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Determination of suitable sowing date of safflower in Diyarbakır conditions

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Abstract

Safflower (*Carthamus tinctorius* L.) oil is widely used both as a cooking oil and in industrial applications and is tolerant to adverse weather conditions such as cold, drought and salinity. This study was conducted to determine the most suitable sowing date and safflower variety for the conditions in Diyarbakır, Türkiye, during the 2009-2010, 2010-2011 and 2011-2012 growing seasons. The experiment followed a randomized complete block design with split plots and four replications, using two safflower varieties: Remzibey-05 and Dinçer. Seeds were planted on the trial field of GAP UTAEM (GAP Internatiolan Agricultural Research and Training Center). The results showed that the highest seed yields were obtained from the Remzibey-05 variety sown on 15 December (2766 kg ha^{-1}) and 15 November (2755 kg ha^{-1}), and from the Dinçer variety sown on 1 December (2677 kg ha^{-1}). The lowest yield was recorded for the variety Remzibey-05 sown on 15 April (1005 kg ha^{-1}). Besides, the highest crude oil yield was obtained in Dinçer cultivar with in 1st December 831 kg ha^{-1} and the lowest was obtained from Dinçer variety in 15th April sowing date with 332 kg ha^{-1}. Based on the results, sowing dates between 15 November and 15 December are recommended for optimal safflower production under Diyarbakır conditions.

Keywords: Cultivar, Oil content, Protein ratio, Yield

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INTRODUCTION

The safflower is oil plant. The flowers, leaves and seeds of the safflower have been used in different areas. Safflower which is more tolerant to drought, cold and salinity than other oil crops. (Kayaçetin et al., 2012). Safflower (*Carthamus tinctorius* L.), recognized as a high-quality oil seed crop, is reported to have originated in southern Russia, Iran, Türkiye, Jordan, Iraq, and Israel (Knowles, 1989; Yaşar & Sezgin, 2023). Safflower is a very important plant in terms of contributing to the biodiesel, dye, high-quality oil and composition of fatty acids suitable for human consumption (Huth et all, 2015; Subaşı et all, 2023) and feed industry, being easily adapted to the application of rotation, being effective in reducing fallow areas, being able to grow in different types of soil, not needing special equipment in the cultivation process, and contributing to the sustainability of agricultural production and employment (Akgün and Söylemez 2022).

Türkiye's safflower production was 39 000 tons, on 32 129 hectares. The provinces with the highest safflower production in 2023 were Kayseri at 29.5%, Isparta at 13.1%, Konya at 12.4%, Kırşehir at 9.3%, Nevşehir at 8.8%, Ankara at 6.2% and Aksaray at 5.9%. In Türkiye, 85.2% of total safflower production occurs in these provinces. Diyarbakır province's production was 12 tons, on 9.9 hectares and average yield of 1 210 kg ha^{-1} in year 2023 (Anon., 2023). Three cultivars had been developed until 2011 in Türkiye. Two of them, Dinçer and Remzibey-05, are still in production. The cultivars in production have an oil rate of about 28-32% (Babaoglu and Guzel 2015).

Safflower oil quality is very high due to fatty acid composition. Its oil constitutes an major source of polyunsaturated fatty acid (Shivani et al., 2010). The fatty acid structure of herbal oil is a significant factor which affects its trading uses (Katar et al., 2014). Many clinical and laboratory studies support the use of safflower for cardiovascular disease, menstrual problems, and swelling and pain associated with trauma (Dajue and Mündel,

1996). Addition of safflower florets to foods is a widespread. Health concerns regarding synthetic food colourings may rise demand for safflower-derived foodcoloration (Weiss, 1983). Safflower is nutritionally like too live oil, with high levels of oleic or linoleic acid, besides lesser costly (Smith, 1996).

Safflower is can be used in biodiesel production. Besides, For the production of safflower, Türkiye has a suitable soil and climati cconditions (Eryılmaz et al., 2014). Türkiye's biodiesel production, which is included in biofuels, which has special importance in energy submission security, is at risk. It is staminal to prioritize the cultivation of energy crops, especially in fallow fields (Karabaş, 2022). When safflower meal is compared with soybean meal which is nearly equal (Özek, 2016). Safflower cultuvars (Dinçer and Remzibey-05) are not suitable to second crop conditions (Sevilmiş et al., 2018). If the salt rate of th earea where safflower cultivation will be carried out is closeto 300 millimoles, Linas and Olas varieties can be recommended, respectively. If the salt rate of the area where safflower cultivation will be carried out is 200 millimoles or below, it can be said that Dinçer andLinas varieties may be more suitable (Kurtuluş and Boydak, 2022).

Previous studies revealed that delayed sowing dates resulted in decreasing seed yields (Keles and Ozturk, 2012; İzgi, 2023). To achieve maximum grain yield in safflower cultivation for the conditions of Sistan region, sowing from early January to late January using, is recommended (Fanaei et al., 2024). For successful and economical safflower cultivation, suitable varieties and growing techniques should be determined. Suitable sowing date constitute a significant growing technique. Sowing date is among the most important factors designating the yield (El Bey et al., 2021). This study was conducted to determine the most variety and suitable sowing date for safflower in Diyarbakır conditions.

MATERIAL AND METHODS

This study was conducted in 2009-2010, 2010-2011 and 2011-2012 in Diyarbakır. Dinçer and Remzibey-05 varieties were used. Seeds were planted on the trial field of GAP UTAEM (GAP Internatiolan Agricultural Research and Training Center). The trial disigned randomized complete block in spling plot with four replication. The soil samples at 0-20 cm depth were analysed (Analysıs was done in GAP UTAEM laboratory) and the soil structure the soil clay-loam, pH was 7.6, total salt concentration was 0.092%; the amount of phosphorus was 14.3 kg ha^{-1} and potassium 1241.7 kg ha^{-1}, the ratio of organic matter was 0.78%. In the province of Diyarbakır the annual rainfall is mostly happened between October and June months. The climate situations of the trial area, are illustrated in Table 1.

Table 1. Long-term and 2009-2012 years climatic data of Diyarbakır province.

	Years	October	November	December	January	February	March	April	May	June
Average temperature (°C)	2009-10	18.5	9.8	7.1	5.4	6.6	11.1	14.2	20.4	27.2
	2010-11	18.1	11.1	6.5	3.5	4.7	9.0	13.0	17.7	25.5
	2011-12	16.4	6.4	2.3	2.4	1.9	5.1	15.2	19.6	27.7
	Long T.	17.0	8.9	3.8	1.7	3.5	8.2	13.7	19.1	26.3
Average humidity (%)	2009-10	42.0	70.6	83.5	80.9	79.9	66.6	60.4	49.3	29.1
	2010-11	56.0	41.1	68.9	73.4	69.5	56.4	75.7	67.6	38.0
	2011-12	41.6	58.8	73.9	84.4	68.2	59.2	58.5	58.0	27.8
	Long T.	48.0	67.1	76.7	77.1	72.8	65.6	63.2	56.3	35.9
Precipitation (mm)	2009-10	62.4	55.6	87.2	113.4	40.2	68.7	22.4	31.6	11.2
	2010-11	63.4	2.0	48.0	40.0	49.9	46.6	209.0	80.1	13.6
	2011-12	11.8	73.0	40.2	78.3	74.4	44.0	26.2	41.0	7.0
	Long T.	34.6	53.3	70.7	62.3	72.1	68.2	64.6	40.2	9.1

Prior to 15 - 20 cm deep soil was processed and for the levelling of the land plows and harrows were used. Plot lengths were 5 m, width were1.8 m and each plot contained 6 rows. The seeds were sown in a way that there would be 3 kg seeds in each decare. In the parcels, 100 kg ha^{-1} nitrogen and 50 kg ha^{-1} phosphorus were used. 50 kg ha^{-1} of the nitrogen and the whole of the phosphorous were given before planting. The remaining 50 kg ha^{-1} nitrogen was applied when plants were 20-30 cm tall. The parcels, were harvested with a trial harvester. for the seed yields in July. After harvest, crude oil ratio (in 2010 and 2012) was determined by Nuclear Magnetic Resonance (NMR) device with protein ratio (in 2010) Kjehldal method. Analysis of variance across was calculated for each trait and LSD (Least significant difference) test was applied to match the variations (Steel and Torrie, 1980).

RESULTS AND DISCUSSION

According to the findings of trial; the lowest was obtained from Remzibey-05 variety in the 15th April sowing date with 51.06 cm and the highest plant height obtained from Dinçer variety in the 15th December sowing dates with 122.99 cm. The average values of the varieties with regards to the sowing date were 54.51 cm in the 15th April sowing date with and 121.41 cm in the 15th December sowing dates. The plant height of Dinçer variety (99.82 cm) was higher than Remzibey variety (95.56 cm) (Table 2). Hatipoğlu et al. (2012) stated that plant height of safflower farming in Şanlıurfa between 45.3-127.9 cm. Coşkun (2014) stated that plant height of safflower farming in Çanakkale between 118.67-108.89 cm. Öz (2016) stated that plant height of safflower farming in Bursa between 158.6 -100.5 cm. Atan et al. (2019) stated that plant height of safflower farming in Hatay between 143.83-163.67 cm. Öner and Şeker (2020) stated that plant height of safflower farming in Çorum between 82.37-107.6 cm. El Bey et al. (2021) stated that plant height of safflower farming in Samsun between 82.3-158.7 cm. Reported differences are likely to be, environmental conditions and variety.

The highest head number per plant was obtained with 15th November sowing date with 29.27 and the lowest was obtained in 15th April sowing date with 13.31. The head number per plant of Remzibey variety (23.58 cm) was higher than Dinçer variety (21.95) (Table 2). Hatipoğlu et al. (2012) stated that the number head of per plant in the conditions of Şanlıurfa changes between 10.5-31.8. Öz (2016) stated that head number per plant in the conditions of Bursa changes between 17.1-29.4. Atan et al. (2019) stated that head number per plant in the conditions of Hatay changes between 11.83-16.20. Öner and Şeker (2020) stated that head number per plant of safflower farming in Çorum between 7.28-10.43. Köse et al. (2021) stated that the number head of per plant in the conditions of Eskişehir changes between 9.2-11.7. Reported differences are likely to be, environmental conditions andvariety.

Table 2. Mean values of safflower varieties at 2009-2010, 2010-2011 and 2011-2012 growing seasons.

Sowing date	Plant height (cm) Varieties		Average	Head number per plant Varieties		Average
	Dinçer	Remzibey-05		Dinçer	Remzibey-05	
1 November	117.50 bc	114.94 c	116.22 b	25.85	27.65	26.75 b
15 November	119.66 ab	120.56 ab	120.11 a	28.71	29.83	29.27 a
1 December	120.21 ab	119.53 ab	119.87 a	26.46	30.64	28.55 ab
15 December	122.99 a	119.83 ab	121.41 a	26.12	30.28	28.20 ab
1 March	95.18 d	89.30 e	92.24 c	18.35	19.11	18.73 cd
15 March	87.88 e	81.08 f	84.48 d	20.63	19.97	20.31 c
1 April	77.17 g	68.39 h	72.78 e	16.06	17.96	17.01 d
15 April	57.96 ı	51.06 j	54.51 f	13.44	13.18	13.31 e
Average	99.82 a	95.56 b		21.95 b	23.58 a	
CV (%)	4.57			19.22		
LSD variety	1.19**			1.12**		
LSD sowing date	2.55**			2.50**		
LSD interaction	3.60**			ns		

ns: nonesignificant, **: significant at 0.01 level

The highest head diameter was obtained with 15th November sowing date with 2.41 cm and the lowest was obtained in 1st April sowing date with 2.08 cm. The head diameter of Dinçer variety (2.33 cm) was higher than Remzibey variety (2.08 cm). (Table 3). Hatipoğlu et al. (2012) stated that head diameter in the conditions of Şanlıurfa changes between 1.63-2.07 cm. İzgi (2023) stated that head diameter in the conditions of Mardin changes between 2.3-2.7 cm. Reported differences are likely to be, environmental conditions and variety.

The highest 1000 seed weight was obtained 15th November sowing date with 34.11 g and the lowest was obtained in 15th April sowing date with 31.19 g. The 1000 seed weight of Dinçer variety (34.08 g) was higher than Remzibey variety (30.85 g) (Table 3). Hatipoğlu et al. (2012) stated that 1000 seed weight in the conditions of Şanlıurfa changes between 37.3-42.5 g. Coşkun (2014) stated that 1000 seed weight in the conditions of Çanakkale changes between 39.00-33.78 g. Öz (2016) stated that 1000 seed weight in the conditions of Bursa changes between 34.1-36.9 g. Atan et al. (2019) stated that 1000 seed weight in the conditions of Hatay changes between 38.87-45.56 g. Köktaş and Güner (2023) stated that 1000 seed weight of safflower farming in Ankara between 39.00-44.42 g.

Table 3. Mean values of safflower varieties at 2009-2010, 2010-2011 and 2011-2012 growing seasons.

Sowingdate	Head diameter (cm)			1000 seed weight (g)		
	Varieties		Average	Varieties		Average
	Dinçer	Remzibey-05		Dinçer	Remzibey-05	
1 November	2.45	2.05	2.25 b	34.65	31.79	33.22 ab
15 November	2.54	2.28	2.41 a	36.10	32.12	34.11 a
1 December	2.44	2.16	2.30 b	34.25	31.25	32.75 ab
15 December	2.39	2.15	2.27 b	33.79	31.09	32.44 bc
1 March	2.25	2.02	2.14 c	33.64	30.04	31.84 bc
15 March	2.15	2.05	2.10 c	33.90	30.40	32.15 bc
1 April	2.19	1.97	2.08 c	33.23	30.81	32.02 bc
15 April	2.24	1.93	2.09 c	33.08	29.30	31.19 c
Average	2.33 a	2.08 b		34.08 a	30.85 b	
CV (%)	8.09			7.79		
LSD variety	0.06**			1.38**		
LSD sowing date	0.10**			1.44**		
LSD interaction	ns			ns		

ns: nonesignificant, **: significant at 0.01 level

According to the findings of trial; the highest crude oil ratio was obtained in Dinçer variety with in 1st November, Remzibey-05 cultivar with in 15th November with in sowing date with 33.7%, 33.6% and in Dinçer and Remzibey-05 variety with in 1st December sowing date with 33.4% respectively and the lowest was obtained from Dinçer variety in 1st April sowing date with 27.9%. The average values of the varieties with regards to the sowing date were 28.7% in the 1th April sowing date with and 33.4% in the 1th December sowing dates. The oil ratio of Remzibey variety (31.50%) was higher than Dinçer variety (30.90%) (Table4). Keleş and Öztürk (2012) stated that crude oil ratio in the conditions of Konya changes between 24.57-33.73%. Coşkun (2014) stated that crude oil ratio in the conditions of Çanakkale changes between 28.67-30.44%. Atan et al. (2019) stated that crude oil ratio in the conditions of Hatay changes between 34.38-38.49%. Baran and Andırman (2019) According to the results of the research, the highest oil content was obtained from the first sowing time (October 5) with 23.36% and the lowest sowing time (December 20) with 19.95%. Aslantaş and Akınerdem (2020) stated that crude oil ratio in theconditions of Konya changes between 21.1-29.0%.

According to the findings of trial; the highest protein ratio obtained from Remzibey-05 variety in the 15th December sowing dates with 22.06% and the lowest was obtained from Remzibey-05 variety in the 15th March sowing date with 16.32%. The average values of the varieties with regards to the sowing date were 17.33% in the 15th November sowing date with and 21.01% in the 15th April sowing dates. (Table4). Keleş and Öztürk (2012) stated that protein ratio in the conditions of Konya changes between 15.47-20.50%. Subaşı and Başalma (2021) stated that protein ratio in the conditions of Ankara and Bolu changes between 11.90-14.53%. Boydak et al (2024) stated that protein ratio in the conditions of Bingöl changes between 19.1-23.2%.

According to the findings of experiment, the highest seed yield was obtained in Remzibey-05 variety with in 15th December, 15th Novembers owing date with 2766 kg ha^{-1}, 2755 kg ha^{-1} and in Dinçer variety with in 1st December sowing date with 2677 kg ha^{-1} respectively and the lowest was obtained from Remzibey-05 cultivar in 15th April sowing date with 1005 kg ha^{-1}. The average values of the varieties with regards to the sowing date were 1012 kg ha^{-1} in the 15th April sowing date with and 2634 kg ha^{-1} in the 15th December sowing dates. The seed yield of Remzibey variety (2038 kg ha^{-1}) was higher than Dinçer variety (1971 kg ha^{-1}) (Table 5). The seed yield depends on the level of fertility of the soil, environmental conditions, sowing dates and variety. Hatipoğlu et al. (2012) stated that in the conditions of Şanlıurfa the highest yield (4260 kg ha^{-1}) is taken on October 30 while the lowest yield (980 kg ha^{-1}) was obtained on April 5. Keleş and Öztürk (2012) stated that seed yield in the conditions of Konya changes between 437.0-1706.1 kg ha^{-1}. Coşkun (2014) stated that seed yield in the conditions of Çanakkale changes between 2643.3-2374.4 kg ha^{-1}. As a result safflower can sow as winter and summer, Remzibey 05 is more suitable than other two varieties for high seed. Ghorbanzadeh et al. (2014) in the autumn sowing times 2330 kg ha^{-1} and in the spring sowing times 1405.4 kg ha^{-1}. Öz (2016) in the autumn sowing times 2380.0 kg ha^{-1} and in the spring sowing times 1405.4 kg ha^{-1}. When considering the performances of varieties according to sowing times, the highest seed yield was given Remzibey-05 variety sown in the autumn with 3156.6 kg ha^{-1} . Yenice cultivar tha tsown in the spring has occured the lowest seed yield with value 1098.3 kg ha^{-1}. Atan et al. (2019) stated that seed yield in the conditions of Hatay changes between 1883.3-2627.8 kg ha^{-1}. Baran and Andırman (2019) According to the results of the research, the highest seed yield was

obtained at the first sowing time (October 5) with 2158.3 kg ha^{-1} in Batman conditions. Koç (2019) stated that seed yield of safflower farming between 2310-3380 kg ha^{-1} in 2018 year. Aslantaş and Akınerdem (2020) stated that seed yield of safflower farming between 423-839 kg ha^{-1}. Öner and Şeker (2020) stated that seed yield of safflower farming in Çorum between 1244-2928 kg ha^{-1}. İzgi (2023) stated that yield of safflower in the conditions of Mardin changes between 1907-3981 kg ha^{-1}.

According to the findings of trial; the highest crude oil yield was obtained in Dinçer cultivar with in 1st December 831 kg ha^{-1} and the lowest was obtained from Dinçer variety in 15th April sowing date with 332 kg ha^{-1} (Table5). Keleş andÖztürk (2012) stated that crudeoil yield in the conditions of Konya changes between 133.8-446.2 kg ha^{-1}. Delayed sowing dates resulted in decreasing seed and oil yields. Coşkun (2014) stated that crude oil yield in the conditions of Çanakkale changes between 761-725 kg ha^{-1}. Atan et al. (2019) stated that crude oil yield in the conditions of Hatay changes between 738.0-1011.7 kg ha^{-1}. Aslantaş and Akınerdem (2020) stated that crudeoil yield in the conditions of Konya changes between 87-213 kg ha^{-1}.

Table 4. Mean values of safflower varieties at 2009-2010, 2010-2011 and 2011-2012 growing seasons.

Sowing date	Crude oil ratio (%) Varieties		Average	Protein ratio (%) Varieties		Average
	Dinçer	Remzibey-05		Dinçer	Remzibey-05	
1 November	33.7 a	31.8 c	32.8 b	19.49 ı	20.49 c	19.99 d
15 November	32.2 b	33.6 a	32.9 b	17.05 o	17.61 l	17.33 h
1 December	33.4 a	33.4 a	33.4 a	18.79 j	20.39 e	19.59 e
15 December	30.2 de	31.8 c	31.0 c	19.85 g	22.06 a	20.95 b
1 March	30.6 d	30.4 d	30.5 d	19.59 h	17.76 k	18.68 f
15 March	29.2 g	32.0 bc	30.6 d	20.30 f	16.32 m	18.31 g
1 April	27.9 h	29.5 fg	28.7 f	19.77 h	21.58 b	20.67 c
15 April	29.6 fg	29.8 ef	29.7 e	21.58 b	20.44 d	21.01 a
Average	30.9 b	31.5 a		19.54	19.57	
CV (%)	1.23				0.23	
LSD variety	0.17**				0.04**	
LSD sowing date	0.27**				0.05**	
LSD interaction	0.38**				0.07**	

ns: nonesignificant, **: significant at 0.01 level

Table 5. Mean values of safflower varieties at 2009-2010, 2010-2011 and 2011-2012 growing seasons.

Sowing date	Seed yield (kg ha^{-1}) Varieties		Average	Crude oil yield (kg ha^{-1}) Varieties		Average
	Dinçer	Remzibey-05		Dinçer	Remzibey-05	
1 November	2418 cd	2276 cd	2347 b	739 bc	677 cd	708 b
15 November	2179 d	2755 a	2467 ab	575 e	783 ab	679 b
1 December	2677 ab	2401 cd	2539 a	831 a	713 cd	772 a
15 December	2502 bc	2766 a	2634 a	660 d	782 ab	721 b
1 March	1750 e	1784 e	1767 c	427 fg	469 fg	448 c
15 March	1735 e	1771 e	1753 c	468 fg	480 f	474 c
1 April	1487 f	1545 ef	1516 d	412 gh	460 fg	436 c
15 April	1019 g	1005 g	1012 e	332 ı	356 hı	344 d
Average	1971 b	2038 a		555 b	590 a	
CV (%)	14.96			11.97		
LSD variety	44.4**			16.9**		
LSD sowing date	171.3**			48.2**		
LSD interaction	242.3**			68.2**		

ns: nonesignificant, **: significant at 0.01 level

CONCLUSION

This study evaluated the effect of different sowing dates and cultivars on the yield and quality of safflower under Diyarbakır conditions. The findings indicate that the most suitable sowing period for optimal seed yield is between 15th November and 15th December, with the highest yields obtained from the Remzibey-05 variety. The study also showed that later sowing dates, particularly in April, result in significantly lower yields. Additionally, the Remzibey-05 variety consistently out performed the Dinçer variety in terms of oil content and protein ratio, further reinforcing its suitability for the region. Overall, the results suggest that adjusting sowing times and choosing the right cultivar, such as Remzibey-05, can significantly enhance safflower productivity in Diyarbakır. These results provide valuable in sights forfarmers and agricultural planners, emphasizing the importance of optimal sowing times to maximize safflower yield and oilcontent in semi-arid region slike Diyarbakır.

Compliance with Ethical Standards

Peer-review

Externally peer-reviewed.

Declaration of Interests

The authors declare that they haven oconflict of interest.

Author contribution

The contribution of the authors to the presentstudy is equal.

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