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EFFECTS OF SOWING DATES ON SOME AGRONOMIC CHARACTERISTICS OF TURKISH SAFFLOWER (*Carthamus tinctorius* (L.) CULTIVARS UNDER DRY-SUMMER SUBTROPICAL (Csa TYPE) CLIMATIC CONDITIONS

Parisa Pourali Kahriz[1,*] and Mahsa Pourali Kahriz[2]

[1]Department of Field Crops, Faculty of Agriculture, Ankara University, 06110, Diskapi, Ankara, Turke; [2]Ardahan Teknik Bilimler Meslek Yüksekokulu, Ardahan Üniversitesi, Halil Efendi Mah. Vahapzade Cad. 9/2, Merkez Ardahan 75100, Türkiye)
***Corresponding author's e-mail: pouraliparisa@gmail.com**

Safflower is a neglected oil seed crop plant that can be used to meet exponential growing vegetable oil deficit in Turkey. The purpose of this study was to establish factors affecting crop yield and yield components of safflower using four cultivars Dincer, Remzibey, Yenice and Balci at dry-summer subtropical climatic conditions (Csa type of climate) of Ankara Turkey during 2012 growing season. The results of the study showed a significant interaction between cultivars and sowing dates for all studied parameters. The maximum 1000 seed weight of 49.46, 45.91 g, 40.47 g and 42.47 g and crude oil yield of 32.31, 30.24 %, 28.21 % and 40.22% the plants was noted on mid sown cv. Dincer, Remzibey, Yenice, and Balci respectively. Both early and late sown plants of all four cultivars had variably reduced yield and oil percentage. It was concluded that it was necessary to optimize cultivation time of cultivars under dry-summer subtropical (Csa type) climatic conditions of Central Anatolia to reap maximum yield.
Keywords: *Carthamus tinctorius* L. *sowing dates.* 1000 seed weight, Oil yield.

INTRODUCTION

Safflower (*Carthamus tinctorius* L.) is an important but neglected annual oilseed plant with oil content in range of 30-50%. It is also known as pseudo saffron or dyers saffron in Turkey. It is highly drought resistant with yellow, red or orange, colored flowers, with or without thistles (Coşge *et al.* 2007, Beyyavas *et al*. 2011, Gürsoy *et al.* 2016). It has multiple uses (Katar *et al* 2014). Safflower oil i is highly rich in unsaturated fatty acids (78% linoleic acid) and Vitamin E (Arslan *et al*. 2003) and is used in many countries of the world as edible oil, as salad dressing and birdseed (Corleto *et al.* 1997). It is used for production of soap, paint, varnish and polish (Kirici, 1998). It is widely used in cosmetics and pharmaceutical industries for extraction of medicinally important alkaloids. The plant has high potential in ornamental plant industry both as cut and dry flowers (Dajue and Mündel, 1996). Safflower tea is used in Afghanistan to prevent infertility and miscarriages by women (Weiss, 1983). The safflower plant is grown both as summer and winter crop in Turkey (Bayraktar 1995), especially in semi-arid regions of Central Anatolia, where soil depth and soil fertility are low. Safflower, is less selective in terms of climate and soil requirements compared to other oilseed plant species (Kaya *et al.* 2015). It has high potential to grow as an alternative to other oilseed plants like sunflower in Turkey (Coşge *et al*. 2007).

Number of days to flower, Number of leaves per plant, Number of seed heads or capitula per plant, Plant length (cm) are important agronomic characteristics (Karaca and Aytac 2007, Baydar, H., 2000a, b) that effect thousand seed weight and crude oil percentage.

This study aimed to compare the effects of three sowing dates on yield potential of 4 safflower cultivars under dry-Summer Subtropical ecological conditions (Köppen-Geiger classification: Csa) of Ankara, Turkey.

MATERIALS AND METHODS

The study made use of 4 safflower cultivars, Dinçer, Remzibey, and Yenice and Balci. The study was conducted at the Experimental Fields of the Department of Field Crops, Ankara University during 2012.

Charachterisitics of safflower cultivars used in the study

***Cv. Dinçer*:** It is thistled cultivar that was bred by Eskişehir Agricultural Research Institute and was registered in 1977. Leaf and flower table texture is uneven, flower crown color is orange, seed color white, 90-100 cm plant tall, yield of 150-250 kg/da, 1000 seed weight of 46-50 g, with oil yield of 30-32% (Anonymous 2017a)

***Cv. Remzibey-05*:** It is thistled cultivar that was bred by the Eskişehir Agricultural Research Institute and was registered in 2005. The leaf and flower table texture is thorny, flower crown color is yellow, seed color is white, thistled, 60-80 cm

plant length, yield of 100-200 kg/da, Yield. 1000 seed weight 46-50 g, with oil yield of 32-35%. (Anonymous 2017a).

***Cv. Yenice*:** (5-38It is thistleless cultivar that was bred by Eskişehir Agricultural Research Institute. It was registered in 1931. Leaf and flower table texture is uneven, flower crown color is red, seed color white, plant height 100-120 cm, seed yield of 80-180 kg/da, 1000 seed weight 38-40 g, with oil percentage of oil percentage 26-28%. (Anonymous 2017a).

***Thistled cultivar Balci*:** was developed by Eskişehir Agricultural Research Institute during 2011 and has yellow colored flowers, seed color cream white and plant height varies between 70-100 cm. It has 1000 grain weight in range of 40-48 g, has oil yield percentage of 38 - 41%. These characteristics make it preferable to compared to other safflower cultivars in Turkey (Anonymous, 2017a).

Total, average, maximum and minimum precipitation during the period was of 103.1 mm, 20.62 mm, 1.2 mm and 65.1 mm respectively. Minimum precipitation was noted during June and the maximum precipitation was noted during May (Table 1). Average, maximum and minimum temperature remained 14.7 and 26.6 C respectively. Minimum temperature was noted during April and the maximum temperature was noted during July. Average, maximum and minimum relative humidity remained 37.4 and 60.1 respectively. Minimum relative was noted during July and the maximum relative humidity was noted was noted during May.

Table 1: Meteorological observations of the experimental area from April - August 2012

Months	Precipitation (mm)	Temperature (°C)	Relative humidity (%)
April	24.8	14.7	51.9
May	65.1	17.2	60.1
June	1.2	23.7	41.8
July	4.6	26.6	37.4
August	7.4	23.7	40.3
Average	20.62	21.18	46.3
Total	103.10	-	-

Source: Directorate General of State Meteorological organization, Ankara, Turkey

Soil specimens were taken at the depth of 0-30 cm depth before planting. The soil analysis was performed at the Department of Soil Science and Plant nutrition of the Ankara University, Turkey as described by Page *et al.* (1986) and Bouyoucos (1951). The report showed that, the soil texture of Ankara location was of clay loam with pH of 7.37, electrical conductivity of 1217 dS/m, total nitrogen of 0.145%, extractable phosphorus content of 5.52 mg/kg, the extractable potassium content of 192 mg/kg and organic matter of 1.05%. The study was conducted in three replications using the two factorial randomized complete block design. The dates were placed in the main plots, and the 4 cultivars were placed in the

Table 2: Effects of sowing dates on various agronomic characteristics of safflower cultivars Dincer, Remzibey, Yenice and Balci under Dry-Summer Subtropical (Csa type) climatic conditions during 2012 sowing season.

Cultivars	Number of days to flower			Number of leaves per plant		
	Early sowing	Mid sowing	Late sowing	Early sowing	Mid sowing	Late sowing
Dincer	81,96bA	79,08aB	71,48aC	127,22bC	302,33cA	254,33aB
Remzibey	84,05aA	79,88aB	72,97aC	122,33cC	306,77cA	235,77bB
Yenice	82,60bA	79,58aB	73,96aC	144,11aC	386,44bA	254,33aB
Balci	82,92bA	76,09bB	72,09aB	103,33dC	406,11aA	257,55aB
Cultivars	**Number of seed heads or capitula per plant**			**Plant length (cm)**		
	Early sowing	**Mid sowing**	**Late sowing**	**Early sowing****	**Mid sowing**	**Late sowing**
Dincer	22,11aC	33,88aA	29,33aB	99,55bA	96,77bA	91,00bB
Remzibey	14,77cC	22,77dA	19,22cB	83,55cA	76,33cB	77,44cB
Yenice	18,33bC	28,56bA	27,88bB	108,77aB	118,00aA	95,33aC
Balci	13,33cC	30,56cA	30,33aB	76,55dA	74,55cA	73,00dA
Cultivars	**Thousand seed weight**			**Crude oil percentage (%)**		
	Early sowing	**Mid sowing**	**Late sowing**	**Early sowing**	**Mid sowing**	**Late sowing**
Dincer	44.72aA	49.46aA	45.30aA	30.33bA	32.31bA	31.22bA
Remzibey	41.66bB	45.91bA	36.74cC	29.02bA	30.24bA	31.73bA
Yenice	32.24cC	40.47cA	35.87cC	26.24bA	28.21cA	28.91cA
Balci	40.24aA	42.47cA	43.87bA	38.37aB	40.22aA	39.43aA

All values given in columns separated by different small letters are significantly different using Duncans Multiple Range test at 0.01 level of significance. All values given in rows separated by different capital letters are significantly different using Duncans Multiple Range test at 0.01 level of significance.

sub plots. Each plot was made up of 4 rows that had 5 meter length with row to row distance of 35 cm. Five seeds each were planted at a distance of 30 cm at all dates. The sprouting seeds were thinned to one seedling at 4 leaf stage. The experiment was sown on 27 April 2012, (early sowing), 12 May 2012 (Mid sowing), and 27 May 2012 (late sowing). Half of the nitrogenous fertilizer (Triple super phosphate and ammonium sulphate) was applied before sowing that was adjusted in such a way as to contain ammonium sulphate (in the form of 60 kg/ha pure N) and TSP (Triple Super Phosphate in the form of 60 kg/ha pure P). The other half of the fertilizer was applied at the beginning of inflorescence during first week of July, after manual hoeing of the experimental fields.

Analysis of variance were performed based on the data obtained from 10 plants per cultivar at each planting time excluding plants sown in border rows by using the SPSS 24 computer software/package. The significance levels of the differences in applications were assessed by employing the Duncan's multiple range test.

RESULTS

***Number of days to flower*:** Significant (p<0.01) differences were noted in number of days to flower on the 3 cultivars used in the study (Table 2). However, All cultivars had non-significant differences in the days to flower with range of 81.96-84.05 d, 76.09- 79-88 days and 71.48 -73.96 days on the plants that were early, mid or late sown respectively. Days to flower reduced with each sowing date. All cultivars took maximum days to flower on early followed by mid and late sowing dates in the descending order.

***Number of leaves per plant*:** Significant differences were noted on number of leaves per plant on each cultivar and their sowing dates (Table 2). Number of leaves per cultivar among four cultivars used in the study ranged 103.33- 144.11, 302.33-406.11, 235.77 -257.55 on first (early), 2nd (mid) and 3rd (late) sowing dates respectively. Regardless of cultivar used in the study, The results show that mid sowing is better compared to early and late sowings; where maximum number of leaves were noted on all cultivars used in the study.

***Number of seed heads or capitula per plant*:** Significant differences were noted on number of seed heads or capitula per plant on each cultivar and their sowing dates (Table 2). Number of seed heads or capitula per cultivar among four cultivars used in the study ranged 13.33-22.11, 22.77- 33.88 and 19.22 -30.33 on early, mid and late sowing dates respectively. Regardless of cultivar used in the study, the results showed that mid sowing was the best choice for all cultivars. No statistical difference was noted in mid and late sowings for cv. Balci. However, other three cultivars showed comparatively low number of seed heads or capitula on late sown plants.

***Plant length* (cm):** Plant length per cultivar used in the study ranged 76.55-108.77, 74.55- 118.00 and 73.00 -95.33 on early, mid and late sowing dates respectively (Table 2). Regardless of cultivar used in the study, the results showed that the cultivars induced maximum length on early sowing. Cultivar Dincer, Balci showed no statistical differences among three sowing dates. A significant reduction in plant height was noted on cv Remzibey and Yenice, on late sowing compared to early and mid sowing.

***Thousand seed weight*:** Thousand seed weight per cultivar used in the study ranged 32.24-44.72, 40.47 - 49.46 and 35.87 -45.30 on early, mid and late sowing dates respectively (Table 2). Regardless of cultivar used in the study, the results showed that early sown cultivars Dincer, Remzibey and Yenice induced maximum 1000 seed weight on mid sowing followed by late and early sowing in order. Cultivar Balci showed no statistical differences among three sowing dates. Maximum seed weight was noted on cv. Dincer irrespective of the sowing dares. A significant reduction in 1000 seed weight was noted on all cultivars on plants obtained from early sowing. The results confirm that safflower is sensitive to planting dates and the 1000 seed weight of safflower varieties in grams differed when the sowing was done on different dates.

***Crude Oil percentage*:** Crude oil percentage per cultivar used in the study ranged 26.24-38.37%, 28.21-40.22% and 31.22-39.43% on early, mid and late sowing dates respectively (Table 2). Regardless of cultivar used in the study, the results showed that early sown cultivars Dincer, Remzibey and Yenice induced maximum crude oil percentage on mid sowing followed by plants of late and early sowing respectively. Cultivar Balci showed no statistical differences among three sowing dates. Maximum crude oil percentage was noted on cv. Balci irrespective of the sowing dates. A significant reduction in crude oil percentage was noted on all cultivars on plants obtained from early sowings.

DISCUSSION

There is need to grow multi date trials in an area to know the best sowing dates to achieve yields. The fruitful safflower cultivation in an area is largely affected by seed and oil yield (Abdolrahmani, 2005 and Kaffka, 2002; Malleshappa *et al*. 2003; Abdolrahmani, 2005). Present study confirms all yield characteristics were affected by sowing dates. Early sowing date was not desired since the plants remained in the field for longer periods of time that affected their vegetative growth positively but had negative impact on other yield characteristics. Mid sowing seemed optimum and had the best results on all growth parameters in terms of seed yield and crude seed oil percentage in confirmation to previous studies by Poordad, 2003, and Ozturk *et al.*, 2008. The seed oil yield reported in this study suggests that this characteristics is affected both by sowing dates and genotypes. Seed oil

contents of 18.24-25.31 % is lower compared to 23.9-40.3% as reported by Ghamarnia and Sepehri (2010) and Arslan and Kucuk (2005), Camas et al. (2007). This variations in results under score the importance of selection of high yielding cultivars and show that the locations may have effect on the oil yield of safflower. Therefore, there is need to establish multilocation and different sowing date under dry-summer subtropical environmental conditions at Ankara.

Likewise significant variations were noted among cultivars for number of seed heads or capitula per plant, plant thousand seed weight as reported by Ghamarnia and Sepehri (2010).

It is well known that being neglected crop, safflower has not been properly bred and genetically improved for the traits like number of days to flower, Number of leaves per plant, number of seed heads or capitula per plant, plant length (cm), thousand seed weight and plant length.

Higher precipitation (65.1%), longer period of moderate temperature of 17.2 °C and relative humidity of 60.1% contributed positively to all growth parameters during mid sowing. Whereas, prolonged period of precipitation, temperature and relative humidity during early growth period acted negatively to these growth parameters. The results are in agreement with Nabipour *et al*. (2007), Istanbulluoglu (2009) and Ghamarnia and Sepehri (2010); with similar observations. This suggest the importance of precipitation, temperature and relative humidity for spring safflower cultivation. Present study shows that prolonged changes in these parameters had negative impact on yield depending on soil moisture regime, showing that if the plants faced long drought or moisture they behave accordingly in agreement with Jabbari *et al*. (2010), Sharrifmoghaddasi and Omidi (2010), Nabipour *et al.* (2007), Movahhedy-Dehnavy *et al.* (2009), Kaffka and Kearney, (1998). The thousand seed weight is an important plant characteristic (Charjan and Tarar, 1992). These results emphasize importance of identifying optimum sowing dates for safflower cultivars (Ozturk *et al.* 2008) and for reaping maximum seed and oil yield (Ghanavati and Knowles, 1977).

***Conclusion*:** This is an important study that provides a better understanding of the effects of sowing dates on yield and yield components of safflower cultivars that might help in efficient management of crop for higher yield. However, more studies are needed to better understand mechanism of seed and oil yield production in safflower.

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