International Journal of Advanced Biochemistry Research

ISSN Print: 2617-4693
ISSN Online: 2617-4707
IJABR 2024; 8(8): 343-347
www.biochemjournal.com
Received: 19-05-2024
Accepted: 23-06-2024

YD Charjan
Associate Professor,
Department of Agronomy,
Agriculture Research Station,
Achalpur, Amravati,
Maharashtra, India

RS Wankhade
Assistant Professor,
Department of Horticulture,
ARS, Achalpur, Maharashtra,
India

BK Farkade
Assistant Professor,
Department of Agronomy,
Oil seed Res. Unit, Dr. PDKV,
Akola, Maharashtra, India

SG Dhodare
Student, Department of
Agronomy, PGI, Dr. PDKV.,
Akola, Maharashtra, India

Corresponding Author:
YD Charjan
Associate Professor,
Department of Agronomy,
Agriculture Research Station,
Achalpur, Amravati,
Maharashtra, India

Effect of different sowing windows and genotypes on growth and yield of safflower under Vidarbha

YD Charjan, RS Wankhade, BK Farkade and SG Dhodare

DOI: https://doi.org/10.33545/26174693.2024.v8.i8e.1752

Abstract
A field experiment was conducted at Oilseed research unit, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola during rabi season 2022-23 with an object to find out suitable sowing date for safflower crop under Vidarbha climatic condition. The experimental site was fairly uniform in topography with clayey in texture and slightly alkaline in reaction. It was low in available nitrogen, medium in available phosphorus and rich in potash with moderate organic carbon. The experiment was laid out with twelve treatment combinations in split plot design with three replications. Main plot consists of four sowing dates (S) *viz*. sowing in 39th MW (S_1), 41th MW (S_2) , 43th MW (S_3), 45th MW (S_4) and sub plot consist of three varieties namely AKS-207 (V_1), PKV-Pink (V_2) and AKS-351 (V_3).
The differences were significant among all the sowing dates and varieties in respect of the growth and yield parameter. Growth attributes *viz*. plant height, number of branches plant^{-1}, number of leaves plant^{-1}, leaf area plant^{-1}, and dry matter accumulation plant^{-1} and yield attributes such as seed weight plant^{-1} (25.1 and 26.1 g) as well as seed (2162 and 1945 kg ha^{-1}), straw (5592 and 4651 kg ha^{-1}) and biological yield (7754 and 6596 kg ha^{-1}) were significantly higher with treatment 41st MW (S_2) sowing and variety AKS-351 (V_3). Significantly higher uptake of nitrogen (76.8 & 67.0 kg ha^{-1}), phosphorous (21.6 & 18.3 kg ha^{-1}), potassium (71.22 & 58.46 kg ha^{-1}) and higher available N (178.09 & 175.51 kg ha^{-1}), P (21.99 & 22.61 kg ha^{-1}) and K (459.70 & 456.01 kg ha^{-1}) in soil after harvest of crop reported by treatment 41st MW (S_2) sowing and variety AKS-351 (V_3).

Keywords: Sunflower, genotypes, sowing window, nutrient NPK

Introduction
Oilseeds have the second largest area in India, sharing 15.07 percent of the gross cropped area. In India, it is grown as major oil seed crop for its manifold uses. Safflower oil is mainly used as cooking oil in salad dressing and for production of margarine as industrial oil. It is considered as drying or semi drying oil that is used in manufacturing paints and other surface coating. The oil content varies from 25 to 35 percent depending upon variety. The safflower oil is nutritionally better because it contains 55.88 percent linoleic acid, which is useful for the patient of heart disease and considered safe, because of unsaturated fatty acid. Safflower cake is rich in protein and easy to digest and profitably be included in the poultry and livestock ration. The cake obtained from un-decorticated seed, it is used as a manure as, it contains 5% N, 1.44% P and 1.23% K. Safflower crop has capacity to withstand in drought, low input requirement for cultivation, no specific preference to any type of soil and capacity to yield reasonably, under rainfed condition. Most oilseed crops have an indeterminate growth habit; adaptation is influenced by tolerance to high temperature and drought stress. In Maharashtra, safflower is mainly grown in Marathwada and Vidarbha region. Buldhana occupies a large area under safflower. Today, it is also grown in parts of Akola, Amravati, and Yavatmal districts. The high productivity of safflower is an outcome of major agronomical practices such as sowing dates and genotypes. The changing climatic conditions responsible for changes in the sowing schedule of crops and cropping systems. Sowing dates mean the effects of edaphic factors and all the environmental conditions on a large scale on the growth and yield of all field crops, which differ widely from region to region. Moreover, sowing dates are considered the most important affecting factors for safflower. Early sowing of safflower suffers from wilt or rust disease, while late sowing increases the chances of attack by aphids.

Appropriate cultivars serve as a pivot around which all other parameters of agriculture are adjusted in order to achieve the highest yield of crop. Finding a suitable cultivar is the first and most crucial aspect affecting the crop's average yield. The capacity to respond to various agronomical elements that are complementary to yield, assuming all other inputs are sufficiently supplied, is the result of the interaction of genetic factors governing growth and yield potential. The right cultivar must be chosen for the area because the climatic conditions of one place may not apply to another. "Cultivar selection is a key management component in any cropping system even more critical in sowing dates for crop production". It is equally important to choose the right sowing date. Utilizing advantageous climatic conditions to their fullest and protecting plants during their growth phases from unfavorable environmental influences are both essential for enhancing crop output. Since temperature and day length have a greater impact on the length of development stages, the sowing date can be chosen to provide for the best temperature and day length for the various stages of plant growth. It is also essential to choose the right planting date by having appropriate knowledge of ecological and environmental growing elements. Crop planting depends on rainfall and soil moisture availability in dry-land environments. Early sowing makes better use of the moisture in the soil. The crop displayed early vigour, growth, and development, which led to a greater yield. The yield fall rate varies from 4 to 80 kg day^{-1} ha^{-1} as a result of delayed seeding. Because pests and diseases are more common, germination is poor due to low temperatures, plant stands are weak, and there is a severe terminal drought, delayed sowing reduces yield. Safflower has a promising future as a salinity and drought resistant crop that has both spring and autumn types. Sowing date is very important in agricultural production management decisions, especially at region having environmental restrictions such as sooner or later coldness or serves (Emami *et al*., 2011) [5]. Cultivar selection is also a key management component in any cropping system even more critical in sowing date for crop production (Soleymani *et al.*, 2011) [11].

All the varieties may not be suitable for timely as well as late sowing. The differences in production of timely sown and late sown crops may be attributed to the unfavourable temperature prevailing at different growth stages, such as low temperature at the time of germination which may delay crop emergence. Low temperature may also slow down the growth and development of the crop, resulting in the accumulation of insufficient biomass and shortening of crop duration (Sooraj Chandra *et al.,* 2015) [12]. The field and quality properties of safflower are largely determined by ecological factors and cultivation techniques. It was reported that the sowing date and cultivars of safflower vary depending on ecological conditions (Daltalab *et al*., 2013) [3]. Therefore, in order to obtain safflower with high yield and quality, it is essential to determine the suitable growth conditions and cultivation techniques.

Safflower is mainly grown in rabi season on residual moisture. Area under safflower in Vidarbha region is increasing but the average yields are low. Improved varieties of safflower having high yield potential have been evolved which may respond in different soil, plant and climatic management complex. Production potential of these promising varieties of safflower needs to be exploited under ecological situations of Vidarbha. The crop responds to seeding time in all season and its performance is pronounced when sown at right time. The present investigation on different dates of sowing and different genotypes might have significant effect on growth, yield, quality, oil content and NPK content in safflower and available NPK after harvest in soil.

Materials and Methods

A field investigation was carried out in the field of oilseed research unit, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola, during the *rabi* season of 2022-2023. The topography of the field was clay loam soil fairly uniform and level. The pH of the soil was 8.24, which indicated that it was slightly alkaline in reaction. The soil was low in available nitrogen172.7 kg ha^{-1} (Subbiah and Asija 1956) [13], medium in available phosphorus 21.4 kg ha^{-1}, and rich in available potash 453.6 kg ha^{-1}(Jackson, 1967) [7]. It was moderate in organic carbon. Akola is situated in the subtropical zone at latitude of 22.42° N and a longitude of 77.02 °E. The altitude of the place is 307.41 m above the mean sea level. The climate of the area is semi-arid, characterized by three distinct seasons: summer, which becomes hot and dry from March to May, the warm and rainy monsoon from June to October; and winter, which is mild and cold from November to February. The average maximum temperature varies from 32.3°C to 29.1°C and minimum temperature varied from 8.4°C to 14.7°C during the crop growth period. Average bright sunshine hours were 7.6, which were below normal value of 8.3. The average wind speed was 1.1 km hr¹, which was below normal of 4.2 km hr^{-1}, the average morning relative humidity was 79.3 percent which was higher than normal value 67.3 and evening relative humidity 35.6 percent, which was higher than normal value 29.6 percent during crop season. The average evaporation rate during the crop season was 3.7 mm day, which was lower than normal of 5.4 mm day^{-1}. The details of the treatment combination involving two factors *viz*., sowing dates and varieties are as follows. The experiment was carried out in split plot design with twelve treatment combinations and three replications.

Treatment	Symbol
Main plot:- Sowing dates	
i) Last week of September (39 MW- 28/09/2022)	S_1
ii) 2nd week of October (41 MW-12/10/2022)	S_2
iii) 4th week of October (43 MW-28/10/2022)	S_3
iv) 2nd week of November (45 MW-09/11/2022)	S_4
Sub plot:- Varieties	
i.AKS -207	V_1
ii.PKV Pink	V_2
iii.AKS – 351	V_3

Harvest index were work out from following formula.

$$\text{H.I. (\%)} = \frac{\text{Economical yield}}{\text{Biological yield}} \text{ x } 100$$

The oil percentage was determined with the help of Soxhlet apparatus instrument treatment wise from seeds.

$$\text{Oil yield (kg ha}^{-1}\text{)} = \frac{\text{Oil content (\%) x seed yield (kg ha}^{-1}\text{)}}{100}$$

Oil yield ha^{-1} was calculated from oil percentage and seed yield.

The available nitrogen from soil was estimated by alkaline permanganate method by Subbiah and Asija (1956) [13], available phosphorus from soil was estimated by Olsen's method. Olsen reagent (0.5 M sodium bicarbonate adjusted to pH 8.5) and available potassium from soil was determined by neutral normal ammonium acetate extract using Flame Photometer (Jackson, 1967) [7]. The statistical analysis of the data on various growth and yield characters studied in the investigation was carried out through the statistical analysis of variance technique as described by Panse and Sukhatme (1967) [8].

Results and Discussion

Growth studies

Significant increase in plant height, number of leaves and branches, leaf area and dry matter plant^{-1} was noticed due to different sowing dates, however maximum plant height (92.8 cm), number of leaves (83) and branches (15.2), leaf area (37.3 dm^2) and dry matter plant^{-1} (58.83 g) was recorded with 41 MW (S_2) as against lowest with sowing at 39th MW (S_1). Similar results in increase in plant height due to advancement in sowing dates were recorded by Patel *et al*. (1996) [10] and Bastia *et al*. (1999) [2].

Among different variety, AKS-351 (V_3) recorded maximum plant height (93.3 cm), number of branches (15.4) and dry matter plant^{-1} (58.83 g), and PKV-Pink (V_2) was remain at par with each other and recorded significantly higher plant height over variety AKS-207 (V_1) at all stages of crop growth. Significant difference in plant height might be due to genetic potential of the variety. Similar results were observed to Patel *et al*. (1997) [9]. The interaction effect of sowing date and variety was found non significant for all except dry matter accumulation plant^{-1}.

Increase in number of branches with sowing 41 MW (S_2) might be due to favourable temperature condition during vegetative growth Beneficial effects of sowing dates on number of branches per plant also reported by Patel *et al*. (1996) [10], Hulihali *et al*. (1997) [6]. More number of branches recorded by varietyAKS-351 (V_3), and PKV-Pink (V_2) at harvest might be due to higher genetic potential. Similar results are in conformity with Patel *et al*. (1997) [9].

Increase in leaf area might be due to more number of leaves and favourable environmental condition during vegetative phase of crop growth. These results are in according with the finding of Hulihali *et al*. (1997) [6].

Higher dry matter accumulation recorded in 41th MW might be due to the reflection of better plant growth in terms of plant height, number of branches and leaf area plant, leading to better photosynthesis, which enhanced the dry matter accumulation. Similar results were reported by Patel *et al*. (1996) [10] and Hulihali *et al*. (1997) [6].

Table 1: Plant height, number of leaves, number of branches, leaf area and dry matter accumulated plant^{-1} of safflower as influenced by various treatments.

Treatments	Plant height (cm)	No. of leaves	No. of branches	Leaf area plant^{-1} (dm^2)	Dry matter plant $^{-1}$ (g)
A) Date of Sowing (S)					
S_1 - Last week of Sept. (39th MW) - 28/09/2022	89.9	80.9	13.7	32.3	55.00
S_2 - 2nd Week of Oct. (41st MW) - 12/10/2022	92.8	83.0	15.2	34.4	58.83
S_3 - 4th Week of Oct. (43rd MW) - 28/10/2022	91.8	82.4	14.3	33.7	55.72
S_4- 2nd Week of Nov. (45th MW) - 09/11/2022	90.1	81.8	13.8	33.2	55.09
SE (m) ±	0.63	0.96	0.20	0.32	0.55
CD (P=0.05)	2.18	2.88	0.71	0.82	1.89
B) Variety (V)					
V_1- AKS-207	87.9	80.3	13.3	31.5	52.3
V_2 – PKV PINK	92.3	83.7	14.1	35.5	57.3
V_3 - AKS-351	93.3	82.0	15.4	33.2	58.9
SE (m) ±	0.51	0.63	0.25	0.50	0.73
CD (P=0.05)	1.52	1.89	0.75	1.49	2.20
C) Interactions (S x V)					
SE (m) ±	1.01	1.26	0.50	0.99	1.47
CD (P=0.05)	NS	NS	NS	NS	4.59

Yield studies

Sowing dates significantly influenced the seed yield. Sowing in 41st MW (S_2) recorded significantly higher seed, straw and biological yield (2162, 5592 and 7754 kg ha^{-1}) over sowing in 43rd MW. Increase in seed, straw and biological yield with sowing 41st MW might be due to convenient temperature for longer time favourable for germination as well as vegetative and reproductive growth of plants and ultimately the resultant effect of contribution of different yield attributes to the yield. Similar finding were also reported by Deokar *et al*. (1984) [4] Patel *et al*. (1996) [10], Patel *et al*. (1997) [9] and Hulihali *et al*. (1997) [6].

Seed yield was significantly influenced due to variety. Variety AKS-351 (V_3) recorded significantly higher seed, straw and biological yield (1945, 4651 and 6596 kg ha^{-1}) over varietyAKS-207 (V_1) and PKV Pink (V_2). Highest seed yield in AKS-351 (V_3), might be attributed to the higher values of the yield attributes *viz*. weight of seed capitla¹ and seed weight plant¹. The interaction effect between sowing dates and variety on seed yield was found to be significant. Similar results were reported by Patel *et al*., (1997) [9] and Hulihali *et al*., (1997) [6].

Table 2: Seed weight plant^{-1}, 100 seed weight, seed yield, straw yield, biological yield of safflower as influenced by various treatments.

Treatments	Seed wt plant^{-1} (g)	100 seed weight (g)	seed yield (kg ha^{-1})	straw yield (kg ha^{-1})	Biological yield (kg ha^{-1})
A) Date of Sowing (S)					
S_1 - Last week of Sept. (39th MW) - 28/09/2022	12.5	4.82	1200	2852	4052
S_2 - 2nd Week of Oct. (41st MW) - 12/10/2022	25.1	5.24	2162	5592	7754
S_3 - 4th Week of Oct. (43rd MW) - 28/10/2022	21.7	5.23	1764	4400	6164
S_4- 2nd Week of Nov. (45th MW) - 09/11/2022	18.7	5.21	1577	3851	5428
SE (m) ±	0.30	0.01	1.99	3.45	5.26
CD (P=0.05)	1.04	0.04	6.87	11.94	18.20
B) Variety (V)					
V_1- AKS-207	18.7	5.89	1640	4080	5720
V_2 – PKV PINK	14.5	3.26	1442	3800	5242
V_3 - AKS-351	26.1	6.22	1945	4651	6596
SE (m) ±	0.37	0.01	0.77	1.88	2.36
CD (P=0.05)	1.11	0.03	2.31	5.63	7.07
C) Interactions (S x V)					
SE (m) ±	0.74	0.02	1.54	3.76	4.71
CD (P=0.05)	2.22	0.06	4.61	11.27	14.13

Quality parameters

Table 3: Protein content and oil content of safflower as influenced by various treatments

Treatments	Protein content (%)	Protein yield (kg ha^{-1})	Oil content (%)	Oil yield (kg ha^{-1})
A) Date of Sowing (S)				
S_1 - Last week of Sept. (39th MW) - 28/09/2022	12.02	144.4	31.1	374.6
S_2 - 2nd Week of Oct. (41st MW) - 12/10/2022	12.32	265.5	31.3	672.0
S_3 - 4th Week of Oct. (43rd MW) - 28/10/2022	12.14	215.5	31.2	547.9
S_4- 2nd Week of Nov. (45th MW) - 09/11/2022	12.30	192.1	30.9	483.1
SE (m) ±	0.21	25.14	0.22	59.17
CD (P=0.05)	NS	75.44	NS	177.52
B) Variety (*V*)				
V1- AKS-207	12.18	200.4	30.7	503.2
V2 – PKV PINK	12.15	175.7	32.1	462.9
V3 - AKS-351	12.26	237.0	30.6	592.1
SE (m) ±	0.10	9.37	0.19	23.25
CD (P=0.05)	NS	28.09	0.58	69.70
C) Interactions (S x V)				
SE (m) ±	0.20	18.74	0.39	46.50
CD (P=0.05)	NS	NS	NS	NS

Data regarding the different sowing dates on protein and oil content found to be non significant. The interaction effect between sowing dates and variety on protein and oil yield was found to be non significant.

Data recorded on oil and protein yield (Kg ha^{-1}) as influenced due to different sowing dates and varieties. Data indicated that Variety AKS-351 (V_3) found recorded highest oil and protein yield over variety AKS-207 (V_1) and PKV Pink (V_2). The interaction effect between sowing dates and variety on oil yield were found to be non significant. The interaction effect between sowing dates and variety on protein yield were found to be non significant. Similar results were reported by Veer *et al*., (1992) [14] and Hulihali *et al*., (1997) [6].

Sowing dates significantly influenced the nitrogen, phosphorus and potassium uptake by safflower crop and available NPK in soil after harvest of crop. Sowing in 41th MW (S_2) recorded significantly highest nitrogen, phosphorus and potassium uptake in plant (76.8, 21.6 and 71.22 kg ha^{-1}) and available soil NPK (178.09, 21.99 and 459.70 kg ha^{-1}). Nitrogen, phosphorus and potassium uptake by safflower crop and available NPK in soil after harvest of crop were significantly influenced by the variety. VarietyAKS-351 (V_3) recorded significantly higher nitrogen, phosphorus and potassium uptake in plant (67.0, 18.3 and 58.46 kg ha^{-1}) and available soil NPK (175.51, 22.61 and 456.01 kg ha^{-1}). The interaction effect between sowing dates and variety on uptake of nitrogen, phosphorus and potassium was found to be significant, however for available NPK it was non significant. Similar results were reported by Veer *et al*., (1992) [14] and Anonymous (2001) [1]. Finally, safflower sowing in 41st MW (S_2) with variety AKS-351 (V_3) recorded highest yield.

Table 4: NPK in plant and available NPK (kg ha^{-1}) in soil as influenced by various treatments.

Treatments	N	P	K	Available (kg ha^{-1})		
				N	P	K
A) Date of Sowing (S)						
S_1 - Last week of Sept. (39th MW) - 28/09/2022	41.0	11.8	33.12	174.02	21.88	455.37
S_2 - 2nd Week of Oct. (41st MW) - 12/10/2022	76.8	21.6	71.22	178.09	21.99	459.70
S_3 - 4th Week of Oct. (43rd MW) - 28/10/2022	61.4	17.0	54.28	177.27	22.50	457.56
S_4- 2nd Week of Nov. (45th MW) - 09/11/2022	54.9	14.7	46.92	175.04	23.60	456.30
SE (m) ±	5.85	1.50	4.94	0.35	0.47	0.31
CD (P=0.05)	20.25	5.18	17.11	NS	NS	NS
B) Variety (*V*)						
V_1- AKS-207	57.3	16.3	50.09	176.00	22.44	457.63
V_2 – PKV PINK	51.2	14.1	45.62	176.81	22.43	458.05
V_3 - AKS-351	67.0	18.3	58.46	175.51	22.61	456.01
SE (m) ±	2.65	0.59	2.00	0.37	0.40	057
CD (P=0.05)	7.95	1.76	5.98	NS	NS	NS
C) Interactions (S x V)						
SE (m) ±	5.30	1.18	3.99	0.74	0.79	1.15
CD (P=0.05)	15.90	3.53	11.97	NS	NS	NS

Conclusion

In conclusion, the study demonstrates that sowing safflower in the 41st MW (S2) significantly enhances plant growth, yield, and nutrient uptake compared to later sowing dates. This timing resulted in the tallest plants with the highest leaf area, number of branches, and dry matter. Among the varieties tested, AKS-351 (V3) exhibited superior growth and yield attributes, including seed yield, straw yield, and oil and protein content. Interaction effects between sowing dates and variety were significant for seed yield and nutrient uptake but not for protein and oil yields. Overall, sowing in the 41st MW with AKS-351 maximized both growth and productivity, aligning with previous research on optimal sowing dates and variety selection.

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