# DETERMINATION OF YIELD AND QUALITY PARAMETERS OF SOME SAFFLOWER (CARTHAMUS TINCTORIUS L.) VARIETIES GROWN IN VAN ECOLOGICAL CONDITIONS

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**Abstract.** This study was conducted during 2019-2020 growing season at the experimental station of the Faculty of Agriculture, Van Yuzuncu Yil University in Türkiye, in order to determine the yield and yield components of some safflower varieties grown in irrigated conditions. The registered varieties including Ayaz, Asol, Olas, Yenice, Remzibey-05, Balci, Gokturk, Linas were studied in Completely Randomized Block designe with three replicates. Several parameters such as plant height, first branch height, number of main and secondary branches per plant, table number, seed number per head, thousand seed weight, hectolitre weight, seed yield, crude oil ratio as well as crude oil yield were measured. Results showed that Asol and Olas varieties had the highest amounts of yield (1169.3 and 1046.3 kg $ha^{-1}$), oil ratio (31.9% and 31.8%) and crude oil yield (374.7 and 333.4 kg $ha^{-1}$), respectively. Based on results as well as climatic and environmental conditions of the studied region, it is suggested to study more on the effects of different types and amounts of fertilizers on these two important plant varieties especially in in dry conditions in order to recommend for the region.

**Keywords**: Crude oil, Registered varieties, Yield, Yield component

**Abbreviations**
LYA- Long Years Average
Ns- non significant
Lsd-Least Significant Difference
CV-Coefficent Variation

## INTRODUCTION

The nutritional problems and starvation are the most important challenges worldwide and specially in our country, Türkiye in present and future time. From 7.8 billion people living in the World, approximately 25 thousands die per day due to starvation. Fort his purpose, increasing of production per unit area has great importance. Generally, in human diet, 1 gram of fat providing 9 kcal energy, 4 kcal protein and 4.5 kcal of carbohydrate.

In the year 2019, Türkiye imported nearly 1.8 billion dollars of oil seeds, 929 million dollars crude oil as well as 572 million dollars of pulp, respectively (Anonymous, 2019) which constitute nearly 1.62% of our country's total imports. The amount of vegetable oil produced in Türkiye is around 900 thousand tons in recent years which supply only one third of the oil needs. So, it is important to increase the cultivation areas of oil crops with high nutrients and ability to grow at non-irrigated systems.

Safflower, also known as american saffron or dyer's saffron, is an annualy broad-leaved plant with yellow, red, orange, white or cream flowers, thorny or non-thorny types, with an average oil content of 25-40% ( Kose & Kose 2011). It is an important oil plant worldwide as well as in Türkiye due to its drought resistance, not being selective in terms of soil requirements, low input costs, and being suitable for mechanization from sowing to harvest (Uysal et al 2006, Kose & Bilir 2017). It can be cultivated in narrowing fallow areas due to its adaptation to barren conditions with high oil quality especially oleic acid which can be used as edible, as a diesel fuel additive that reduces emissions or as a raw material in biodiesel production.

The Van region has long and cold winters with short and warm summers due to its altitude and geographical location which limits the variety of cultivated plants in the region. Based on crop production data of Van province (2019), the wheat (72.158 tons) had the first place and sugar beet (40.868 tons) as well as barley (26.857 tons) put in the second place (Anonymous, 2020a). It is necessary to increase the cultivation of the safflower to supply the grains and other products and play an important role in the product variety as well as economy of the region. Fort his purpose, this study designed to determination several yield and yield parameters of registered safflower varieties in Van ecological conditions.

## MATERIALS AND METHODS

This study was conducted during 2019-2020 growing season at the experimental station of the Faculty of Agriculture, Van Yuzuncu Yil University in Türkiye. The eight registered safflower varieties were used in this study (Table 1). The meteorological data of Van region and soil analysis are given in Table 2 and Table 3, respectively.

Table 1

Features of the registered varieties used in the research

| | Variety Name | Registered Institution | Registration Year | Properties |
|---|---|---|---|---|
| 1 | Ayaz | Bahri Dagdas International Agrıcultural Research Institute | 2014 | Thorny, Red flowering |
| 2 | Asol | Trakya Agricultural Research Institute | 2018 | Thorny, Orange flowering |
| 3 | Olas | Trakya Agricultural Research Institute | 2015 | Thorny, Yellow flowering |
| 4 | Yenice | Transitional Zone Agricultural Research Institute | 1964 | Non-Thorny, Red flowering |
| 5 | Remzibey-05 | Transitional Zone Agricultural Research Institute | 2005 | Thorny, Yellow flowering |
| 6 | Balci | Transitional Zone Agricultural Research Institute | 2011 | Thorny, Yellow flowering |
| 7 | Gokturk | Bahri Dagdas International Agricultural Research Institute | 2016 | Thorny, Yellow-Orange flowering |
| 8 | Linas | Trakya Agrıcultural Research Institute | 2013 | Thorny, Orange flowering |

(Anonymous, 2021)

Table 2

Some meteorological parameters during the 2019-2020

| | Mean Temp.(ºC) | | | Rainfall (mm) | | | Humidity (%) | | |
|---|---|---|---|---|---|---|---|---|---|
| **Months** | **2019** | **2020** | **LYA** | **2019** | **2020** | **LYA** | **2019** | **2020** | **LYA** |
| January | -0.8 | -2.5 | -2.5 | 31.1 | 43.8 | 33.2 | 69.5 | 74.5 | 66.7 |
| February | -0.6 | -1.7 | -1.5 | 21.3 | 79.9 | 31.5 | 73.8 | 77.1 | 67.2 |
| March | 2.9 | 4.9 | 2.8 | 24.4 | 40.9 | 47.7 | 73.4 | 72.5 | 65.4 |
| April | 7.2 | 8.6 | 8.4 | 36.2 | 50.9 | 57.4 | 66.1 | 65.4 | 59.3 |
| May | 15.4 | 14.5 | 13.4 | 15.3 | 27.8 | 45.3 | 51.9 | 54.0 | 55.1 |
| June | 21.4 | 19.3 | 18.8 | 7.2 | 13.4 | 16.4 | 45.4 | 44.4 | 47.1 |
| July | 23.0 | 23.0 | 22.7 | 0.4 | 17.9 | 6.9 | 39 | 46.4 | 42.3 |
| August | 23.7 | 21.6 | 22.9 | 0.9 | 10.0 | 5.3 | 40.2 | 44.5 | 40.5 |
| September | 18.8 | 20.1 | 18.3 | 0.8 | 5.6 | 20.4 | 43.9 | 41.3 | 43.9 |
| October | 13.4 | 13.3 | 12 | 24.1 | 1.8 | 48.2 | 52.9 | 47.2 | 57.3 |
| November | 5.2 | 6.7 | 5.1 | 22.9 | 12.8 | 48.8 | 58.2 | 65.5 | 64.2 |
| December | 3.0 | 1.4 | 0.2 | 46.7 | 27.7 | 45.1 | 71.3 | 71.4 | 67.5 |
| **Mean** | 11.1 | 10.76 | 10.05 | 19.27 | 27.7 | 33.85 | 57.13 | 58.68 | 56.37 |

Source, Van meteorology station (Anonymous, 2020b)

The study was carried out in a completely randomised block design (CRBD) with three replicates. The distance between plot and blocks 1 and 2 meters, respectively. Each plot size was 3 × 1.8 m = 5.4 m2 in 6 rows with a row spacing of 30 cm. Deep tillage was done using a mouldboard plow in the autumn of the previous year followed by light tillage by a disc harrow in the spring season. Before planting, 200 kg $ha^{-1}$DAP (Di Ammonium Phosphate) and 60 kg $ha^{-1}$ Urea (46% N) were applied to each plot and mixed with a rake. Then, rows were opened with a hand marker and the seeds (30 kg $ha^{-1}$) planted in the first week of April at 3-5 cm depth. As a maintenance process, when the plants were in the rosette stage (3-4 leaves period), dilution was performed 10 days after dilution, 10 cm on the row. Irrigation was done with a sprinkler irrigation system (120 mm in total) during the upturn and pre-flowering periods. All the necessary cultural practices were applied to the plots during vegetation period.

Table 3

Soil analysis results of the trial area

| **Depth (cm)** | **Texture** | **pH** | **Lime (%)** | **Total Salt (µS/cm)** | **Organic matter** |
|---|---|---|---|---|---|
| 0-20 | Sandy-Loam | 7.65 | 188 | 8.8 | 0.94 |
| 20-40 | Sandy-Loam | 7.73 | 152.1 | 9.1 | 0.63 |

Source, Van Yuzuncu Yil University, Faculty of Agriculture, Department of Soil Science and Plant Nutrition

Each plot is separated by a row from each side, 50 cm from the bottom and top parts of the plot, and the remaining 0.8 m x 2.0 m = 1.6 m2 area is harvested. The crop

harvest was carried out on 20.08.2019 in the first year, and on 25.08.2020 in the second year, when the seeds ripened.

Several parameters such as plant height (cm), the number of branches, number of secondary branches, first branch height (cm), number of heads in the plant, number of seeds per head, thousand-seed weight (g), hectoliter weight (g), seed yield (kg $ha^{-1}$), oil content (%) and oil yield (%) were measured. The morphological parameters such as plant height, first branch height, number of main and secondary branches, number of heads, number of seeds in the head were measured on 10 randomly selected plants from each plot during harvest maturity period. The parameters such as thousand seed weight, hectoliter weight, seed yield, crude oil ratio and crude oil yield, measurements were also made from the seeds obtained from each plot separately.

**Statistical analysis**. The obtained data were statistically analysed using COSTAT software and the means compared by Duncan Multiple Range Test.

## RESULTS AND DISCUSSIONS

The average values of the measured parameters (Tables 4, 5, 6) showed that there are significant differences among the varieties in all the studied parameters and there are statistically significant differences between the years in terms of the number of secondary branches, number of heads in the plant, number of seeds per head, thousand seed weight, seed yield, crude oil ratio and crude oil yields. Also, it was determined that the effect of Variety x Year interaction on the number of secondary branches, number of heads in the plant, number of seeds per head, seed yield, crude oil ratio and crude oil yield was significant.

Table 4

The average values of the safflower varieties grown in the study and the importance of the F values

| | Plant height (cm) | | First branch height (cm) | | Number of main branches (piece) | | Number of secondary branches (piece) | |
|---|---|---|---|---|---|---|---|---|
| **Varieties** | **2019** | **2020** | **2019** | **2020** | **2019** | **2020** | **2019** | **2020** |
| Ayaz | 71.43 b | 71.33 b | 40.90 b | 48.73 b | 6.46 | 5.73 c | 8.10 a | 3.00 cd |
| Asol | 63.20 bc | 60.26 c | 32.50 cd | 38.40 cd | 6.63 | 6.66 bc | 8.63a | 2.60 d |
| Olas | 65.83 b-d | 64.80 bc | 35.1 b-d | 32.80 de | 6.56 | 7.40 ab | 7.83 a | 4.93 b |
| Yenice | 96.66 a | 92.70 a | 71.43 a | 68.40 a | 6.36 | 6.53 bc | 7.50 ab | 6.80 a |
| Remzibey-05 | 58.03 d | 45.86 d | 28.50 d | 26.40 e | 6.36 | 5.93 c | 6.93 ab | 2.66 d |
| Balci | 65.13 b-d | 60.6 c | 33.50 b-d | 32.66 de | 6.83 | 7.86 a | 8.36 a | 3.40 c |
| Gokturk | 60.53 cd | 66.00 bc | 28.70 d | 37.60 cd | 6.73 | 8.00 a | 5.66 b | 2.46 d |
| Linas | 68.70 bc | 73.06 b | 39.33 bc | 44.00 bc | 6.53 | 7.46 ab | 7.33 ab | 2.53d |
| **Mean of year** | **68.690** | **66.829** | **38.740** | **41.125** | **6.560** | **6.950** | **7.545 a** | **3.55 b** |
| **Lsd ( %5 )** | 8.487 | 9.025 | 8.003 | 10.073 | 1.375 | 1.184 | 1.979 | 0.627 |
| **CV** | 7.055 | 7.712 | 11.795 | 13.987 | 11.967 | 9.728 | 14.983 | 10.091 |
| **Variety** | ** | ** | ** | ** | ns | ** | * | ** |

| | | | | |
|---|---|---|---|---|
| **Year** | ns | ns | ns | ** |
| **Variety * Year** | ns | ns | ns | ** |

* Mean values in the same column without a common letter are significantly different (P < 0.05) according to the Duncan multiple range test. **p<0.01 *p<0.05

**Plant Height.**

Results showed that there are significant differences (P<0.01) in plant height among plant varieties in both years, while the year and variety x year interaction was not statistically significant (Table 4).The average plant height in both years was 68.7 and 66.8 cm, respectively. On the other hand, the highest (96.7 and 92.7 cm) and the least (58.0 and 45.9 cm) plant height in both years were observed in Yenice and Remzibey-05 varieties, respectively. Okcu et al (2010) also obtained the highest (100.5 cm) and the least (64.0 cm)plant height values from Yenice and Remzibey-05 varieties in their 3-year study conducted under Erzurum conditions. Ozturk et al (2009), conducted a 2-year study under Konya conditions and found that plant height values ranged between 94.7 cm-122.9 cm in irrigated conditions and the highest plant height was obtained in Yenice variety. Uysal et al (2006) found also the the highest (96.0 cm) and the least (56.6 cm) plant height values in Yenice and Remzibey-05 varieties under Isparta conditions. Our study results were similar to above mentioned studies conducted in different regions at different times.

**First Branch Height**

The difference among varieties in terms of first branch height was significant (P<0.01) in both trial years but the year and variety x year interaction were not found statistically significant (Table 4). In the study, the average first branch height values in both years were 38.7 and 41.1 cm, respectively. Also, the highest (71.4 and 68.4 cm) and the least (28.5 and 26.4 cm) first branch height were observed in Yenice and Remzibey-05 varieties. The first branch height is an important index in suitability of the varieties for mechanized agriculture and direct correlated with plant height. Okcu et al (2010) in their 3-year study conducted under Erzurum conditions, found the highest (46.9 cm) and the least (17.6 cm) amounts of first branch height in Yenice and Remzibey-05 varieties. Also, Yılmazlar (2008) in his two-years study obtained the highest and the least (41.1 cm and 29.8 cm, respectively) first branch height values in Yenice and Remzibey-05 varieties. Our results were similar to these previous results.

**Number of Main Branches**

According to the results of variance analysis, the difference among varieties in terms of the number of main branches was insignificant in the first trial year, while it was found to be significant at 1% level in the second trial year. In both years, year and variety x year interactions were found to be insignificant (Table 4). The average number of main branches in two years were 6.5 and 6.9, respectively. In the second year, the highest number of main branches (8.0 pieces) obtained in Gokturk variety which put in the same Duncan group with the Balci variety (Table 4). The least value was observed in the Ayaz variety (5.7 pieces) which had no statistically significant difference with the Remzibey-05 variety. Yılmaz & Tuncturk (2018) found the number of main branches values ranged between 6.9 and 7.2 in their study under the ecological conditions of Muş/Türkiye. Subasi (2019) found that the number of main branches was between 5.5-7.3 under Izmir conditions. Yılmazlar (2008) was also reported that the

value of the number of main branches was between 6.1-8.2 in Konya conditions. Although the rate of branching in plants depends on variety, it is affected by cultural practices and ecological factors (Gencer et al. 1987). Having main and secondary branches at the end of each main branch is one of the main factors affecting the number of headers and the yield.

**Number of Secondary Branches**

Results showed that the effect of variety, year and variety x year interaction on the number of secondary branches was found to be significant at the level of 1% (Table 4). The average number of secondary branches in two years was 7.5 and 3.5, respectively. In the first year, the highest secondary branch number value was obtained in Asol variety (8.6 pieces) which put in the same Duncan group with Ayaz, Olas and Balci varieties. In the second year, the highest number of secondary branches (6.8 pieces) was observed in Yenice variety. The least number of secondary branches was obtained in Gokturk variety (5.7 and 2.5 pieces) in both years. In the second year, no statistical difference was found between the Asol and Remzibey-05 varieties. Tuncturk & Tuncturk (2017) reported that the number of secondary branches ranged between 5.6 and 6.5 pieces. Also Subasi (2019) reported the number of secondary branches ranged between 5.5 and 7.3 pieces.

Table 5

The average values of the safflower varieties grown in the study and the importance of the F values

| | Number of heads in the plant (piece) | | Number of seeds per head (piece) | | Thousand seed weight (g) | | Hectoliter weight (g $l^{-1}$,) | |
|---|---|---|---|---|---|---|---|---|
| **Varieties** | **2019** | **2020** | **2019** | **2020** | **2019** | **2020** | **2019** | **2020** |
| Ayaz | 12.03 a | 8.63 c | 25.64 d | 27.80 ab | 41.00 ab | 31.52 b | 574.33 b | 600.66 a |
| Asol | 10.76 a-c | 9.33 bc | 54.10 a | 34.13 a | 39.18 a-c | 37.44 a | 571.66 b | 576.33 ab |
| Olas | 9.60 c | 11.66 a | 35.19 c | 29.66 ab | 42.76 a | 37.81 a | 555.33 b | 544.00 c |
| Yenice | 9.20 c | 8.70 bc | 19.30 e | 23.73 b | 34.93 c | 32.30 b | 562.33 b | 584.66 ab |
| Remzibey-05 | 9.90 bc | 8.60 c | 46.41 b | 26.66 b | 37.65 bc | 31.14 b | 607.33 a | 587.00 ab |
| Balci | 11.43 ab | 11.06 a | 34.43 c | 29.00 ab | 43.35 a | 37.63 a | 572.00 b | 584.66 ab |
| Gokturk | 9.30 c | 10.20 ab | 44.92 b | 28.73 ab | 38.99 a-c | 38.45 a | 594.66 a | 601.33 a |
| Linas | 11.46 ab | 9.26 bc | 34.19 c | 28.20 ab | 41.36 ab | 37.81 a | 557.66 b | 564.33 bc |
| **Mean of year** | 10.46 a | 9.68 b | 36.77 a | 28.49 b | 39.91 a | 35.671 b | 574.42 | 577.96 |
| **Lsd ( %5 )** | 1.651 | 1.532 | 6.016 | 7.158 | 4.744 | 4.204 | 19.604 | 30.808 |
| **CV** | 9.015 | 9.039 | 9.341 | 14.347 | 6.789 | 6.730 | 1.948 | 3.043 |
| **Variety** | * | ** | ** | * | * | ** | ** | * |
| **Year** | ** | | ** | | ** | | ns | |
| **Variety * Year** | ** | | ** | | ns | | ns | |

* Mean values in the same column without a common letter are significantly different (P < 0.05) according to the Duncan multiple range test. **p<0.01 *p<0.05

**Number of Heads in the Plant**

Results showed that the number of heads was significantly different among varieties in the first year (P<0.01) and second year (P<0.05). Also, the effects of year

as well as variety x year interaction were significant (P<0.01) on this parameters. The average number of heads in plant in two years was determined 10.5 and 9.7, respectively. The highest value was observed in Ayaz variety (12.0 pieces) in the first year and Olas variety (11.7 pieces) in the second year. Also, the least value was obtained in Yenice variety (9.2 units) in the first year and in Remzibey-05 variety (8.6 units) in the second year. In the first year, Yenice, Olas and Gokturk varieties and in the second year Ayaz and Remzibey-05 were included in the same Duncan group. The high differences of values among varieties in two years as well as the importance of variety x year interaction may be due to the different responses of genotypes to the growing environment. One of the most important criteria determining the seed yield in safflower is the number of trays (Uysal et al 2006) and well-developed 12-14 heads are considered sufficient in modern safflower varieties (Weiss, 2000). Different ranges of number of heads (8.6-16.3; 5.6-9.1; 8.0-14.5; 6.3-13.0) were reported in prevoius studies (Steberl et al. 2020; Omidi et al. 2012; Arslan & Culpan, 2020; Uysal et al. 2006).

**Number of seeds Per Head**

The effect of year and variety x year interaction on number of seeds per head were significant (P<0.01). Also, this parameter had significant difference among varieties (P<0.01 and P<0.05) in first and second year, respectively. The average number of seeds per head in two years were 36.8 and 28.5, respectively. The highest (54.1 and 34.1) and the least (19.3 and 23.7) number of seeds per head was obtained in Asol and Yenice varieties, respectively. However, in the second year, no statistically significant difference was found between the Yenice variety and the Remzibey-05 variety. Like the number of head in safflower, the number of seeds in the head is an important index affecting the yield (Uysal et al 2006). Although nearly 100 flowers are formed in the safflower head, an average of 20% of these flowers can only produce seeds (Baydar, 2000). The previous studies (Ozturk et al. 2009; Yılmazlar, 2009; Omidi et al. 2012; Gursoy et al. 2018) showed different ranges of number of seeds per head (22.5-28.8; 26.7-42.1; 18.6-47.2).

**Thousand Seed Weight**

In terms of thousand seed weight, the differences between varieties and years were found to be significant at 1% level, while variety x year interaction was found to be insignificant. However, in the first year, the effect of varieties on a thousand grain weight was found to be statistically significant at the level of 5%. The average weight of one thousand seeds in two years was 39.9 g and 35.7 g, respectively. The highest value of thousand seed weight (43.3 g) was obtained in Balci variety in the first year which put in the same group with Olas variety. In the second year, the highest thousand seed weight value was observed in Gokturk variety (38.4 g) which was in the same Duncan group with Asol, Olas, Balci and Linas varieties. Also, the least thousand seed weight value was obtained in Yenice variety (34.9 g) in the first year and in Remzibey-05 variety (31.1 g) in the second year. However, in the second year, it was put in the same group with Ayaz and Yenice varieties. Thousand seed weight is one of the important criteria affecting the yield. Previous studies showed different ranges of thousand seed weight values. Uysal et al (2006) reported 28.3-41.5 g, Okcu et al (2010) between 34.1-44.4 g, Ozturk et al (2009) between 34.1-42.6 g, Tuncturk & Tuncturk (2017) reported 35.2-37.9 g. Our results were similar to previous reports with different values arise from climate and soil structure.

**Hectolitre Weight**

Based on results of variance analysis, the difference between the varieties on hectoliter weight was found to be significant (P<0.01, P<0.05) in first and second years, respectively. The effect of year and variety x year interaction on the hectoliter weight was not found to be statistically significant (Table 5). Hectoliter average values in first and second years were 574.4 g $l^{-1}$, and 577.9 g $l^{-1}$, respectively. The highest hectoliter weight value in the first year (607.3 g l-1,)was observed in Remzibey-05 variety which put in the same statistical group with Gokturk variety. In the second year, the highest value (601.3 g $l^{-1}$) was obtained in Gokturk variety which put in the same group with Ayaz variety. The least value (555.3-544.0 g $l^{-1}$) was also obtained in Olas variety in both years. However, in the first year, all varieties except Remzibey-05 and Gokturk were in the same Duncan group. Previous studies (Mirzakhani et al. 2009; Calisir et al. 2005; Martin et al. 2017) showed different values of the hectoliter weight (642.8-689.6 g $l^{-1}$; 488.6-526.9 g $l^{-1}$,; 540.0-605.0 g $l^{-1}$, respectively). The difference between our results and others may be due to that the hectoliter weight is affected by many factors such as the shape, structure, shell ratio and fat ratio of the grain.

Tablo 6

The average values of the safflower varieties grown in the study and the importance of the F values

| | Seed Yield (kg $ha^{-1}$) | | Crude Oil Ratio (%) | | Oil Yield (kg $ha^{-1}$) | |
|---|---|---|---|---|---|---|
| **Varieties** | **2019** | **2020** | **2019** | **2020** | **2019** | **2020** |
| Ayaz | 916.71 de | 798.12 cd | 17.96 d | 20.36 c | 164.11 d | 162.30 c |
| Asol | 1328.83 a | 1009.44 ab | 32.57 a | 31.30 a | 432.94 a | 316.65ab |
| Olas | 1005.16 cd | 1087.60 a | 32.83 a | 30.79 a | 330.26 bc | 336.62 a |
| Yenice | 824.70 e | 756.82 d | 22.17 c | 23.36 bc | 183.84 d | 176.46 c |
| Remzibey-05 | 1233.33 ab | 763.10 d | 29.55 b | 24.12 b | 364.52 b | 185.10 c |
| Balci | 1068.0 b-d | 953.55 b | 32.46 a | 30.83 a | 346.74 bc | 293.65 ab |
| Gokturk | 958.58 c-e | 973.34 ab | 31.55 ab | 28.41 a | 302.70 c | 275.82 b |
| Linas | 1134.66 bc | 899.60 bc | 32.78 a | 31.26 a | 370.43 b | 282.22 b |
| **Mean of year** | 1058.75 a | 905.20 b | 28.98 a | 27.55 b | 311.94 a | 253.66 b |
| **Lsd ( %5 )** | 176.48 | 118.730 | 2.267 | 3.703 | 61.294 | 54.244 |
| **CV** | 9.517 | 7.490 | 4.466 | 7.674 | 11.220 | 12.215 |
| **Variety** | ** | ** | ** | ** | ** | ** |
| **Year** | ** | | ** | | ** | |
| **Variety * Year** | ** | | ** | | ** | |

* Mean values in the same column without a common letter are significantly different (P < 0.05) according to the Duncan multiple range test. **p<0.01 *p<0.05

**Seed Yield**

The effect of variety, year and variety x year interaction on seed yield was found to be significant (P<0.01) . The average seed yield in first and second years was 1058.75 and 905.20 kg $ha^{-1}$, respectively. The highest seed yield in first and second year (1329.2 kg $ha^{-1}$, 1088.4 kg $ha^{-1}$) were obtained in Asol and Olas varieties, respectively. In both years, the least seed yield (825.0 and 757.5 kg $ha^{-1}$) was observed in Yenice variety. However, there is no statistical difference between Yenice and Remzibey-05 variety in the second year. In the first year, rainfall immediately after planting led to earlier emergence and relatively better plant growth compared to the second year. This indirectly affected the yield values. Increasing the seed yield in safflower is the most important breeding goal (Röbbelen et al 1989). Other researchers (Tuncturk & Tuncturk, 2017; Ozturk et al. 2009; Ozaydın, 2020; Kose, 2017; Omidi et al. 2012) reported different values for seed yield (929-1137 kg $ha^{-1}$; 689-1988 kg $ha^{-1}$; 842-1190 kg $ha^{-1}$; 533-2160 kg $ha^{-1}$; 1360-2190 kg $ha^{-1}$, respectively).

**Crude Oil Ratio**

Results showed that the effect of variety, year and cultivar x year interaction on crude oil ratio were significant (P<0.01). The average crude oil ratio in first and second years were 29.0% and 27.5%, respectively. In the first year, the highest crude oil content (32.8%) was obtained in Olas variety which put in the same Duncan group with Asol, Balci and Linas varieties. On the other hand, in the second year, the highest crude oil ratio (31.3%) was observed in Asol variety which had no significant difference with Olas, Balci, Gokturk and Linas varieties. In both years of the study, the least crude oil content (18.0-20.4%) was obtained in Ayaz variety. The oil content of the seed is an important index for the safflower plant as well as the seed yield. Crude fat ratio in previous studies (Yılmazlar, 2008; Uysal et al. 2006; More et al. 2005; Sakir & Basalma, 2005) were different (40.1%-48.3%; 21.8%-27.8%; 28.0%-28.9%; 37.1%-50.0%, respectively). Variety, ecological factors and applied cultural processes have a great effect on the safflower oil ratio and can have a positive or negative effect. The reason for the difference in oil ratios even in multi-year studies is due to the variation in climatic conditions over the years.

**Crude Oil Yield**

Variety, year and variety x year interaction had a significant effect on crude oil yield at the level of 1% (Table 6). The average crude oil yield in first and second years were 311.94 and 253.66 kg $ha^{-1}$, respectively. In the first year, the highest crude oil yield (432.94 kg $ha^{-1}$) was obtained in Asol variety, while in the second year (336.62 kg $ha^{-1}$) was obtained in Olas variety. The least crude oil yield (164.11 and 162.30 kg $ha^{-1}$) was also obtained in Ayaz variety in both years. However, there is no difference between the Yenice variety in the first year and the Yenice and Remzibey-05 varieties in the second year. Seed yields and oil ratios of the cultivars are two criteria that directly affect the crude oil yield. The parameters affecting these two criteria such as plant height, number of main and side branches, number of trays, number of seeds in the tray indirectly affect the crude oil yield. In previous studies (Akbari et al. 2019; La bella et al. 2019; Ozturk et al. 2009; Yıldırım et al. 2004) different values for crude oil yield were reported (437-614 kg $ha^{-1}$; 220- 590 kg $ha^{-1}$; 178-748 kg $ha^{-1}$; 456-988 kg $ha^{-1}$, respectively). The reason for the difference between our study results and researcher's findings may be due to the parameters affecting oil yield directly or indirectly, as well as the differences in environmental conditions and cultural practices.

## CONCLUSIONS

Based on results, it was concluded that Asol and Olas varieties had higher yield values among all the studied varieties in irrigated conditions and were determined as suitable varieties for the Van region. Due to increasing oil deficiency in Türkiye as well as the limited cultivation of other oil crops resulted from the insufficient climatic and environmental conditions in Van region, safflower plant is suggessted for cultivation in this region. Also, it is recommended to carry out further and detail studies on effects of different fertilizer types and amounts with these varieties especially in dry conditions.

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