Evaluation of Seed and Oil Yield with Some Yield Components of Safflower Varieties in Kahramanmaras (Turkey) Conditions

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Abstract— *Oilseeds production of Turkey is not available to meet domestic requirements. Turkey has been facing a recurring shortage of vegetable oils for many years. Presently, about 50% of vegetable oil being consumed in Turkey has to be imported. Turkey has a suitable climate for producing of many oilseeds. Safflower (Carthamus tinctorius L.) is a multipurpose crop. Traditionally, the crop was grown for its seeds, and flower petals were used for coloring and flavoring foods. For the last fifty years, the plant has been cultivated mainly for the vegetable oil extracted from its seeds. Thus, there is an urgent need to take immediate actions for increasing oilseed production through growing underutilized and minor oilseeds like safflower. Increased safflower production will reduce the import of oilseeds and help meet our domestic oil requirement. This research was conducted to determine the seed and oil yield with some yield components of safflower (Carthamus tinctorius L.) varieties in Kahramanmaras (Turkey) conditions using a randomized complete block design with four replications in 2015. In the study, Dincer, Balcı, Remzibey, Rio, Nebraska 10, Oleicleed, Quiriego 88, San Jose 89, Sina and Gila cultivars were used as the plant material. These ten safflower varieties were evaluated for plant height, branch number and head number per plant, 1000-seed weight, hull ratio, seed oil content, seed and oil yield. The results showed that plant height, branch number per plant, head number per plant, 1000-seed weight, hull ratio and seed oil content for ten safflower cultivars ranged between 40.15-46.80 cm, 4.58-6.65, 8.23-14.20, 34.85-45.99 g, 36.12-45.51 % and 29.53-35.31 %, respectively. The highest seed yield (992.3 kg ha^{-1}) and the lowest seed yield (826.8 kg ha^{-1}) were obtained from the varieties Balcı and Sina, respectively. Balcı variety had the highest seed yield and gave the highest oil yield.*

Keywords— Safflower, Carthamus tinctorius L., seed yield, oil yield, yield components.

I. INTRODUCTION

Increasing world population leads to an increase in demand for food. This demand also increases the demand for vegetable oil. The basic raw material for the vegetable oil production is oilseeds. According to data in 2014, oilseed plants were cultivated in the 231 million hectares of land and 536 million tons of oilseeds were produced in the world. The same year, world crude vegetable oil production was 176 million tons. Sixty-four percent of the world crude vegetable oil production comes from palm and soybean oil (Ozturk, 2016).

Oilseed crops growing have always been an important subject in Turkey agriculture. Due to rapid population growth and limited amount of oilseeds production in Turkey, vegetable oil need of our country continues to increase. Despite the efforts of the government to increase oilseeds production, Turkey continues to be import dependent due to a net deficit of oilseeds and products. Turkey, in 2014 the realized crude vegetable oil production around 1.5 million tones, but the total crude oil supply in the market has been around 3 million tons. The highest crude oil supply in Turkey is seen in sunflower and palm oil. Approximately 75% of the total supply of crude oil are provided from abroad (crude oil imports directly and domestic crude oil production from imported oilseeds) (Ozturk, 2016). In order to increase our production of vegetable oil, it should be utilize from our different ecological areas that had an agricultural potential determining the crop patterns and the region is necessary to expand the cultivation of other oilseed crops.

In this context, safflower has a potential to meet much of Turkey's oil demand. Safflower (*Carthamus tinctorius* L.) is an important oilseed crops that can be used for many different purposes. Considering the oil consumption of our country, safflower is an important plant can be grown in areas where rainfall is limited, especially. Therefore, in different parts and location of our country it is useful to continue the study on this plant. In this study, seed and oil yield with some yield components of 10 safflower cultivars were investigated in Kahramanmaras conditions.

II. MATERIALS AND METHODS

Ten safflower cultivars (Dincer, Balcı, Remzibey, Rio, Nebraska 10, Oleicleed, Quiriego 88, San Jose 89, Sina and Gila) were used plant material. Seeds of all these varieties were kindly provided by the plant genetic resources service of United States Department of Agriculture (USDA) and the Anatolian Agricultural Research Institute (Eskisehir - Turkey). These ten

safflower varieties were sown at 15 April in 2015 at the Agricultural Research Institute of Kahramanmaras province, Turkey. Kahramanmaras province is located in the East-Mediterranean region of Turkey between 37° 36' north parallel and 46° 56' east meridians. The studies were established on alluvial clay loam with the following mean properties; pH = 7.5, organic matter = 1.7%, N = 0.05%, CaCO3 = 19.8%, available P = 51.5 kg ha^{-1}, and available K = 73 kg ha^{-1}. Based on soil test conducted in test year, nitrogen and phosphorus at the rate of 80 kg N and P_2O_5 ha^{-1} were applied, respectively. Cultural practices, control of insects and weeds and furrow irrigation were given as needed during the growth season according to the local recommendations. All other receded production practices were followed. The trials were conducted using a randomized complete block design with four replications. Each plot consisted of four rows 5 m in length with 50 cm between rows and 20 cm hill spacing. Individual plots were spaced 2.0 m apart. The safflower seeds were sown by putting three seeds to hills by hand. Plants were thinned to one plant per hill 15 days after sowing. Ten randomly tagged plants from each plot were evaluated plant height, branch number and head number per plant, 1000-seed weight, hull ratio, seed oil content, seed and oil yield. Seed yield were obtained from an area 1.0 m wide and 4 m long of the center two rows of each plot. Seed samples were collected from each plots and ground with an electric coffee mill. A small portion of ground seeds (5 g) was transferred to a disposable filter column and seed oil content was determined by the Soxhlet apparatus. Hull ratio was determined following the procedure reported by Urie et al. (1968). In the experiment, safflower cultivars were harvested 5th August by hands. All data were analyzed using the SAS statistical software. Significant differences among mean values were compared by protected least significant difference (Protected LSD, $P < 0.05$).

III. RESULTS AND DISCUSSION

As a result of variance analyses, highly significant cultivar effects were noted on plant height, number of branch per plant, number of head per plant, 1000-seed weight, seed oil content, seed and oil yield (Table 1).

According to varieties (Table 2), significant differences in plant height values were found ($p<0.01$). The comparison of the plant height values of ten safflower varieties shows that Dinçer, San Jose and Quirieqo 88 present the higher plant height values while Balcı presents the lower value. Safflower plant height values of the ten varieties ranged from 40.15 cm (Balcı) to 46.80 cm (Dincer). The observed values plant heights were close to those reported by (Yılmazlar, 2008).

TABLE 1
THE RESULTS OF ANALYSES OF VARIANCE, SHOWING CULTIVAR EFFECTS ON INVESTIGATED CHARACTERISTICS

Source	Df	Plant height	Number of branch per plant	Number of head per plant	1000-seed weight	Hull ratio	Seed oil content	Seed yield	Oil yield
Cultivar	9	23.4**	1.7*	17.3**	51.7**	25.1**	12.9*	83.3**	22.9*
*, P <0.05; **, P<0.01									

TABLE 2
MEAN VALUES OF PLANT HEIGHT, NUMBER OF BRANCH AND HEAD PER PLANT, 1000-SEED WEIGHT FOR THE TEN TESTED CULTIVARS

Cultivars	Plant height (cm)	Number of branch per plant	Number of head per plant	1000-seed weight (g)
Dincer	46.80 a	4.58 b	8.28 bc	39.24 d
Balcı	40.15 b	6.23 ab	10.95 abc	39.59 cd
Remzibey	40.50 b	5.08 ab	11.53 abc	34.85 e
Rio	44.63 ab	5.60 ab	12.73 ab	45.99 a
Nebraska	40.93 b	4.70 b	8.23 c	43.80 ab
Oleicleed	41.95 ab	5.90 ab	11.28 abc	34.92 e
Quirieqo 88	46.15 a	6.65 a	14.20 a	42.92 b
San Jose	46.35 a	5.35 ab	11.75 abc	41.39 bc
Sina	42.25 ab	5.68 ab	14.03 a	41.16 bc
Gila	40.70 b	5.93 ab	13.00 a	42.24 bc
Mean values in the same column without a common letter are significantly different ($P < 0.05$) according to the Least Significant Difference (LSD) multiple range test.				

The cultivar Quirieqo 88 had the highest number of branch per plant while the two cultivars (Dincer and Nebraska) had similar and the lowest. The number of branches per plant is an important characteristic affecting to number of heads per plant

indirectly. In the present study, number of branch per plant of 4.58-6.60 was similar to those obtained previously Baydar and Turgut (1993). The three cultivars Quirieqo 88, Sina and Gila had similar head number per plant (14.20, 14.03 and 13.00, respectively). Previous literature reported head number per plant of 6.7-8.9 (Kirici and Ozguven, 1995), 10.3-19.2 (Ozturk et al., 2000), 2.33-14.60 (Kaya et al., 2004), 6.00-6.41 (Camas et al., 2005) and 9.84-15.98 (Basalma, 2007). Number of head per plant of safflower varieties ranged from 8.23 to 14.20 was similar previous literature mentioned above. Among the cultivars, significant differences in thousand seed weight were observed ($p<0.01$). Cultivar Rio had the highest thousand seed weight while the two cultivars (Remzibey and Oleicleed) had the lowest. In studies related with safflower, different results of thousand seed weight values have been reported by the researchers. Bayraktar (1984), Kaya et al. (2005), Uysal et al. (2006), Tonguc and Erbas (2009), Killi and Ermis (2009) and Ozturk et al. (2008) reported thousand seed weight of 38.2 – 53.8 g, 29.87 – 34.23 g, 28.3 – 38.7 g, 27.0 – 52.0 g, 42.32 – 46.84 g, 40.2 – 44.6 g, respectively.

Significant differences were observed among the cultivars for hull ratio (Table 3). Cultivars Remzibey and Dinçer had higher hull ratio, while Oleicleed had the lowest. In the present study, hull ratio ranged from 36.12-45.51%. Low hull ratio is an important characteristic and it can be affected by factors such as cultivar, growing conditions and plant nutrition (Esendal 1981). Our obtained hull ratio results were close to those reported by (Bayraktar, 1984). There is a strong negative correlation between hull ratio and oil content (Gencer et al., 1987 and Weiss, 1983). The lowest hull ratio (36.12%) and the highest oil content (35.31%) were obtained from Oleicleed cultivar. Besides Dinçer cultivar with high hull ratio had the low oil content. Oil content values of safflower cultivar ranged from 29.53-35.31% were similar to those obtained previously in Turkey (Baydar, 2000; Pasa et al., 2009).

TABLE 3
MEAN VALUES OF HULL RATO, OIL CONTENT, SEED YIELD AND OIL YIELD FOR THE TEN TESTED CULTIVARS

Cultivars	Hull ratio (%)	Oil content (%)	Seed yield (kg ha^{-1})	Oil yield (kg ha^{-1})
Dincer	44.36 ab	29.53 d	916.8 bcd	271.2 cd
Balcı	40.82 c	33.89 abc	992.3 a	336.5 a
Remzibey	45.51 a	31.25 bcd	880.5 cde	275.4 cd
Rio	40.17 c	33.65 abc	864.0 de	291.0 bcd
Nebraska	42.07 bc	30.83 cd	923.5 bc	284.4 cd
Oleicleed	36.12 d	35.31 a	912.3 bcd	322.1 ab
Quirieqo 88	41.86 bc	31.19 bcd	924.5 bc	288.3 bcd
San Jose	40.72 c	34.28 ab	937.5 ab	321.7 ab
Sina	41.49 bc	32.41 abcd	826.8 e	268.0 d
Gila	41.21 bc	32.69 abc	940.0 ab	307.5 abc

Mean values in the same column without a common letter are significantly different ($P < 0.05$) according to the Least Significant Difference (LSD) multiple range test.

The differences for seed and oil yields of safflower cultivars were statistically significant (Table3). Seed and oil yield of Balcı cultivar were significantly higher than those of the other nine cultivars. Seed and oil yields of this variety (992.3 and 336.5 kg ha^{-1} seed and oil yields, respectively) were the highest as compared with the other cultivar under study. Sina cultivar was shown to have the lowest values of seed and oil yield. In the present study, seed yield of 826.8-992.3 kg ha^{-1} and oil yield of 268.0-336.5 kg ha^{-1} were similar to those obtained previously in Turkey (Inan and Kirici, 2001; Tonguc and Erbas, 2009; Okcu et al., 2010; Beyyavas et al., 2011) but lower than those reported by some other authors. Previous literature reported seed yield of 1030 - 1290 kg ha^{-1} (Bayraktar et al., 2005; Cosge and Kaya, 2008) and oil yield of 416-1031 kg ha^{-1} (Koutroubas and Papakosta, 2005; Basalma, 2007; Killi and Ermis, 2009). The high variations in yield values can be due to environmental conditions or to the genetic potential for seed and oil yield of the tested cultivars. Significant differences were found between cultivars for seed yield and seed oil content, as already reported by Camas et al. (2007). High yielding cultivars Balcı, San Jose and Gila were shown to have the high number of head per plant, number of seeds per head, thousand seed weight and seed yield per plant. Arslan (2007) reported that seed yield of safflower plant were directly affected by head diameter, head number per plant and seed number per head. Weiss (2000) reported that three important selection criterias affected on seed yield were number of head per plant, number of seed per head and seed weight.

Significant correlations were found between seed yield and oil yield, reported by Eslam et al. (2010) and Katar (2013). To have a high oil yield of Balcı, San Jose and Oleicleed cultivars were due to have high seed yield and oil content. Similarly, low oil yielding cultivar Sina had the lowest seed yield.

IV. CONCLUSION

In the present study, which was conducted under the conditions of Kahramanmaraş (Turkey) province to determine the performance of 10 safflower cultivars, demonstrated that all investigated characteristics were significantly affected by cultivar. Among the tested cultivars, seed yield of 826.8-992.3 kg ha^{-1} and oil yield of 268.0- 336.5 kg ha^{-1} were changed and the highest seed and oil yield were obtained from cultivar Balcı, but Sina gave the lowest. The results obtained in the study suggest that genotype, environmental factors and cultivation techniques had influence on the variation among cultivars for seed and oil yield. Significant differences were observed between cultivars for oil content, which is considered as a significant criterion. Based on the study, the highest oil content was produced by Oleicleed (35.31%). In conclusion, in this study, which was conducted to demonstrate the performance of 10 safflower cultivars, the cultivar Balcı were shown to have the highest seed and oil yield.

REFERENCES

[1] Arslan, B. (2007). The path analysis of yield and its components in safflower (Carthamus tinctorius L.). Journal of Biological Sciences, 7(4): 668-672.

[2] Basalma, D. (2007). The effects on yield and yield components of different sowing dates and row spacing in safflower cultivar and lines under Ankara conditions. 7th Turkish Field Crops Congress (Jun 25-27, 2007) p. 411, Erzurum (Turkey).

[3] Baydar, H. (2000). The effect of Gibberellic Acid on male sterility, seed yield with oil content and fatty acid syntehsis of safflower. Turkish Journal of Biology 24, 159–168.

[4] Baydar, H. and Turgut, I. (1993). The possibilities of safflower (Carthamus tinctorius L.) growing as a winter sown in Antalya conditions. University of Mediteranean, J. Faculty Agric., 5 (1-2): 75-92.

[5] Bayraktar, N. (1984). The effect of hybridization on yield and some characters of safflower (Carthamus tintorius L.). Natural Science Istitue of Ankara University, Agricultural Faculty, Field Crops Department (PhD Thesis), Ankara (Turkey).

[6] Bayraktar, N., Can, O., Kosar, F.C., Balcı, A. and Uranbey, S. (2005). The potential of oilseed crops production and development in middle Anatolian region. 6th Turkish Safflower Conference, 257-260 p., İstanbul (Turkey).

[7] Beyyavas, V., Haliloglu, H., Copur, O. and Yilmaz, A. (2011). Determination of seed yield and yield components of some safflower (Carthamus tinctorius L.) cultivars, lines and populations under the semi-arid conditions. African J. of Biotechnology, 10 (4): 527-534.

[8] Camas, N., Ayan, A. K. and Cirak, C. (2005). Relationships Between Seed Yield and Some Characters of Safflower (Carthamus tinctorius L.) Cultivars Grown in the Middle Black Sea Conditions. VI. International Safflower Conference. (6- 10 June), 193-198, İstanbul.

[9] Camas, N., Cirak, C. and Esendal, E. (2007). Seed yield, oil content and fatty acids composition of safflower. University of Ondokuz Mayıs. J. Faculty Agric. 22(1): 98-104.

[10] Cosge, B. and Kaya, D. (2008). The performance of some safflower cultivars sown autum and spring. University of Sulayman Demirel, J. Natural Sci., 12 (1): 13-18.

[11] Esendal, E. (1981). The effects on yield and yield componentes of different row spacing, nitrogen and phousphorus applications in safflower (Carthamus tintorius L.). Ankara University Agricultural Faculty, Field Crops Department (Assoc. Professor Thesis), Ankara (Turkey).

[12] Eslam, B. P., Monirifar, H. and Ghassemi, M. T. (2010). Evaluation of late season drought effects on seed and oil yields in spring safflower genotypes. Turkish J. of Agric. Forestry, 34: 373-380.

[13] Gencer, O., Sinan, N.S. and Gulyasar, F. (1987). A research on determination of optimum row space in safflower grown in unirrigated areas under Cukurova conditions. University of Cukurova, J. Faculty Agric. 2(2): 54-68.

[14] Inan, M. and Kirici, S. (2001). The effect on flower yield, dye and agricultural characters of different sowing dates in safflower under Çukurova conditions. 2nd Agricultural Congress in Southestern Anatolian Region, (October 24-26, 2001) Şanlıurfa (Turkey), 841-848.

[15] Kaya, M. D., Ipek A., Uranbey, S. and Kolsarici, O., 2004. The effects of ethephone on yield and yield componentes of safflower. University of Ankara, J. Faculty Agric., 10 (2): 182-186.

[16] Katar, D. (2013). Determination of efficiency of yield components on oil yield per plant in safflower breeding by different statistical methods. Global Journal of Science Frontier Research Agriculture and Veterinary, 13 (8): 11-20.

[17] Killi, F. and Ermis, H. (2009). Effect on seed yield, yield components and the content of macro-micro elements of different nitrogen doses and times in safflower (Carthamus tinctorius L.) under Kahramanmaras conditions. 8th Turkish Field Crops Congress, (October 19-22, 2009), 107-110, Hatay (Turkey).

[18] Kirici, S. and Ozguven, M. (1995). Flower yield and some plant properties of safflower in Çukurova conditions. Workshop, Ege University Agricultural Faculty, Proceeding of Medicinal and Aromatic Plants (May 25-26, 1995): 35-36, İzmir (Turkey).

[19] Koutroubas, S. and Papakosta, D.K. (2005). Adaptation, grain yield and oil content of safflower in Greece. VIth International Safflower Conference, Jun 06-10, 2005, İstanbul (Turkey).

[20] Okcu, M., Tozlu, E., Dizikısa, T., Kumlay, M., Pehluvan, M. and Kaya, C. (2010). Determination of agricultural properties of some safflower cultivars in Erzurum irrigated conditions. The journal of Ataturk University Agricultural Faculty, 41 (1): 1-6.

[21] Ozturk, O., Akinerdem, F. and Gonulal, E. (2000). The effects of sowing dates and plant populations on yield and yield components of safflower. University of Selcuk, J. Faculty Agric., 14 (21): 142-152.

[22] Ozturk, E., Özer, H. and Polat, T. (2008). Growth and yield of safflower genotypes grown under irrigated and non-irrigated conditions in a highland environment. Plant Soil Environ. 54, (10): 453-460.

[23] Ozturk, A. B. (2016). The sector of vegetable oil production. Work Bank of Turkey, Economic Research Department, https://ekonomi.isbank.com.tr/pdf/sr201605.

[24] Pasa, C., Esendal, E. and Arslan, B. (2009). The effect of spring and winter sowing on yield and plant traits of safflower (Carthamus tinctorius L.). 8th Field Crop Congres (19-22 October 2009): 168-171, Hatay (Turkey).

[25] Tonguc, M. and Erbas, S. (2009). Determination of yield and yield components of domestic and foreign safflower (Carthamus tinctorius L.) cultivars. 8th Field Crop Congress (19-22 October 2009): 115-119, Hatay (Turkey).

[26] Urie, A. L., Leinger, L. N. and Zimmer, D. E. (1968). Effects of degree and time of defoliation on yield and attributes of safflower. Crop Sci., 8: 747-450.

[27] Uysal, N., Baydar, H. and Erbas, S. (2006). Determination of agricultural and technological properties of safflower lines developed from Isparta populations. University of Sulayman Demirel, J. Faculty Agric., 1(1): 52-63.

[28] Weiss, E.A. (1983). Safflower: In: Oilseed Crops, Tropical Agriculture Series, Longman Inc., Leonord Hill Books, New York, USA.

[29] Weiss, E.A. (2000). Safflower. In: Oilseed Crops, Blackwell Sci. Ltd., Victoria, Australia.

[30] Yilmazlar, B. (2008). The effect on agricultural characteristics of different sowing dates in safflower under Konya conditions. University of Ankara, Natural Science Institue, Field Crops Department (PhD Thesis), p. 143, Ankara (Turkey).