

Aspir (*Carthamus tinctorius* L.) Çeşitlerinin Diyarbakır Ekolojik Koşullarında Tarımsal Performanslarının Belirlenmesi

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Bu çalışma, 2016 ve 2017 yetiştirme sezonlarında, Diyarbakır'ın iklim koşullarına uygun aspir çeşitlerini belirlemek amacıyla yürütülmüştür. Deneme, Tesadüf Blokları Deneme Desenine göre üç tekrarlı olarak tasarlanmıştır. Çalışmada Balcı, Dinçer 5-18-1, Linas, Olas ve Remzibey-05 çeşitleri kullanılmıştır. İki yıllık ortalamalardan elde edilen sonuçlara göre; en yüksek tohum verimi Balcı çeşidinden (236,0 kg/da) elde edilirken, en düşük tohum verimi Linas çeşidinden (201,5 kg/da) elde edilmiştir. Diğer önemli bulgulara göre en yüksek yağ verimi Balcı çeşidinden (78,9 kg/da) elde edilirken, en düşük yağ verimi Linas çeşidinden (60,1 kg/da) ve en yüksek yağ oranı Olas çeşidinden (%34,6), en düşük yağ oranı ise Dinçer 5-18-1 çeşidinden (%26,6) elde edilmiştir. Ayrıca, bitki boyu (108,2-119,0 cm), bitki başına tabla sayısı (15,2-16,1), tabla çapı (2,09-2,22 cm) ve bin tane ağırlığı (34,8-39,6 g) belirlenmiştir. İki yıllık bu çalışmanın sonuçlarına dayanarak, Diyarbakır'ın ekolojik koşullarında ve gecikmiş kışlık aspir ekimlerinde Balcı çeşidini yetiştirmenin en uygun seçim olduğu görülmektedir.

Determination of Agricultural Performances of Safflower (*Carthamus tinctorius* L.) Varieties Under Diyarbakır Ecological Conditions

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ABSTRACT

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This study aimed to identify suitable safflower cultivars for the climatic conditions of Diyarbakır, conducted over the 2016 and 2017 growing seasons. The experiment was designed using a Randomized Complete Block Design (RCBD) with three replications. The cultivars used in this study were Balcı, Dinçer 5-18-1, Linas, Olas, and Remzibey-05. Based on the two-year average, the highest seed yield was obtained from the Balcı cultivar (2360 kg ha⁻¹), while the Linas cultivar produced the lowest seed yield (2015 kg ha⁻¹). Other key findings the highest oil yield was obtained from the Balcı cultivar (789 kg ha⁻¹), while the Remzibey-05 cultivar produced the lowest oil yield (601 kg ha⁻¹) and the highest oil content was obtained from the Olas cultivar (34.6%), while the Dinçer 5-18-1 cultivar produced the lowest oil content (26.6%). Besides, plant height (108.2-119.0 cm), head number per plant (15.2-16.1), head diameter (2.09-2.22 cm), and thousand seed weight (34.8-39.6 g) were determined. Based on the results of this two-year study, the Balcı cultivar seems to be the most suitable choice for cultivation under the ecological conditions of Diyarbakır and in delayed winter safflower sowing.

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1. Introduction

Safflower is considered more tolerant to cold, drought, and salinity conditions than other oil crops, offering significant potential for contributing to edible oil production in Türkiye (Kayacetin et al., 2012). Safflower (*Carthamus tinctorius* L.), recognized as a high-quality oilseed crop, is reported to have originated in southern Russia, Iran, Türkiye, Jordan, Iraq, and Israel (Knowles, 1989; Yasar and Sezgin, 2023). Safflower plays a vital role in contributing to the biodiesel, dye, high-quality oil, and fatty acid composition suitable for human consumption (Huth et al., 2015; Subaşı et al., 2023) and the feed industry. It is easily adaptable to crop rotation, effective in reducing fallow areas, capable of growing in different soil types, does not require special equipment during cultivation, and contributes to the sustainability of agricultural production and employment (Akgün and Söylemez, 2022).

The oil quality of safflower is very high due to its fatty acid composition. Safflower oil is an essential source of polyunsaturated fatty acids, recognized as healthy fatty acids for humans (Shivani et al., 2010). The oil content of registered commercial safflower varieties in Türkiye ranges from 24% to 41%, and varieties rich in linoleic and oleic acids are cultivated (Arslan et al., 2019). The nutrient content of safflower meals varies depending on the extraction methods used. Compared to soybean meal, dehulled safflower meal has almost the same nutritional value (Ozek, 2016). Safflower is used in a wide range of industries, including pharmaceutical production, paint production, cosmetic product development, various food production, ruminant and poultry nutrition, and biodiesel production, and it has applications in both traditional and modern medicine (Dinçel, 2024).

Türkiye's safflower production was 39.000 tons, on 321.298 ha⁻¹. The provinces with the highest safflower production ratio 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 the total safflower production ratio occurs in these provinces. Diyarbakır province's production was 12 tons, on 9.9 ha in 2023 (Anonymous, 2023a).

The world's safflower production was 723 874 tons on 910 848 hectares, with an average yield of 795 kg ha⁻¹ in 2023 (Anonymous, 2023b). In Türkiye, edible vegetable oil production does not meet domestic demand, resulting in a vegetable oil deficit (Babaoglu and Guzel, 2015). In 2022, 3.17 billion dollars were spent on oilseed imports, and 3.02 billion on vegetable and animal oils in Türkiye (Duru, 2024). Türkiye has very favorable climatic and soil conditions for safflower cultivation (Eryılmaz et al., 2014). The gene center of the safflower plant is Anatolia. It is highly adaptable to different ecologies, and its cultivation is similar to seed production, which farmers are accustomed to. It is compatible with seed mechanization and can be planted in spring and winter.

The introduction of safflower as a new crop to a regional cropping system requires information concerning its performance under local environmental conditions (Sayılır et al., 2019). Studies conducted in various environments suggest that variations in yield, environmental conditions, genetic structures of varieties, and breeding practices are significant (Yasar and Sezgin, 2022). Kahraman et al.,

(2025) reported that sowing dates of 15th November and 15th December for yield and other characteristics, may be suitable for Diyarbakır conditions. In a study conducted by Atan et al., (2019), it was reported that the highest grain yield (2.628 kg ha⁻¹) and oil yield (38.49%) were obtained from the Asol variety in Hatay conditions. This study was conducted to determine safflower cultivars suitable under Diyarbakır conditions.

2. Material and Method

This study was conducted in Diyarbakır, Türkiye during the 2016 and 2017 growing seasons. The research site is located between 37°30' and 38°43' North latitudes and 40°37' and 41°20' East longitudes, at an altitude of 600 meters above sea level. Soil samples from the 0-20 cm depth were analyzed (analysis was conducted in the GAP UTAEM Laboratory). The soil structure was clay-loam, with a pH of 7.9, total salt concentration of 0.085%, phosphorus content of 16.1 kg ha⁻¹, potassium content of 1273.4 kg ha⁻¹, and an organic matter ratio of 0.91%. Phosphorus content and organic matter ratio are low in amount in the soil. Therefore, phosphorus and nitrogen fertilization was applied in safflower trials.

Sowing was carried out at the GAP International Agricultural Research and Training Center. The experiment was designed as a Randomized Complete Block Design with three replicates. The cultivars used in this experiment were Balcı, Dinçer 5-18-1, Linas, Olas, and Remzibey-05. Before sowing, the soil (15-20 cm deep) was ploughed and harrowed. The seeds were trial sowing machine sown at a rate of 120 seeds per square meter on 16 February 2016 and 25 January 2017. Each plot consisted of four rows, with 30 cm between rows and a length of 5 meters. A total of 100 kg ha⁻¹ of nitrogen was applied in two stages: 50 kg ha⁻¹ before sowing, and the remaining 50 kg ha⁻¹ when the plants reached a height of 20-30 cm. Additionally, 50 kg ha⁻¹ of phosphorus was applied before sowing (Anonymous, 2002). In the province Diyarbakır, where the field experiments were conducted, the annual rainfall predominantly occurs between October and June. The relative humidity is relatively low. Summers are typically hot, dry, and clear, while winters are cold and partly cloudy. In 2016, average temperature, precipitation and average humidity values were mostly higher than in 2017 (Table 1). The amount and timing of rainfall had a positive impact on safflower yield in 2016. During the growing season, no irrigation was provided. Plants in each plot were trial harvester machine harvested for grain yield measurements on 27 July 2016 and 28 July 2017.

Procedures for the features examined

Plant height (cm): The distance between the root collar (soil surface) and the top point of 10 plants at harvest maturity in each plot was measured (Anonymous, 2002).

Number of heads per plant: The number of mature heads on the main stem and lateral branches of 10 plants at harvest maturity in each plot was determined.

Head diameter (cm): The head diameter of 10 plants at harvest maturity in each plot was measured using callipers.

Thousand seed weight (g): After harvest, the weight of 4x100 seeds randomly taken from each parcel was averaged and multiplied by 10 to calculate the thousand seed weight.

Seed yield (kg ha⁻¹): After harvest, the yield per hectare was calculated based on the seed yield obtained from each plot (Anonymous, 2002).

Oil content (%): After harvest, safflower seeds were kept in the oven at 70° for 48 hours to remove moisture. The % crude oil content of 4 g seeds with moisture removed was calculated in the Nuclear Magnetic Resonance (NMR) device.

Oil yield (kg ha⁻¹): Oil yield was calculated by multiplying the oil content and the seed yield of each individual plot (Anonymous, 2002).

Analysis of variance (ANOVA) was performed using the JMP Statistics program. The LSD (Least Significant Difference) test was applied to determine the groups formed, the differences between the groups, and the significance levels (Steel and Torrie, 1980).

Table 1. Climate data for the Diyarbakır province over the long term and for the 2015-16 and 2016-17* years

Months	Average Temperature			Total Precipitation (mm)			Average humidity (%)		
	2016	2017	LY	2016	2017	LY	2016	2017	LY
January	1.1	1.5	1.8	77.2	20.6	68.0	79.3	71.6	77.1
February	7.9	1.5	3.5	69.2	3.8	68.8	71.7	55.0	72.8
March	9.7	9.4	8.5	55.6	90.2	67.3	66.1	69.5	65.6
April	15.7	12.8	13.8	29.0	98.8	68.7	56.2	68.5	63.2
May	19.9	18.8	19.3	41.4	30.6	41.3	51.9	57.6	56.3
June	26.8	26.9	26.3	18.4	2.6	7.9	32.0	30.0	35.9
Mean/Tota	13.5	11.8	12.2	290.8	246.6	281	59.5	58.7	61.8

LY: Over the long term *(Anonymous, 2017).

Table 2. Comparison of some properties of registered safflower varieties

Cultivars	Spininess	Flower color	Registrant institution	Registration year
Balcı	spiny	yellow	Transitional Zone Agricultural Research Institute	2011
Dinçer 5-18-	spineless	red	Transitional Zone Agricultural Research Institute	1983
Linas	thorny	yellow	Thrace Agricultural Research Institute	2013
Olas	thorny	yellow	Thrace Agricultural Research Institute	2015
Remzibey-05	thorny	yellow	Transitional Zone Agricultural Research Institute	2005

Reference: Arslan et al. 2019

3. Results and Discussion

Plant height (cm): Statistically significant differences ($p < 0.05$) among the cultivars were found regarding plant height (Table 3). According to the results of this experiment, the highest plant height was recorded for the cultivars Olas (119.0 cm), Linas (117.5 cm), and Dinçer 5-18-1 (112.5 cm) while the Balcı cultivar exhibited the lowest height at 108.2 cm (Table 4). Although the highest plant height was observed in the Olas cultivar, no statistical difference was found between it and the Linas and Dinçer 5-18-1 cultivars. Coşkun (2014) reported that the plant height of safflower ranges from 108.89 to 118.67 cm. Similarly, Oz (2016) reported that the plant height of safflower ranges from 100.5 to 158.6 cm. In

another study, Atan et al. (2019) observed that safflower plant height ranged from 143.83 to 163.67 cm. Sayılır et al., (2019) observed that the plant height of safflower ranged from 86.3 to 103.3 cm. The plant height values obtained in this study were greater than those reported by Sayılır et al., (2019) in İzmir, while our values were found to be lower than those reported by Oz (2016) in Bursa and Atan et al., (2019) in Hatay. Additionally, the results were similar to those reported by Coşkun (2014) in Çanakkale. The observed differences may be attributed to environmental factors (e.g., winter versus spring sowing, amount and timing of precipitation, soil structure) and variations in the cultivation practices and cultivars used.

Table 3. Mean squares values of the examined features

Source	Degree of freedom	Plant height	The number of heads per plant	Head diameter	Thousand seed weight	Seed yield	Oil content	Oil yield
Years (Y)	1	1.633	3.072	0.0177	539.328*	11926.8	3.4	1377.34
Cultivar (C)	4	125.55*	0.617	0.0161*	20.247**	1501.38	75.44**	346.132
YxC	4	10.216	1.994	0.0067	4.425**	589.346	0.286	35.1759
Error	29	39.63	2.4735	0.0064	23.839	2033.09	10.756	238.423

significant at 0.05 level, **: significant at 0.01 level

Table 4. Average values for plant height, number of heads per plant, and head diameter of safflower cultivars

Cultivars	Plant height (cm)			The number of heads per plant			Head diameter (cm)		
	2016	2017	Mean	2016	2017	Mean	2016	2017	Mean
Balcı	107.7	108.7	108.2 c	15.0	16.3	15.7	2.22	2.15	2.19 a
Dinçer 5-18-1	112.3	112.7	112.5 ac	16.1	15.3	15.7	2.05	2.12	2.09 b
Linas	119.0	116.0	117.5 ab	15.6	14.8	15.2	2.16	2.24	2.20 a
Olas	120.7	117.3	119.0 a	16.2	15.3	15.8	2.18	2.26	2.22 a
Remzibey-05	109.3	112.0	110.7 bc	17.0	15.2	16.1	2.12	2.21	2.17 a
Mean	113.8	113.3	113.6	16.0	15.4	15.7	2.15	2.20	2.17
CV (%)	5.2			9.1			2.9		
LSD cultivar	7.2*			ns					
LSD year	ns			ns			ns		
LSD interaction	ns			ns			ns		

ns: none significant, *: significant at 0,05 level

Number of heads per plant: No significant differences were observed among cultivars, years, and their interaction in terms of number of heads per plant (Table 3). The head number per plant ranged between 15.2 and 16.1 (Table 4). Katar et al., (2014) reported that the head number per plant varied between 12.5 and 18.7. Similarly, in a study conducted by Oz (2016), the head number per plant was found to range from 17.1 to 29.4. Atan et al., (2019) observed that the head number per plant ranged between 11.83 and 16.20, while Sayılır et al., (2019) reported values between 13.38 and 25.61. The head numbers obtained in this study were lower than those reported by Oz (2016) and Sayılır et al., (2019), though they were partially consistent with other findings. Oz (2016) utilized a row and intra-row spacing of 40 × 15 cm in their experiment. The observed differences may stem from variations in agricultural practices,

climatic conditions (e.g., winter versus spring sowing, timing and amount of precipitation), or the cultivars utilized. Moreover, Zarei et al., (2011) highlighted that the number of heads per plant is significantly affected by environmental factors, particularly plant density.

Head diameter (cm): Statistically significant differences ($p < 0.05$) among cultivars were observed regarding head diameter (Table 3). The largest head diameter was recorded for the Olas cultivar (2.22 cm), followed by Linas (2.20 cm), Balcı (2.19 cm), and Remzibey (2.17 cm), all within the same statistical group. The Dinçer 5-18-1 cultivar, with a head diameter of 2.09 cm, formed the last statistical group (Table 4). In previous studies, head diameters were reported as 1.63–2.07 cm by Hatipoğlu et al., (2012), 1.90–2.62 cm by Adalı and Öztürk (2016), and 1.8–2.3 cm by Sayılır et al., (2019). Similarly, Aslantaş and Akinerdem (2020) recorded head diameters ranging from 2.06 to 2.25 cm. Additionally, our the findings obtained partially coincide with those reported in other studies. Tahernezhad et al., (2018) noted that head diameter is less influenced by environmental factors and is largely determined by genetic factors. In contrast, Çamaş and Esendal (2006) emphasized the significant impact of environmental conditions on head diameter.

Thousand-seed weight (g): Statistically significant differences ($p < 0.01$) were observed regarding thousand-seed weight among the interactions between cultivars and years. Additionally, statistically significant differences ($p < 0.05$) were noted for the interaction effects (Table 3). The highest thousand-seed weight was recorded for the cultivars Linas (44.3 g), Olas (44.3 g), and Balcı (42.4 g) in 2016, whereas the Remzibey cultivar exhibited the lowest value (31.4 g) in 2017. Similarly, the highest thousand-seed weights in 2017 were observed in the cultivars Olas (39.6 g), Linas (38.8 g), and Balcı (38.4 g), while the Remzibey-05 cultivar exhibited the lowest value (34.8 g) (Table 5). In a study conducted by Coşkun (2014), thousand-seed weight values ranged between 33.78 and 39.00 g. Similarly, Oz (2016) reported values ranging between 34.1 and 36.9 g. Adalı and Öztürk (2016) documented thousand-seed weights between 32.77 and 43.28 g. Sayılır et al., (2019) reported a range of 42.8 to 54.1 g, while Yazdani et al., (2019) found thousand-seed weights between 29.27 and 47.58 g. Köse et al., (2021) observed values ranging from 32.1 to 40.4 g. The thousand-seed weights obtained in this study were lower than those reported by Yazdani et al., (2019) and Sayılır et al., (2019) but showed partial similarities with the findings of other researchers. Tahernezhad et al., (2018) noted that environmental factors less influence head diameter and are primarily determined by genetic factors. In contrast, Çamaş and Esendal (2006) emphasized the significant impact of environmental conditions on head diameter. Additionally, the findings obtained partially coincide with those reported in other studies.

Seed yield (kg ha⁻¹): No statistically significant differences were observed among cultivars, years, or their interactions concerning seed yield (Table 3). The statistically insignificant finding may be due to the difference between the replications of the varieties. The seed yield in this study ranged from 2015

to 2360 kg ha⁻¹ (Table 4). The timing and amount of rainfall may have affected seed yield in 2016 and 2017. Coşkun (2014) reported seed yields between 2374.4 and 2643.3 kg ha⁻¹. In previous studies, Katar et al., (2014) observed yields ranging from 1485 to 1838 kg ha⁻¹. Ghorbanzadeh et al., (2014) recorded 2330 kg ha⁻¹ for autumn sowing. Hatipoğlu et al., (2017) noted a seed yield of 2300 kg ha⁻¹ from sowing on February 20. Gürsoy et al., (2018) documented seed yields between 1040 and 1577 kg ha⁻¹. Atan et al., (2019) reported seed yields ranging from 1883.3 to 2627.8 kg ha⁻¹, while Sayılır et al., (2019) reported values between 1560 and 2500 kg ha⁻¹. Arslan and Çulpan (2020) found seed yields ranging from 982 to 1712 kg ha⁻¹, and Köse et al., (2021) recorded values between 834 and 1795 kg ha⁻¹. Aslan and Sirat (2022) reported seed yields ranging from 935.2 to 1280.6 kg ha⁻¹. The seed yields obtained in this study were lower than those reported by Coşkun (2014) but higher than the findings of Katar et al., (2014), Gürsoy et al., (2018), Köse et al., (2021), Arslan and Çulpan (2020), and Aslan and Sirat (2022). Furthermore, our results showed partial similarity with other studies. The observed differences may be attributed to environmental factors, such as the timing of precipitation, soil structure, and the differences between winter and spring sowing, as well as variations in cultivars and management practices. Studies conducted by Köse et al., (2021), Arslan and Culpan (2020), and Aslan and Sirat (2022) were based on spring sowing. It is well established that the yield potential of winter sowing is generally higher than that of spring sowing.

Oil content (%): Statistically significant differences ($p < 0.01$) were observed among the cultivars in terms of oil content (Table 3). The highest oil content was recorded in the Olas cultivar at 34.6%, while the lowest was observed in the Dinçer 5-18-1 cultivar at 26.6% (Table 5). Similarly, Coşkun (2014), Koç et al., (2017), Köse et al., (2018), Sayılır et al., (2019), Koç (2019), and Atan et al., (2019) reported oil ratios ranging from 28.67% to 30.44%, 31.0% to 36.4%, 31.2% to 39.3%, 25.35% to 35.03%, 28.8% to 36.5%, and 34.38% to 38.49%, respectively. Our results partially align with these findings. Variations in oil ratios may be attributed to environmental conditions, genotypes differences, oil analysis methods, and cultivation practices.

Oil yield (kg ha⁻¹): No significant differences were observed among cultivars, years, and their interaction for oil yield (Table 6). The highest oil yield was obtained from the Balcı cultivar (789 kg ha⁻¹), while the Remzibey-05 cultivar produced the lowest oil yield (601 kg ha⁻¹). Oil yield ranged between 503 and 820 kg ha⁻¹ in interaction (Table 6). Coşkun (2014) reported oil yields ranging from 578 to 875 kg ha⁻¹, while Koç (2019) recorded values between 820 and 1100 kg ha⁻¹. Atan et al., (2019) reported a range of 723 to 1012 kg ha⁻¹, and Sayılır et al., (2019) noted values between 492 and 873 kg ha⁻¹. Arslan and Culpan (2020) stated that oil yield ranged between 334 and 558 kg ha⁻¹, and Köse et al., (2021) found values between 273 and 599 kg ha⁻¹. Our findings were lower than those of Koç (2019) and Atan et al., (2019) but higher than those reported by Köse et al., (2021) and Arslan and Culpan (2020). However, our results closely aligned with the findings of Sayılır et al., (2019).

Table 5. Average values of thousand-seed weight, seed yield, and oil content for safflower cultivars

Cultivars	Thousand-seed weight (g)			Seed yield (kg ha ⁻¹)			Oil content (%)		
	2016	2017	Mean	2016	2017	Mean	2016	2017	Mean
Balcı	42.4 ab	34.5 d	38.4 ab	2407	2314	2360	34.0	32.7	33.4 b
Dinçer 5-18-1	41.7 b	34.4 d	38.0 b	2536	2069	2303	26.7	26.6	26.6 d
Linaz	44.3 a	33.4 de	38.8 ab	2227	1803	2015	34.0	33.3	33.6 b
Olas	44.3 a	34.8 d	39.6 a	2222	1850	2036	34.9	34.3	34.6 a
Remzibey-05	38.2 c	31.4 e	34.8 c	2422	1783	2103	28.9	28.2	28.5 c
Mean	42.2 a	33.7 b	37.9	2363	1964	2163	31.7	31.0	31.4
CV (%)		3.2			15.9			1.19	
LSD cultivar		1.46**			ns				
LSD year		2.79**			ns			ns	
LSD interaction		2.06*			ns			ns	

ns: none significant, *: significant at 0.05 level, **: significant at 0.01 level

Table 6. Average values of oil yield for safflower cultivars

Cultivars	Oil yield (kg ha ⁻¹)		
	2016	2017	Mean
Balcı	820	757	789
Dinçer 5-18-1	677	551	614
Linaz	755	600	678
Olas	774	635	705
Remzibey-05	698	503	601
Mean	745	609	677
CV (%)		16.3	
LSD cultivar		ns	
LSD year		ns	
LSD interaction		ns	

ns: none significant

4. Conclusion

In conclusion, based on the two years of this study, the cultivar Olas exhibited good performance in terms of plant height (119.0 cm), head diameter (2.22 cm), thousand-seed weight (39.6 g), and oil rate (34.6%). Similarly, the Balcı cultivar exhibited high values in seed yield (2360 kg ha⁻¹), oil yield (789 kg ha⁻¹), thousand-seed weight (38.4 g), and head diameter (2.19 cm) under Diyarbakır conditions. For this reason, the Balcı cultivar seems to be the most suitable choice for cultivation under the specific conditions of Diyarbakır and in delayed winter safflower sowings.

Conflict of Interest Declaration

The author of the article declares that he has no conflict of interest.

Researchers' Contribution

The author declares that he has contributed 100% to the article.

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