days for flower initiation 50% flowering and 100% flowering was received by cultivar A-1 under 30th November sowing.

Table 5 (A) Impact of sowing dates and cultivars on flower initiation, 50% flowering and 100% flowering

Treatments		Number of days for flower initiation	Number of days for 50% flowering	Number of days for 100% flowering
Sowing dates	1 November	92.08	99.50	106.67
	15 November	94.50	101.58	109.17
	30 November	89.42	92.92	102.33
	SEm ±	**0.27**	**0.41**	**0.20**
	CD at 5 %	**0.96**	**1.43**	**0.69**
Cultivars	A-1	86.58	93.17	99.67
	NARI-6	98.50	105.75	113.42
	NARI-57	90.92	97.50	105.08
	SEm ±	**0.18**	**0.33**	**0.25**
	CD at 5 %	**0.56**	**0.98**	**0.74**

Table 5 (B) Interaction impact of sowing dates and cultivars on flower initiation, 50% flowering and 100% flowering

Sowing dates (D)	**Cultivars (V)**		
	A-1	**NARI-6**	**NARI-57**

	Flower initiation	50% flowering	100% Flowering	Flower Initiation	50% Flowering	100% flowering	Flower initiation	50% flowering	100% flowering
1 November	86.00	93.50	100.00	99.50	107.50	115.00	90.75	97.50	105.00
15 November	89.00	96.50	103.50	101.50	109.50	117.00	93.00	98.75	107.00
30 November	84.75	89.50	95.50	94.50	100.25	108.25	89.00	96.25	103.25

	(D×V)1			(D×V)2		
	Flower initiation	**50% Flowering**	**100% flowering**	**Flower initiation**	**50% Flowering**	**100% flowering**
SEm ±	0.32	0.58	0.43	0.54	0.88	0.57
CD at 5 %	0.97	1.70	1.28	1.22	1.98	1.25

3.4 Number of primary branches

The mean number of primary branches plant^{-1} at harvest the maximum number of primary branches per plant was recorded in the treatment 1st November sowing followed by 15th November sowing significant difference over rest of the treatments. The minimum number of primary branches plant $^{-1}$ was recorded under 30th November sowing.

The data indicated in Table 6 (A) that number of primary branches was not affected significantly by safflower cultivars. However maximum number of primary branches (10.33 plant^{-1}) was recorded in safflower cultivar NARI-6 followed by NARI-57 at harvest. Minimum number of primary branches plant^{-1} was recorded in A-1 cultivar.

The data showed that sowing dates and safflower cultivars combinations were not found the significantly impact on primary branches plant^{-1} at harvesting stage. However, maximum number of primary branches was obtained by 1st November sowing with NARI-6 cultivar. Table 6 (B) The data indicate that the maximum number of primary and secondary branches per plant at harvest was recorded in 1st November sowing. Dadashi and khajehpour [24] in his study observed that branch plant^{-1} gets reduced with delay in sowing date and he supposed that the changing environment, temperature and day length would become the main reason for these results. The results are close conformity with the findings of Tomar [14].

The maximum number of primary branches was obtained in cultivar NARI-6. The results are in close conformity with the findings of Singh *et al*. [15]. Maximum secondary branches were obtained in cultivar A-1. Maximum primary branches were given by cultivar NARI-6 under 1st November sowing. However maximum number of secondary branches was obtained by 1st November sowing with A-1 cultivar. The results are in close conformity with the findings of Mohankumar and Chimmad [16].

3.4 Number of secondary branches

It was observed that majority of secondary branches (18.84) emerged under 1st November sowing followed by 15th November sowing. Minimum number of secondary branches plant^{-1} recorded in 30th November sowing. The maximum number of secondary branches plant^{-1} was obtained in cultivar A-1 (13.02) followed by cultivar NARI-57 (11.98). The minimum number of secondary branches plant^{-1} was recorded with cultivar NARI-6 at harvest. Table 6 (A). The on sowing dates and safflower cultivars combinations did not show significantly impact on secondary branches plant^{-1} at harvesting stage. However maximum number of secondary branches was obtained by 1st November sowing with A-1 cultivar.

Table 6 (A) Impact of sowing dates and cultivars on primary and secondary branches

Treatments		Number of primary branches	Number of secondary branches
Sowing dates	1 November	12.16	18.84
	15 November	9.42	11.38
	30 November	7.58	4.98
	SEm ±	**0.50**	**1.09**
	CD at 5 %	**1.74**	**3.80**
Cultivars	A-1	9.17	13.02
	NARI-6	10.33	10.20
	NARI-57	9.66	11.98
	SEm ±	**0.38**	**0.47**
	CD at 5 %	**NS**	**1.41**

Table 6 (B) Interaction impact of sowing dates and cultivars on number of primar branches

Sowing dates (D)	Cultivars (V)		
	A-1	**NARI-6**	**NARI-57**
1 November	10.71	13.65	12.11

15 November	9.66	9.56	9.03
30 November	7.14	7.77	10.45
	(D×V)1		**(D×V)2**
SEm ±	**0.67**		**0.74**
CD at 5 %	**NS**		**NS**

Table 6 (C) Interaction impact of sowing dates and cultivars on number of secondary branches

Sowing dates (D)	**Cultivars (V)**		
	A-1	**NARI-6**	**NARI-57**
1 November	20.93	15.82	19.78
15 November	12.67	10.71	10.75
30 November	5.46	4.06	3.88
SEm ±	**(D×V)1**		**(D×V)2**
	0.82		**1.28**
CD at 5 %	**NS**		**NS**

3.5 Crop growth rate (CGR)

CGR is directly related with the growth pattern of the crop, it is correlation between crop growth and time. It indicates that at what rate the crop is growing i.e. whether the crop is growing is at a faster rate or a slower rate than normal. CGR was computed at all successive stages of plant. It is obvious from the Table 7, that CGR was significantly influenced by different sowing dates at all growth stages. Up to 30 DAS, the maximum CGR (0.085), 30-60 DAS (0.53) and 60-90 DAS (0.54) were observed with 1st November sown crop and proved significantly superior over 30th November sowing but at par with 15th November sowing. 90 DAS – At harvest the maximum CGR (0.26) was observed 15th November sown crop.

A perusal of data Table 7 indicated that different cultivar registered a significant variation in at all growth stages. The maximum CGR i.e. 0.86, 0.45, 0.40 and 0.22 received A-1 which was significantly superior to other cultivars at up to 30 DAS, 30-60 DAS 60-90 DAS and 90 DAS-at harvest, respectively. CGR was significantly influenced by sowing dates at all growth stages and cultivars of safflower also significantly influenced at all growth stage. Among date of sowing 1st November, was superior to other sowing dates at all growth stages except at harvest stage. CGR was significantly influenced by cultivars at all growth stages. The maximum CGR received A-1 which was significantly superior to other cultivars at up to 30 DAS, 30DAS-60 DAS, 60 DAS-90 and DAS and 90 DAS-at harvest, respectively.

Table 7 Impact of sowing dates and cultivars on CGR

Treatments		CGR (g m^{-2} day^{-1})			
		Up to 30 DAS	**30-60 DAS**	**60-90 DAS**	**90-At-harvest**
Sowing dates	1 November	0.085	0.53	0.54	0.18
	15 November	0.074	0.41	0.30	0.26
	30 November	0.062	0.22	0.17	0.09
	SEm ±	**0.001**	**0.005**	**0.009**	**0.011**
	CD at 5 %	**0.005**	**0.017**	**0.034**	**0.04**
Cultivars	A-1	0.086	0.45	0.40	0.22
	NARI-6	0.061	0.33	0.26	0.16
	NARI-57	0.074	0.39	0.33	0.15
	SEm ±	**0.003**	**0.004**	**0.010**	**0.008**
	CD at 5 %	**0.008.**	**0.013**	**0.030**	**0.02**

3.6 Relative growth rate (RGR)

The data indicated that RGR was significantly influenced by different sowing dates at 30-6 DAS, 60-90 DAS and 90 DAS-At harvest. The maximum RGR was observed with 1st November sown crop at 30-60 DAS and 60-90 DAS and 15th November at 90 DAS – harvest. A perusal of data presented in Table 8 indicated that different cultivar registered a significant variation in at 30-60 DAS, 60-90 DAS and 90-harvest. The maximum RGR received with A-1 at 30-60 DAS, 60-90 DAS and 90 DAS-At harvest which was significantly superior to other cultivars. RGR was significantly influenced by different sowing dates at all growth stages. Among date of sowing, 1st November, was superior to other sowing dates at all growth stages except at harvest stage. The maximum RGR received with A-1 at 30-60 DAS, 60-90DAS and at 90-At harvest which was significantly superior to other cultivar.

Table 8 Impact of sowing dates and cultivars on RGR

Treatments	RGR (g g^{-1} day^{-1})		
	30-60 DAS	**60-90 DAS**	**90-At harvest**

Sowing dates	1 November	0.040	0.040	0.017
	15 November	0.036	0.030	0.020
	30 November	0.026	0.023	0.012
	SEm ±	**0.00022**	**0.00048**	**0.00085**
	CD at 5 %	**0.00078**	**0.00165**	**0.00295**
Cultivars	A-1	0.036	0.033	0.018
	NARI-6	0.031	0.027	0.016
	NARI-57	0.034	0.032	0.015
	SEm ±	**0.00023**	**0.00055**	**0.00072**
	CD at 5 %	**0.00069**	**0.00164**	**0.00214**

3.7 Chlorophyll content

Chlorophyll content was determined at flower initiation stage. It is seen from the data of the table and fig that the chlorophyll content significantly influenced by the different sowing dates, safflower cultivar and their interaction. The highest chlorophyll content (59.64) was obtained in 1st November sowing followed by 15th November sowing at flower initiation. Table 9, the highest chlorophyll content was obtained in NARI-6 (61.33) followed by A-1 (56.93) at flower initiation. Table 9, The data indicated that sowing dates and safflower cultivars combinations were found the significant impact on chlorophyll content at flower initiation stage. Maximum chlorophyll content was given by cultivar NARI-6 **(**63.96) under 1st November sowing compared to other treatment combinations. The highest chlorophyll content was obtained in 1st November sowing. The results are close conformity with the findings of Khalil *et al.* [25]. The highest chlorophyll content was obtained in cultivar NARI-6. The results are in close conformity with the findings of Singh *et al*. [15] and Aakash et al. [5]. The differential behavior of these cultivars could also be explained solely by the variation in their genetic makeup. Maximum chlorophyll content was given by cultivar NARI-6 under 1st November sowing compared to other treatment combinations.

Table 9 (A) Impact of sowing dates and cultivars on Chlorophyll content and leaf area index

Treatments		**Chlorophyll content (SPAD)**	**LAI**
Sowing dates	1 November	59.64	1.62
	15 November	55.89	1.32

	30 November	54.50	0.59
	SEm ±	**0.32**	**0.08**
	CD at 5 %	**1.12**	**0.30**
Cultivars	A-1	56.93	1.41
	NARI-6	61.33	0.98
	NARI-57	51.77	1.14
	SEm ±	**0.22**	**0.02**
	CD at 5 %	**0.66**	**0.08**

Table 9 (B) Interaction impact of sowing dates and cultivars on chlorophyll content

Sowing dates (D)	**Cultivars (V)**		
	A-1	**NARI-6**	**NARI-57**
1 November	58.95	63.96	56.01
15 November	56.58	60.95	50.15
30 November	55.28	59.07	49.15
	(D×V)1		**(D×V)2**
SEm ±	0.39		0.64
CD at 5 %	1.14		1.44

3.8 Leaf area index (LAI)

Leaf area index was determined at flower initiation stage. It is seen from the data of the table and fig that the LAI significantly influenced by the different sowing dates, safflower cultivar and their interaction. The highest LAI (1.62) was obtained in 1st November sowing followed by 15th November sowing at flower initiation. The highest LAI was obtained in A-1 (1.41) followed NARI-57 (1.14) at flower initiation. Data documented in indicated that sowing dates and safflower cultivars combinations were found the significant impact on LAI at flower initiation stage. Maximum LAI was given by cultivar A-1 (1.93) under 1st November sowing compared to other treatment combinations. The data indicate that the LAI was influenced by sowing dates at flower initiation. The highest LAI was obtained in 1st November sowing. Sowing in 1st November induced early maturity in cultivars with a significant increase in the Number of leaves. The results are close conformity with the findings of Sabale and Deokar [26] and Rajput *et.al*. [19]. The highest LAI was obtained in cultivar A-1 which was significantly superior to other cultivar. The differences in LAI due to cultivar also noted by [5]. The highest LAI (leaf area index) was given by cultivar A-1 under 1st November sowing compared to other treatment combinations.

Table 10 Interaction impact of sowing dates and cultivars on leaf area index

Sowing dates (D)	Cultivars (V)		
	A-1	**NARI-6**	**NARI-57**
1 November	1.93	1.39	1.54
15 November	1.64	1.06	1.21
30 November	0.64	0.47	0.67
	(D×V)1		**(D×V)2**
SEm ±	0.04		0.14
CD at 5 %	0.13		0.31

Conclusion

The choice of location specific cultivar has advantages over other cultivars since it well adopted and responded better to local environment/growing conditions and applied inputs leading to significant higher production. The cultivar NARI-6 was given the maximum plant height (125.54 cm) under 1st November sowing at harvest. Cultivar A-1 accumulated maximum dry matter at 30 DAS, 60 DAS, 90 DAS and at harvest. Cultivar A-1 took minimum number of days for phenological development as compared to other cultivars. While maximum number of primary branches plant^{-1} was recorded in safflower cultivar NARI-6 (10.33) followed by NARI-57 (9.66) at harvest. It was observed that majority of secondary branches emerged under 1st November sowing (18.84) followed by 15th November sowing. The maximum CGR and RGR were received by A-1 which was significantly superior to other cultivars. The Maximum chlorophyll content was given by cultivar NARI-6 under 1st November sowing compared to other treatment combinations. The highest LAI was obtained in cultivar A-1 which was significantly superior to other cultivar. It is concluded that cultivar A-1 and NARI-6, and 1st November sowing performed better in terms of above parameters and recommended for cultivation.

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