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The Effect of Different Planting Times on the Agricultural Characters of Some Safflower Cultivars Planted in Elazig Ecological Conditions

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Abstract

This study was carried out in 2021-2022 and 2022-2023 growing seasons to determine the yield and some yield characteristics of different safflower cultivars at different planting times in Elazig ecological conditions. The planting dates were 25 October, 10 November and 25 November in both years and Dincer, Linas, Olas and Zirkon cultivars were used. Among the agricultural traits examined in this study, winter resistance rate ranged from 4.58-100 %, flower yield ranged from 143.55-508.25 mg plant^{-1}, plant height ranged from 51.90-82.04 cm, number of lateral branches ranged from 1.71-5.50 pcs plant^{-1}, number of heads ranged from 3.20-10.01 pcs plant^{-1}, head diameter ranged from 15.91-24.43 mm, thousand seed weight ranged from 33.73-46.17 g, and seed yield ranged from 23.74-160.96 kg da^{-1}. In Elazig ecological conditions, it was determined that safflower, which is generally planted as summer safflower, can also be grown as winter safflower, although early sowing causes too much plant loss, planting can be done between 10 November and 30 November, and Dincer and Zirkon varieties came to the fore in this study.

Research Article

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1. Introduction

Fats, carbohydrates and proteins are the most important organic molecules in living organisms. In living organisms, fats serve many functions, such as providing more energy than carbohydrates and proteins, ensuring the absorption of vitamins A, D, E and K, and protecting internal organs. Fats of vegetable and animal origin are categorised into two groups, and their importance for human health has increased in terms of human health, as vegetable origin fats are more unsaturated. Oil is found in the seeds or fruits of many plants, but oil ratios are greater in certain plant groups. In general, vegetable oils are obtained from sunflower, canola, soya, safflower, peanut, sesame, olive, palm, etc., plants (Arıoğlu et al., 2010).

In the last 10 years, vegetable oil production and consumption have increased worldwide. Vegetable oil production increased from 172 million tonnes to 218 million tonnes, and vegetable oil consumption increased from 167 million tonnes to 213 million tonnes (Anonymous, 2023b). Looking at the oilseed production in Turkey, oilseed production increased from 2.7 million tonnes to 4.2 million tonnes in the 10-year period from 2013-2014 to 2022-2023, while vegetable oil consumption increased from 991 thousand tonnes to 1.9 million tonnes (Anonymous, 2024). According to these figures, it is predicted that vegetable oil consumption will increase in parallel with population growth in the future.

Most vegetable oils are used for food purposes, and some are utilised in industry. Vegetable oils are used in industry in areas such as paint, varnish, and biodiesel (Kıllı and Beycioğlu, 2019). Today, oils from plants such as rape and safflower are utilised in biodiesel. However, the spread of electric vehicles worldwide, reservations in ensuring food safety, and the negative effects of biodiesel on diesel engines and automotive manufacturers, which reduce the production of diesel vehicles due to emission problems, suggest that biodiesel production will decrease in the future (Yusuf et al., 2011; Cunanan et al., 2021).

The continuous production of vegetable oils worldwide is important for food security. In particular, global climate change, the COVID-19 pandemic, and the Russia-Ukraine War negatively affected food security. Due to these problems of global origin, increases and volatilities were observed in vegetable oil prices in Türkiye, which is a net importer in terms of vegetable oils. To overcome such problems in Türkiye, it is imperative to increase the production of oil crops and to develop appropriate policies (Ortaş, 2022; Kılavuz and Yücer, 2023).

Drought caused by climate change in our country in recent years has negatively affected vegetable oil production. The safflower plant, which has the potential to close vegetable oil deficit and is resistant to drought, has potential for use in this area. When evaluated in terms of cultivation, safflower plants are easy to produce. Since safflower plants can be cultivated in summer and winter, it is important to utilise fallow areas effectively. The presence of oleic-type cultivars in safflower may enable the product to find buyers at higher prices. Input costs are low because there are few diseases and pests, and the need for fertiliser is low. However, bird damage in sunflower is not observed in safflower. In addition, seed casting problems observed in plants such as rapeseed and sesame in the later stages of maturation do not exist in safflower. The safflower plant is very suitable for mechanised use in cereals in agriculture, and it can be easily cultivated without any equipment changes (Yılmaz et al., 2015; Taşlıgil and Şahin, 2016).

Not only oil is produced from safflower seeds. After the oil is extracted from safflower seeds, the remaining cake is used for animal nutrition. The breeding of varieties with thin seed coats has potential for the use of seeds as nuts. As safflower flowers can colour food and fabrics such as saffron flowers, safflower plants are also known as false saffrons (Taşlıgil and Şahin, 2016). Due to the high cost of saffron flowers, the use of safflower flowers has increased in recent years (Andırman and Karaaslan, 2021).

The safflower production in Türkiye and in Elazig Province over the last 10 years fluctuated with the safflower cultivation area and production in Türkiye, but this fluctuation was less in Elazig Province. The highest safflower cultivation area and production in our country in the last 10-year period were observed in 2014 and 2015. In Türkiye, in 2014, 62 000 tons were produced on an area of 443 000 da, and in 2015, 70 000 tons were produced on an area of 431 000 da. In Elazig Province, while production was carried out in the 220 da area in 2014, production started in the 1000 da area, with a five fold increase in 2015. In the last 10 years, the highest production in Elazig was obtained in 2018, with an area of 3993 da and 596 tons of production. By 2022, 353 tons of safflower were produced from the 2670 da area (Anonymous, 2023a).

Table 1. Safflower cultivation area (da) and production amount (tons) in the last ten years in Türkiye

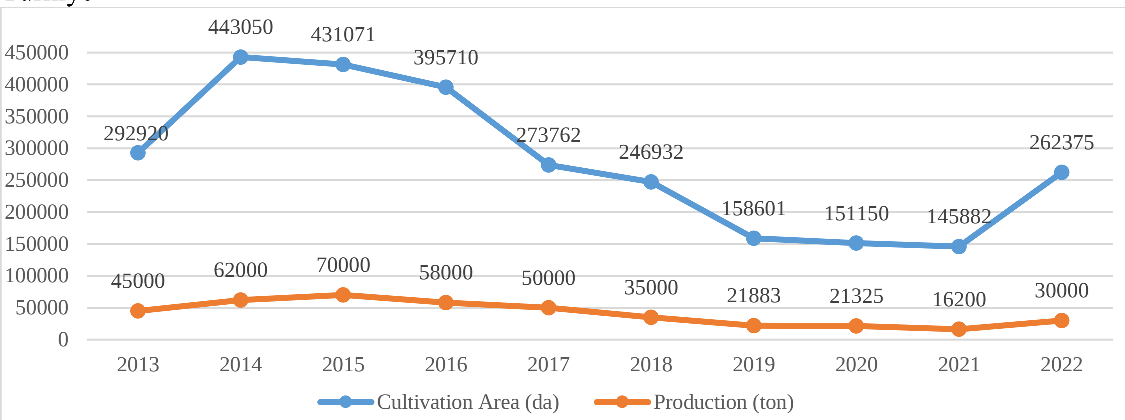
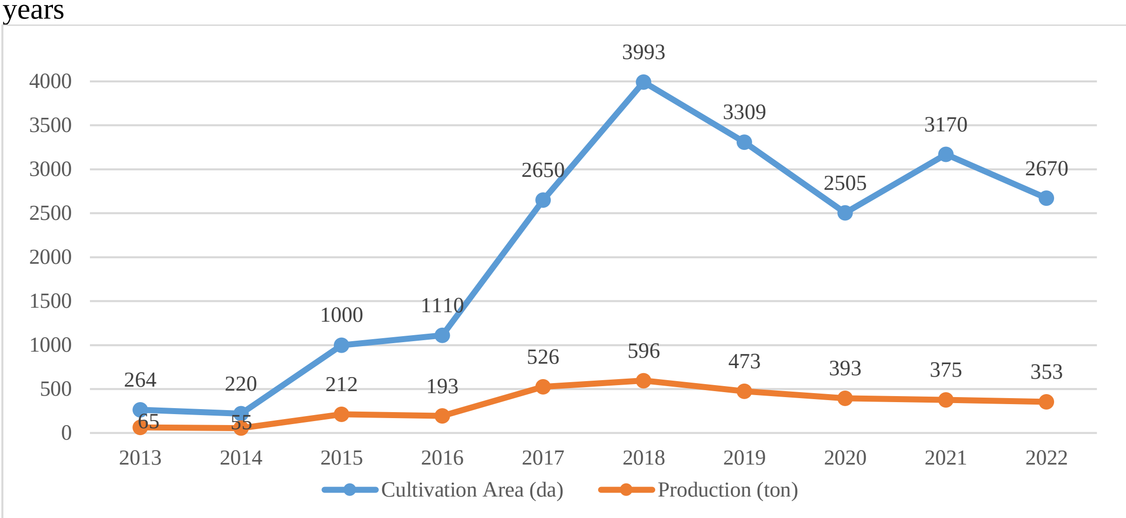


Table 2. Safflower cultivation area (da) and production amount (tons) in Elazig over the last ten years



In safflower plants, issues such as planting time, row spacing, cultivar and fertilisation have important effects on agricultural characters and are important in terms of cultivation practices (Oruç and Yılmaz, 2019; Andırman and Karaaslan, 2021; Arslan and Güler, 2022). According to this perspective, there are few scientific studies on safflower and no studies on its cultivation in Elazig Province. The aim of this study was to determine the agronomic characteristics of different safflower cultivars sown at different planting times for winter in Elazig Province. It is thought that further studies on cultivation will contribute both to the literature and to safflower cultivation practices in Elazig Province.

2. Materials and Methods

The trial was conducted during the 2021-2022 and 2022-2023 growing seasons at the Agriculture and Livestock Research and Application Centre of Firat University. In the trial, four different cultivars were used at three different planting times. The experiment was carried out according to the split-split design in randomised blocks with 4 replications, with the main plots were designed as planting times and the subplots were designed as cultivars. In this study, the length and width of each sub-plot were determined as 6 m and 1.2 m, respectively, and consisted of 6 rows. The seeds were sown between 20 cm row spacing with 5 kg per decare and no thinning was done. The plantings were made on 25 October, 10 November, 25 November in two growing years. The cultivars used were Dincer, Linas, Olas and Zirkon. The cultivars were obtained from Isparta University of Applied Sciences Faculty of Agriculture (Zirkon), Dicle University Faculty of Agriculture (Dincer) and Trakya Agricultural Research Institute (Linas and Olas). In the trial, 5 kg da^{-1} of pure nitrogen and 5 kg da^{-1} of pure phosphorus were applied to the planted winter plants, and 5 kg da^{-1} of pure nitrogen was applied as top fertiliser in March (Katar et al., 2012). Safflower fly (*Acanthiophilus helianthi*) and seedhead weevil (*Bangasternus planifrons*) were observed in the trials, and were treated with *imidacloropid*. Outlet irrigation was used in cases where rainfall was insufficient, especially at the first planting times. Since all plants matured at the same time in the experiment, harvesting was carried out on 19 August 2022 in the first year and 14 August 2023 in the second year. To determine whether the error variances of the trials of both years were homogeneous, the error variances of both years of the trial were subjected to Bartlett's homogeneity test. According to the results of this test, since the error variances were homogeneous, the trials of the two years were combined and analysed for variance. Duncan's multiple comparison test was used to compare the statistically significant means (Açıkgöz, 1993). Winter resistance rate, flower yield, plant height, number of lateral branches, number of heads, head diameter, thousand seed weight and yield per decare were analysed.

The Climatic data for the experimental site were obtained from the 13th Elazig Regional Directorate. According to the average temperatures in Table 3, the coldest month was January, with a temperature of -1.6 °C in the 2021-2022 growing years; -1.1 °C in February in the 2022-2023 growing years; -0.8 °C in February. The hottest month was August in both growing years and long years, and these values were higher in both growing years than in long years.

When the monthly maximum temperatures were analysed, the lowest monthly maximum temperature occurred in January in both growing years and long years. The highest monthly maximum temperature occurred in August in both growing years and in July in the long years. The analysis of the monthly minimum temperatures showed that the monthly minimum temperature decreased to -24.6 °C in December and January, while it decreased to -11.2 °C in January in the first growing year and to -9.5 °C in February in the second growing year. In August, which is one of the hottest months of the year, a decrease of up to 10.2 °C was observed, while a decrease of up to 18.6 °C was observed in the first growing year, and a decrease of 14.9 °C was observed in the second growing year (Table 3).

Table 3. Climatic data of the experimental site

Months	Average temperature			Monthly maximum temperature (°C)			Monthly minimum temperature (°C)			Monthly total precipitation (mm)		
	2021 2022	**2022 2023**	**Long Years**	**2021 2022**	**2022 2023**	**Long Years**	**2021 2022**	**2022 2023**	**Long Years**	**2021 2022**	**2022 2023**	**Long Years**
October	14.8	16.1	15.00	25.8	28.5	32.40	3.2	5.1	-2.20	37.40	13.60	39.50
November	9.5	8.8	7.50	18.4	18.3	24.30	1.9	2.4	-15.20	23.50	73.70	48.90
December	1.9	4.7	1.80	10.6	11.7	19.60	-9.4	-1.6	-22.60	20.10	13.90	45.70
January	-1.6	0.1	-0.80	7.2	6.5	13.00	-11.2	-8.7	-22.60	27.20	16.10	42.00
February	2.8	-1.1	0.70	12.4	13.6	18.60	-5.4	-9.5	-21.40	44.50	30.30	42.60
March	1.8	8.1	5.60	16	16	26.40	-7.9	-3.5	-17.00	78.90	217.50	56.10
April	13.9	10.5	12.00	25.3	21.3	32.20	-2.7	-2.6	-7.00	6.00	84.90	62.90
May	14.6	15	17.20	30.9	24.6	36.60	4.5	4.2	0.00	49.9	84.40	53.10
June	22.5	21	22.80	33.7	32	38.60	11.5	12	4.00	45.00	4.90	12.40
July	25.8	25.7	27.20	36.2	36.2	42.40	13.5	12.8	6.70	0.00	0.60	3.30
August	28.5	28.4	27.00	36.8	38.3	42.20	18.6	14.9	10.20	0.50	4.30	1.80
Total										**333.00**	**544.20**	**408.30**

When the total monthly precipitation amounts were analysed, it was found that while 408.3 mm of precipitation occurred in the long years, 333.0 mm of precipitation was received in the first growing year, and 554.2 mm of precipitation was received in the second growing year. Accordingly, the amount of precipitation received in the first growing year was lower than in the long years, while the amount of precipitation received in the second growing year was greater than that in the long years (Table 3).

Table 4. Soil analysis results of the experimental site

Name of Analysis	Results	Rating
Saturation (%)	60.5	Clay - Loamy
pH	8.03	Slightly Alkaline
Total Salt (%)	0.02	Unsalted
Lime (%)	26.04	Too much lime
Organic Matter (%)	2.59	Medium
Available Phosphorus (P_2O_5- kg da^{-1})	4.29	Low
Available Potassium (K_2O- kg da^{-1})	63.23	High

Soil analyses of the experimental area were carried out at the Soil Analysis Laboratory of the Elazig Provincial Directorate of Agriculture and Forestry. According to the data obtained, Table 4 shows that the soil texture is clayey-loamy, the soil pH is slightly alkaline at 8.03, the total salt content is salt-free at 0.02 %, it contains high lime content at 26.04 %, the organic matter content in the soil is moderate at 2.59 %, the available phosphorus is low at 4.29 kg per decare, but the available potassium is high at 63.23 kg per decare.

3. Results and Discussion

3.1. Winter resistance rate

When the years were analysed separately, the lowest winter resistance rate was obtained for the Dincer cultivar, with 4.58 % at the 1st planting time in 2021-2022.

In the following year, it was determined that Dincer cultivar was found to be the most sensitive cultivar to winter under Elazig ecological conditions, with 5.90 % sensitivity at 1st planting time (Table 8). Koç (2019), in his study conducted under Konya ecological conditions, determined that the most sensitive cultivar to winter was Dincer, followed by Linas cultivar. However, winter resistance rates were lower in the study conducted by Koç (2019). This is because the minimum temperature values in the years in which the trial was conducted were lower than the minimum temperature values in this trial (Table 3). Koç (2019) and Johnson et al. (2016) determined a resistance between 80 % and 100 % in the Chinese origin BJ-27 line, and these values were found to be low compared to this study, and the reason for this situation can be said that this Chinese origin line used in these trials has a genetically higher cold resistance.

Table 5. Variance analysis results of the trial

VK	DF	Winter resistance rate (%)	Flower yield (mg plant^{-1})	Plant height (cm)	Number of lateral branches (pcs plant^{-1})	Number of heads (pcs head^{-1})	Head diameter (mm)	Thousand seed weight (g)	Yield per decare (kg da^{-1})
B	3	**	NS	NS	NS	NS	NS	NS	NS
Y	1	**	**	NS	**	*	**	**	*
PT	2	**	**	**	**	**	NS	NS	**
Y x PT	2	**	**	**	**	**	**	NS	**
C	3	**	**	**	**	**	NS	**	**
Yx C	3	**	**	NS	**	**	NS	**	**
PTx C	6	**	**	**	NS	*	**	NS	**
Y x PT x C	6	**	**	NS	NS	NS	**	*	**
CV (%)		9.23	13.79	6.32	15.62	15.52	4.59	4.39	14.48

**: Statistically significant at the 1% level, Statistically significant at the 5% level, NS: Not significant, B: Block, Y: Year, PT: Planting time, C: Cultivar, CV: Coefficient of variation, DF: Degree of freedom.

3.2. Flower yield

Since the safflower flowers are used in different fields and have a positive relationship with seed yield, it is important to investigate this character (Singh et al. 2008). Table 5 shows that the effects of year, planting time, cultivar, year × cultivar, year × planting time, planting time × cultivar, and year × planting time × cultivar on flower yield were statistically significant at the 1 % level. The effects of different years, planting times and cultivars alone and together caused differences in flower yield. Table 6 shows that flower yield was higher in the first year of the experiment than in the second year. When the development of the plants was examined, the flowering period occurred in June. An analysis of the climatic data (Table 3) revealed that the amount of rainfall in the first year was significantly higher than that in the second year in June during the first and second years of the experiment. The flower yield in the second year decreased due to the effects of heat and drought. The highest flower yield per plant was obtained from 508.25 mg of Olas and 494.50 mg of Zirkon at 1st planting time in the 2021–2022 growing period (Table 8). The obtained data were lower than those in the study of Uysal et al. (2006), and it was determined that this difference was not due to a lack of rainfall during the years when the experiment was carried out; rather, the plant density affected flower yield, possibly due to low plant density. It was determined that the flower yield was higher than that in the study conducted by Koç and Güneş (2021) in summer. The rainfall in June, especially in the first year of the experiment, and the cultivar used and other ecological factors affected this situation.

3.3. Plant height

Plant height is an important agricultural character of safflower, as is it for many crops. According to the results of the variance analysis, year, year × cultivar interaction and year × planting time × cultivar interaction had no significant effect on plant height. The effects of planting time, cultivar and year × planting time, and planting time × cultivar interactions on plant height were found to be statistically significant at the 1 % level (Table 5). When the effect of planting time was analysed, it was observed that plant height increased gradually from 1st planting time to 3rd planting time (Table 6). This can be explained by the fact that 1st planting time was exposed to more cold and drought than was 3rd planting time. The longer this period is, the more the meristem tissues that support plant growth will be negatively affected. The lowest and highest plant heights were obtained from the first year of the experiment. The lowest plant height was obtained from Dincer cultivar at 51.90 cm at 1st planting time, while the highest plant height was obtained from Linas cultivar at 82.04 cm at 3rd planting time (Table 8). In a study conducted by El Bey et al. (2021), Linas cultivar was found to have higher plant height than Olas cultivar, which was similar to the findings of this study. However, when the general plant height values of the trials were examined, the values were lower than those reported by El Bey et al. (2021), Paşa (2008), and Hatipoğlu et al. (2012) and were somewhat similar to those reported by Oruç and Yılmaz (2019). This may be related to the response of the ecological conditions in which the trials were carried out, especially whether the winter conditions were harsh.

3.4. Number of lateral branches

The number of lateral branches is an important character in safflower plants, and a head is usually formed at the end of each lateral branch. In this study, the differences between the averages of the number of lateral branches, year, planting time, year × planting time, cultivar and year × cultivar were statistically significant at the 1% level, while the differences between the interactions of planting time × cultivar and year × planting time × cultivar were not statistically significant (Table 5). The number of lateral branches varied between 2.71 and 5.50. The lowest number of lateral branches was obtained from Zirkon cultivar at 3rd planting time in the 2022-2023 growing season, while the greatest number of lateral branches was obtained from Olas cultivar at 3rd planting time in the 2021-2022 growing season (Table 8). Kızıl (2002) and Hatipoğlu et al. (2012), who studied winter planting times, reported that the number of lateral branches in safflower decreased with increasing planting time increased, and in this study, when the effect of planting time alone on the number of heads was examined, it was determined that there was a decrease from 1st planting time to 2nd planting time and an increase in 3rd planting time (Table 6). This can be explained by the fact that the number of plants per m^2 at 1st and 3rd planting times was less than that at 2nd planting time. This result is in partial agreement with the study conducted by Baran and Andırman (2019). Number of lateral branches was lower than the values obtained by Kızıl (2002), Hatipoğlu et al. (2012), and Baran and Andırman (2019). This may be due to the ecological conditions under which the studies were conducted.

Table 6. Data from the experiment for year, planting time, cultivar, and year × planting time interaction

		WRR		FY		PH		NLB		NH		HD		TSW		Y	
Year																	
2021 2022		52.95	A	423.29	A	67.02		3.76	A	6.25	A	22.67	A	25.76	A	105.88	A
2022 2023		40.56	B	270.42	B	67.85		2.86	B	5.17	B	16.92	B	22.11	B	73.88	B
Planting Time																	
1. PT		18.02	C	377.15	A	65.03	B	3.44	A	6.07	A	19.60		39.76		64.25	B
2. PT		41.52	B	352.99	A	66.98	AB	2.87	B	4.76	B	19.66		39.90		106.63	A
3. PT		80.73	A	310.42	B	70.30	A	3.61	A	6.30	A	20.12		40.04		98.74	A
Cultivar																	
Dincer		42.14	C	355.57	A	67.57	B	3.13	B	6.60	A	19.84		41.64	A	87.62	BC
Linas		45.75	B	290.69	B	74.45	A	3.33	B	5.10	B	19.94		40.09	B	92.03	AB
Olas		46.80	B	366.51	A	66.24	B	3.78	A	6.08	A	19.85		38.21	C	80.61	C
Zirkon		52.35	A	374.65	A	61.48	C	3.00	B	5.06	B	19.55		39.65	B	99.26	A
Year x Planting Time Intraction																	
2021 2022	**1. PT**	19.65	D	427.25	AB	57.22	D	3.11	BC	4.74	B	21.93	B	41.93		69.72	C
	2. PT	39.20	C	450.13	A	70.30	AB	3.18	BC	5.19	B	22.66	AB	43.34		142.78	A
	3. PT	100.00	A	392.50	B	73.53	A	4.98	A	8.81	A	23.41	A	43.53		105.13	B
2022 2023	**1. PT**	16.39	D	327.05	C	72.83	A	3.77	B	7.39	A	17.28	C	37.58		58.78	C
	2. PT	43.84	C	255.86	D	63.66	C	2.57	CD	4.34	B	16.66	C	36.45		70.49	C
	3. PT	61.46	B	228.34	D	67.06	BC	2.24	D	3.78	B	16.82	C	36.54		92.35	B

WRR: Winter resistance rate, FY: Flower Yield, PH: Plant Heigh, NLB: Number of Lateral Branches, NH: Number of Heads, HD: Head Diameter, TSW: Thousand Seed Weight, Y: Yield, PT: Planting Time.

3.5. Number of heads

The effects of planting time, year × planting time, cultivar, year × cultivar were statistically significant at the 1 % level; year and planting time × cultivar interaction were statistically significant at the 5 % level; and year × planting time × cultivar interaction was not significant (Table 5). The number of heads varied between 3.20 and 10.01. The lowest number of heads was obtained from Zirkon cultivar at 3rd planting time and from Linas cultivar at 2nd planting time in the growing years 2022-2023, while the greatest number of heads was obtained from Olas cultivar at 1st planting time in the same growing year (Table 8). When the single effect of number of heads was analysed, similar to number of lateral branches, there was a decrease in number of heads from 1st planting time to 2nd planting time and then an increase from 2nd planting time to 3rd planting time (Table 6). This situation can be explained by plant density per m^2. Plant density per m^2 at 2nd planting time was higher than that at 1st and 3rd planting times. Therefore, fewer heads were obtained during 2nd planting time. While the data on number of heads were consistent with those of El Bey et al. (2021) and Aslantaş and Akınerdem (2020), they were lower than those of Baran and Andırman (2019), Öz (2016) and Samancı et al. (2001).

3.6. Head diameter

The effects of year, year × planting time, planting time × cultivar and year × planting time × cultivar were statistically significant at the 1 % level, while the effects of planting time, cultivar and year × cultivar were not statistically significant. Head diameter varied between 15.91 and 23.43 mm (Table 5). The smallest head diameter was obtained for the Olas cultivar at 3rd planting time in the 2022-2023 growing season, while largest head diameter was obtained for Olas cultivar at 3rd planting time in the 2021-2022 growing season (Table 8). In the first year of the trial, the number of plants per m^2 at 3rd planting time was low at 3rd planting time, and in second year, it was high at 2nd planting time, so head diameter remained low due to the increase in density. Head diameter was similar to that reported by Hatipoğlu et al. (2012) and lower than that reported by Aslantaş and Akınerdem (2020).

3.7. Thousand seed weight

According to the analysis of variance, the effects of year, year × planting time, planting time × cultivar and year × planting time × cultivar were statistically significant at the 1 % level; the effect of year was statistically significant at the 5 % level; and the effects of planting time, cultivar and year × cultivar were statistically nonsignificant on the difference between the average thousand seed weights (Table 5). The thousand seed weight varied between 33.73 and 46.17 g. The lowest thousand seed weight was obtained from Linas cultivar at 3rd planting time of the 2022-2023 growing season, and the highest thousand seed weight was obtained from Linas cultivar at 2nd planting time of the 2021-2022 growing season (Table 8). Considering these values, Linas cultivar showed wide variation in terms of thousand-seed weight. In general, it was found to be higher than that of Öztürk (2019) and Aslantaş and Akınerdem (2020) and lower than that of El Bey et al. (2021), Hatipoğlu et al. (2012) and Karaaslan et al. (2011). One of the factors affecting thousand seed weight in safflower is related to seed filling after the flowering period. In particular, in this study, poor seed formation was observed due to the drought experienced after the flowering period, and it was observed that some seeds were not filled.

3.8. Seed yield

According to the results of variance analysis, the effects of planting time, cultivar, year × planting time, year × cultivar, planting time × cultivar, year × planting time × cultivar and year × planting time × cultivar were statistically significant at the 1 % level, and the effect of year at the 5 % level on the difference between the mean seed yields (Table 5). The lowest seed yield was obtained from Dincer cultivar at 1st planting time in the 2022-2023 growing season (23.74 kg da^{-1}), while the highest seed yield was obtained from Dincer cultivar at 2nd planting time in the 2021-2022 growing season (160.96 kg da^{-1}), (Table 8).

Table 7. Data of the trial for year × cultivar and planting time × cultivar interactions.

		WRR		FY		PH		NLB		NH		HD		TSW		Y	
Year x Cultivar Intraction																	
2021-2022	**Dincer**	47.09	CD	391.92	B	66.75		2.80		6.26	AB	22.71		27.00	A	106.04	A
	Linas	54.09	B	376.75	B	73.32		3.03		5.64	BC	22.42		26.70	A	109.96	A
	Olas	50.98	BC	464.17	A	65.96		3.18		6.95	A	23.06		24.42	B	88.66	B
	Zirkon	59.64	A	460.33	A	62.04		2.44		6.15	ABC	22.49		24.92	B	118.85	A
2022-2023	**Dincer**	37.18	E	319.22	C	68.40		3.13	B	6.93	A	16.98		22.96	C	69.19	C
	Linas	37.40	E	204.63	D	75.57		3.33	B	4.56	DE	17.46		21.40	D	74.09	BC
	Olas	42.62	D	268.86	C	66.53		3.78	A	5.21	CD	16.64		21.42	D	72.55	C
	Zirkon	45.06	D	288.97	C	60.92		3.00	B	3.98	E	16.61		22.67	C	79.67	BC
Planting Time x Cultivar Intraction																	
1. PT	**Dincer**	5.24	F	402.53	A	59.09	E	3.26		7.66	A	19.40	AB	41.00		28.64	E
	Linas	18.70	E	303.28	BCD	72.18	B	3.45		5.42	BCD	19.77	AB	40.96		74.64	D
	Olas	25.48	D	405.40	A	65.19	CDE	3.93		6.36	B	19.11	AB	37.35		75.85	D
	Zirkon	22.68	DE	397.40	A	63.65	DE	3.14		4.83	CDE	20.13	A	39.71		77.88	D
2. PT	**Dincer**	39.56	C	385.53	A	71.73	B	2.84		5.64	BC	19.95	AB	41.73		123.50	A
	Linas	39.83	C	303.78	BCD	70.80	BC	2.59		3.80	E	19.78	AB	40.28		97.82	BC
	Olas	36.50	C	338.65	ABC	66.09	BCD	3.45		5.36	BCD	20.27	A	38.30		89.77	CD
	Zirkon	50.21	B	384.03	A	59.30	E	2.62		4.27	DE	18.66	B	39.27		115.45	AB
3. PT	**Dincer**	81.61	A	278.65	CD	71.90	B	3.28		6.50	AB	20.17	A	42.18		110.71	AB
	Linas	78.71	A	265.03	D	80.36	A	3.94		6.09	BC	20.27	A	39.03		103.61	BC
	Olas	78.42	A	355.48	AB	67.45	BCD	3.96		6.51	AB	20.17	A	38.96		76.20	D
	Zirkon	84.17	A	342.53	ABC	61.49	DE	3.25		6.09	BC	19.86	AB	39.98		104.45	BC

WRR: Winter Resistance Rate, FY: Flower Yield, PH: Plant Height, NLB: Number of Lateral Branches, NH: Number of Heads, HD: Head Diameter, TSW: Thousand Seed Weight, Y: Yield, PT: Planting Time.

Dincer cultivar showed a wide variation seed yield per decare. In the first planting of both years, it was determined that seed yield per decare was low in Dincer cultivar. It is understood from the winter resistance rate that Dincer cultivar is highly affected by cold, especially during early planting, such as in winter. In a winter cold resistance study conducted by Koç (2019) with different safflower cultivars and lines, Dincer cultivar was among the most sensitive cultivars to winter cold. Considering 2nd planting times of both years, the highest seed yields were obtained from Dincer cultivar compared to the other cultivars (2021-2022: 160.96 kg da^{-1}, 2022-2023: 86.04 kg da^{-1}). When 3rd planting times were also evaluated, although it followed Linas cultivar in the first year of the experiment, it had almost the same seed yield (Linas: 124.75 kg da^{-1}, Dincer: 123.62 kg da^{-1}) and followed Zirkon cultivar in 2nd year of the experiment (Zirkon: 100.51 kg da^{-1}, Dincer: 97.79 kg da^{-1}). When the general situation of the trial was evaluated, it was determined that the seed yield of the first year was higher than that of the second year due to precipitation, and in terms of planting times, the highest seed yield was obtained from 2nd planting time, but the same statistical group was shared with 3rd planting time.

The highest seed yield was obtained from Zirkon cultivar (99.26 kg da^{-1}), and it was determined that this cultivar had a more stable yield than the other cultivars. According to the 2-year average of the experiment, while the lowest seed yield was obtained from Dincer cultivar at 1st planting time, the highest seed yield was obtained from Zirkon cultivar, and it shared the same statistical group with the other cultivars except Dincer. At 2nd planting time, the greatest seed yield was obtained from Dincer cultivar followed by Zirkon cultivar and the lowest seed yield was obtained from Olas cultivar. At 3rd planting time, the highest seed yield was obtained from Dincer cultivar, followed by Zirkon cultivar. At the same time, Zirkon and Linas shared the same statistical group. The lowest seed yield was obtained from Olas cultivar at the same planting time (Table 7). In this study, seed yield was higher than that obtained by Aslantaş and Akınerdem (2020) and lower than that obtained by Culpan (2023), Hatipoğlu et al. (2012), and Karaaslan et al. (2011). These differences are due to the cultivars used, the different ecological conditions in which the trials were conducted and some differences in the conduct of the trials.

Table 8. Data of the trial for year × planting time × cultivar intraction

			WRR		FY		PH	NLB	NH	HD		TSW		Y	
2021-2022	1. PT	Dincer	4.58	K	383.50	BCDE	51.90	3.20	5.31	21.93	BC	44.03	ABCD	33.55	KL
		Linas	22.34	IJ	322.75	DEF	62.58	2.75	4.18	21.53	BC	43.01	BCDE	73.96	GHIJ
		Olas	21.60	IJ	508.25	A	56.73	3.60	5.05	21.57	BC	39.54	FGHI	73.77	GHIJ
		Zirkon	30.09	HI	494.50	A	57.67	2.90	4.43	22.69	ABC	41.16	EFG	97.62	EFG
	2. PT	Dincer	36.70	FGH	438.50	ABC	71.98	2.70	4.85	22.82	ABC	45.51	AB	160.96	A
		Linas	39.92	FG	421.00	ABCD	75.35	2.95	4.40	23.31	ABC	46.17	A	131.17	BC
		Olas	31.35	GH	463.25	AB	70.81	4.04	6.49	23.18	ABC	40.23	EFGH	128.45	BC
		Zirkon	48.84	DE	477.75	AB	63.07	3.02	5.03	21.34	C	41.46	DEFG	150.53	AB
	3. PT	Dincer	100.00	A	353.75	CDEF	76.37	4.45	8.63	23.37	AB	45.48	AB	123.62	CDE
		Linas	100.00	A	386.50	BCDE	82.04	5.19	8.35	22.42	BC	44.34	ABC	124.75	BCD
		Olas	100.00	A	421.00	ABCD	70.36	5.50	9.30	24.43	A	42.34	CDE	63.76	HIJ
		Zirkon	100.00	A	408.75	ABCD	65.37	4.80	8.98	23.43	AB	41.96	CDEF	108.40	CDEF
2022-2023	1. PT	Dincer	5.90	K	421.55	ABCD	66.28	3.32	10.01	16.88	DE	37.98	HIJKL	23.74	L
		Linas	15.05	J	283.80	EFGH	81.78	4.15	6.65	18.01	D	38.91	GHIJ	75.32	GHIJ
		Olas	29.35	HI	302.55	EFG	73.65	4.25	7.68	16.65	DE	35.17	LMN	77.94	GHIJ
		Zirkon	15.27	J	300.30	EFG	69.62	3.37	5.23	17.57	DE	38.26	HIJK	58.13	IJK
	2. PT	Dincer	42.41	EF	332.55	DEF	71.48	2.98	6.43	17.07	DE	37.96	HIJKL	86.04	FGHI
		Linas	39.75	FG	186.55	HI	66.25	2.23	3.20	16.25	DE	34.39	MN	64.48	HIJ
		Olas	41.64	EF	214.05	GHI	61.38	2.85	4.23	17.37	DE	36.38	JKLMN	51.09	JK
		Zirkon	51.57	D	290.30	EFG	55.53	2.23	3.50	15.97	E	37.08	IJKLM	80.37	GHI
	3. PT	Dincer	63.23	BC	203.55	GHI	67.43	2.11	4.37	16.97	DE	38.88	GHIJ	97.79	EFG
		Linas	57.41	CD	143.55	I	78.68	2.70	3.83	18.12	D	33.73	N	82.47	FGHI
		Olas	56.85	CD	289.97	EFG	64.55	2.43	3.73	15.91	E	35.58	KLMN	88.64	FGH
		Zirkon	68.34	B	276.30	FGH	57.60	1.71	3.20	16.30	DE	37.99	HIJKL	100.51	DEFG
Ort.			46.76		346.85		67.44	3.31	5.71	19.79		39.90		89.88	

WRR: Winter Resistance Rate, FY: Flower Yield, PH: Plant Height, NLB: Number of Lateral Branches, NH: Number of Heads, HD: Head Diameter, TSW: Thousand Seed Weight, Y: Yield, PT: Planting Time.

4. Conclusions

An evaluation of the results obtained from this trial over two years revealed that safflower, which is generally grown as a summer crop under Elazig ecological conditions, can also be grown as a winter crop. Planting time should be taken into consideration as an important factor in winter cultivation. Early planting had a particularly negative effect on seed yield. For high yields, winter planting should be started on 10-15 November and completed on 25-30 November. These dates are generally a period of increased rainfall, and there is limited time to reach the land for planting. Considering the 2-year averages of the cultivars in terms of yield, Dincer cultivar was more prominent than the other cultivars in terms of yield at 2nd and 3rd planting times, but Zirkon cultivar should be considered separately in terms of cultivar preference since it has the greatest single effect in terms of yield and the highest winter resistance rate.

Authors' Declaration of Contribution

The authors declare that they have contributed equally to the manuscript and have read and approved the final version of the manuscript for publication.

Conflict of Interest Declaration

All authors declare that they have no conflict of interest for this study.

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