Effect of winter and spring sowing on yield and plant traits of safflower (*Carthamus tinctorius* L.)

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Abstract
The aim of the study was to determine effect of winter and spring sowing on yield and plant traits of safflower (*Carthamus tinctorius* L.) cultivars under Tekirdağ conditions. This research was conducted at Applying Research Field, Faculty of Agriculture University of Namık Kemal in 2006-2007. Fourteen safflower cultivars were used in this study. The research was conducted using a randomized complete block, split plot design with three replicates.

Different sowing time significantly affected some agronomic characters of the genotypes used in this study. There was interaction between genotypes and sowing times. According to the results of this research; Yenice has showed the tallest values in winter sowing 207.5 cm for plant height, Montola 2000 has showed the smallest values in spring sowing 55.2 cm for plant height. GW 9003 has showed the highest values in spring sowing 45.4 gr for 1000 seed weight; Kazakhstan Population has showed the lowest values in spring values 36.7 gr for 1000 seed weight. Dinçer has showed the hightest values in winter sowing 357.0 kg/da for yield, Yenice has showed the lowest values in spring sowing 104.6 kg/da for yield. Dinçer has showed the highest values in winter sowing 103.8 kg/da for oil yield, Yenice has showed the lowest values in spring sowing 26.5 kg/da for oil yield. Montola 2000 has showed the highest values in winter sowing 36.9 % for oil ratio of gain; Yenice has showed the lowest values in spring sowing 25.3 % for oil ratio. According to the results of the study it was found that winter sown safflower varieties that annual precipitation is suitable.

Key words: Safflower - seed yield - thousand seed weight - oil content - sowing time

Introduction

Safflower is one of humanity's oldest crops, but has remained a minor crop with world seed production of around 717.778 t per year. More than 60 countries grow safflower, but over half the production takes place in Mexico. Safflower has been grown for centuries, primarily for its colorful petals to use as a food coloring and flavoring agent, for vegetable oil and also for preparing textile dye in the Far East, Central and North Asia, America, North Africa, Europe and Caucasia (Esendal, 2001). While the safflower oil is used mainly as cooking fat in the developing world, a significant proportion is processed into products such as industrial oil, colorless varnishes and paints in the developed world (Salunhke et al., 1992).

Safflower oil is obtained from the seeds of the plant *Carthamus tinctorius* L. of the Compositae family. In old varieties of the seeds of this plant there is approximately 25-37 %; however, in new varieties, which have reduced shell content and increased kernel and oil ratio, this proportion is approximately as high as 46-47 % (Nagaraj, 1993).

Among more than 200 safflower varieties existing globally, variations can be seen in protein content from 16.7 % to 37.6 %, in oil ratio from 38.3 % to 70 % (Rojas et al., 1993).

Safflower is, in the first place, very resistant to drought, cold and saltiness in dry agricultural areas. Moreover, it is conveniently cultivated in various regional conditions since it is less selective in climatic and soil demands compared to other plants (Er et al., 1999).

Safflower, which has various usage areas and certain characteristics superior to other oil plants, may play a significant role to close the vegetable oil shortage if it is given due importance. The most

important cause why safflower cultivation is not progressing is that the existing varieties have low yields. Currently, safflower plants are grown without irrigation since it is known to be resistant to drought and the yield is realized to be below 100 kg/da. In order to spread safflower sowing areas and to increase production, firstly high quality seed plants with high yield must be identified (Şakir and Başalma, 2005).

The objective of this research is to investigate the effects of winter and spring sowing on yield and on plant traits of safflower varieties and lines under Tekirdağ conditions.

Material and Methods

This research was conducted at Applying Research Field, Faculty of Agriculture University of Namik Kemal in 2006-2007. The place where the trial was established reflected the typical characteristics of the climatic conditions of Tekirdag. 2006-2007 years average temperature and relative humidity being closer to the data for a long past.

The soil of the trial area was caly and loam, pH value 8.4, organic matter was 1.3 %, clay was 34.9 %, sand was 43.8 % and silt was 21.3 %.

In this research, one of the safflower line (PI 306924) and thirteen safflower varieties (Dinçer, Yenice, Remzibey, Syrian, Montola 2000, Centennial, Kazakhstan Population, Finch, GW 9003, GW 9005, GW 9023, GW 9305 and Gifford) were used material.

The experiment was carried out using a randomized complete block, split plot design with three replicates. Sowing date on September 20 (autumn) 2006, on March 16 (spring) 2007. In the sowing, the row width 35 cm. Intra-row spacing was stabilized as 10 cm by thinning. All treatments were fertilized with 10 kg nitrogen and 10 kg phosphorus per decare. Weed control was obtained by mechanical rotary tillage in the inter-row and by manual weeding in the row. Sowing was performed on nonirrigated.

For the oil analysis, three replicated samples were separated and their crude oil analysis was done in NMR. Statistical analysis was subjected to Analysis of Varience using MSTAT software program. The DUNCAN test was applied to the results using the same program.

Results and Discussion

Plant height

The significant effects of cultivars, sowing time and cultivar x sowing time ($P < 0.01$) were observed on plant height. The differences between the means were compared by Duncan's multiple range tests and are shown in Table 1.

The results (Table 1) show that the maximum plant height of 207.5 cm was observed in cultivars. Yenice from the winter sowing and spring sowing crop.

Considering cultivars, the maximum plant height of 148.6 cm was observed in cultivars Yenice with minimum plant height of 93.7 cm in cultivars Montola 2000. Considering cropping season, the maximum and minimum plant height 150.6 cm and 67.7 cm was recorded from winter sowing to spring sowing. The results clearly show that the winter sowing compared to spring sowing had more positive effects on plant height.

Abo-Hegazi ve Shabaly (1992) found that plant height value varied from 89.0-169.0 cm respectively. These results also support our findings.

Ekiz ve Bayraktar (1986), Esendal (1990), Bayraktar (1991), Günel et al. (1994), Sergek (2001) found that plant height value varied from 69.6-77.6 cm; 64.4-104.7 cm; 105.0-112.5 cm; 41.5-47.4 cm; 73.9-107.6 cm respectively. This result also does not support our findings.

A deviation in the plant height values is observed; this might be due to different sowing dates, the tall vegetable period in winter sowing, cultivars and ecologic conditions under which the experiments were carried out.

Thousand seed weight
The significant effects of cultivars, sowing time and cultivar x sowing time (P <0.01) were observed on thousand seed weight. The differences between the means were compared by Duncan's multiple range tests and are shown in Table 2.

The Table 2 shows that minimum thousand seed weight 36.7 g. was observed in cultivars Kazakhstan Population (spring sowing). The highest thousand seed weight of 45.4 g. was obtained in cultivars GW 9003 (spring sowing).

On the basis of cultivars the highest thousand weight value was 44.4 g. from cultivars Dinçer and the minimum thousand seed weight value was 37.5 g. from cultivars Montola 2000. Analysis on the basis of sowing times shows that the highest thousand seed weight value was 41.9 g. (spring sowing), and the minimum thousand seed weight value was 40.2 g. (winter sowing).

Mundel et al. (1985) Ekiz ve Bayraktar (1986), Esendal (1990), Bayraktar (1991) found that thousand seed weight value varied from 36.7 g.; 31.5-36.7 g.; 43.7 g.; 36.4-49.9 g. respectively. Thousand seed weight value ranged between 36.7-45.4 g. in this study. A deviation in the thousand seed weight values is observed; this might be due to different sowing dates, cultivars and ecologic conditions under which the experiments were carried out.

Table 1. A comparison of the effects of sowing time on plant height (cm) Duncan's Multiple Range Test*

	Sowing time					
Varieties	Winter		Spring		Means	
Gifford	137.1	h	72.9	k	105.0	ef
GW 9023	144.3	ef	62.6	o	103.4	fg
PI 306924	153.4	bc	72.3	kl	112.8	b
Yenice	**207.5**	**a**	**89.8**	**j**	**148.6**	**a**
Kazak Pop.	138.5	h	69.8	m	104.2	ef
GW 9305	153.1	bc	69.5	m	111.3	b
Centennial	150.7	d	63.5	no	107.1	cd
Montola 2000	**132.2**	**ı**	**55.2**	**r**	**93.7**	**h**
Dinçer	152.3	cd	65.0	n	109.7	c
Syrian	143.0	fg	60.2	p	101.6	g
GW 9005	142.0	g	68.9	m	105.4	de
Remzibey	153.9	bc	57.2	q	105.5	de
GW 9003	145.4	e	69.4	m	107.4	cd
Finch	154.9	b	70.8	lm	112.9	b
Mean	**150.6**	**a**	**67.7**	**b**		

* P <0.01; LSD: 1.9; Sx: 0.5; CV: 19.2

Table 2. A comparison of the effects of sowing time on thousand seed weight (g) Duncan's Multiple Range Test*

	Sowing time					
Varieties	Winter		Spring		Means	
Gifford	38.2	ıj	43.1	cde	40.6	de
GW 9023	41.2	fgh	40.1	h	40.7	de
PI 306924	40.7	fgh	44.8	ab	42.7	abc
Yenice	38.0	j	40.9	fgh	39.4	ef
Kazak Pop.	40.9	fgh	**36.7**	**j**	38.8	fg
GW 9305	39.9	h	42.2	def	41.1	cd
Centennial	41.8	efg	42.2	def	42.0	bcd
Montola 2000	**37.4**	**j**	37.7	j	**37.5**	**g**
Dinçer	**44.6**	**abc**	44.2	abc	**44.4**	**a**

Syrian	41.3	fgh	39.9	h	40.6	de
GW 9005	40.2	gh	42.2	def	41.2	cd
Remzibey	37.7	j	43.5	bcd	40.6	de
GW 9003	41.0	fgh	**45.4**	**a**	43.2	ab
Finch	39.6	hı	44.2	abc	41.9	bcd
Mean	**40.2**	**b**	**41.9**	**a**		

* P <0.01; LSD:1.6; Sx: 0.4; CV: 6.0

Seed yield per Decare

The significant effects of cultivars, sowing time and cultivar x sowing time (P <0.01) were observed on seed yield per decare. The differences between the means were compared by Duncan's multiple range tests and are shown in Table 3.

The Table 3 shows that minimum seed yield 104.6 kg/da was observed in cultivars Yenice (spring sowing). The highest seed yield of 357.0 kg/da was obtained in cultivars Dinçer (winter sowing).

Considering cultivars, the maximum seed yield of 251.2 kg/da was observed in cultivars Dinçer with minimum seed yield of 128.3 kg/da in cultivars Yenice. Considering cropping season, the maximum and minimum plant height 229.3 kg/da and 139.0 kg/da was recorded from winter sowing to spring sowing. The results clearly show that the winter sowing compared to spring sowing had more positive effects on seed yield.

Ghanavati ve Knowles (1977) report that for the summer type safflower variety "Arak-2811", the seed yield is 116.6 kg/da; this results also does not support our findings.

A deviation in the seed yeld per decare values is observed; this might be due to different sowing dates, cultivars and ecologic conditions under which the experiments were carried out.

Table 3. A comparison of the effects of sowing time on seed yield (kg/da) Duncan's Multiple Range Test*

	Sowing time					
Varieties	Winter		Spring		Means	
Gifford	173.6	fg	111.2	n	142.4	f
GW 9023	205.2	e	147.8	ı-l	176.5	d
PI 306924	324.4	b	136.3	lm	230.4	ab
Yenice	**152.1**	**ıjk**	**104.6**	**n**	**128.3**	**g**
Kazak Pop.	270.0	c	157.8	hı	213.9	bc
GW 9305	217.1	de	142.6	jkl	179.9	d
Centennial	207.9	e	156.5	hıj	182.2	d
Montola 2000	168.6	gh	128.5	m	148.5	f
Dinçer	**357.0**	**a**	145.6	ı-l	**251.2**	**a**
Syrian	209.9	e	145.7	ı-l	177.8	d
GW 9005	210.6	e	111.8	n	161.2	e
Remzibey	224.7	d	137.6	lm	181.1	d
GW 9003	271.3	c	138.6	klm	205.0	c
Finch	217.7	de	**182.1**	**f**	199.9	c
Mean	**229.3**	**a**	**139.0**	**b**		

* P <0.01; LSD: 9.1; Sx:2.4; CV: 13.7

Oil content

The minimum oil content 25.3 % was obtained from cultivars Yenice (spring sowing). On the other hand, the highest oil content 36.9 % was obtained from cultivars Montola 2000 (winter sowing).

The significant effects of cultivars, sowing time and cultivar x sowing time (P <0.01) were observed on oil content. The differences between the means were compared by Duncan's multiple range tests and are shown in Table 4.

On the basis of cultivars the highest oil ratio value was % 35.9 from cultivars Montola 2000 and the minimum oil content value was % 26.9 from cultivars Yenice. Analysis on the basis of sowing times shows that the highest oil content value was % 32.4 (winter sowing), and the minimum oil content value was % 29.5 (spring sowing).

Mundel et al. (1985), Ekiz ve Bayraktar (1986), Günel and Arslan (1997); Ahmadi ve Omidi (1997), Bayrak (1997), Corleto et al. (2001) found that oil content value varied from 25.6-35.2 %; 28.9-35.7%; 29.0-30.2 % (spring sowing) 30.8 % and 32.3 % respectively. These results also support our findings.

Cosentino et al. (1997) 33.4-43.4 %; Uslu et al. (1997) 38.3 % (winter sowing), 35.9 % (spring sowing) found that oil content value varied from respectively. This result also does not support our findings.

Oil yield per decare

The significant effects of cultivars, sowing time and cultivar x sowing time (P <0.01) were observed on oil yield per decare. The differences between the means were compared by Duncan's multiple range tests and are shown in Table 5.

The minimum oil yield 26.3 kg/da was obtained from cultivars Yenice (spring sowing). On the other hand, the highest oil yield 103.8 kg/da was obtained from cultivars Dinçer (winter sowing).

On the basis of cultivars the highest oil yield value was 74.1 kg/da from cultivars Dinçer and the minimum oil yield value was 34.9 kg/da from cultivars Yenice. Analysis on the basis of sowing times shows that the highest oil yield value was 73.9 kg/da (winter sowing), and the minimum oil yield value was 41.2 kg/da (spring sowing).

Günel et al. (1997), Corleto et al. (2001) found that plant height value varied from 39.8-49.5 kg/da (spring sowing); 47.0-86.3 kg/da respectively. These results also support our findings.

A deviation in the oil yield per decare values is observed; this might be due to different sowing dates, oil ratio, seed yield per decare, cultivars and ecologic conditions under which the experiments were carried out.

Table 4. A comparison of the effects of sowing time on oil content (%) Duncan's Multiple Range Test*

	Sowing time					
Varieties	Winter		Spring		Means	
Gifford	31.3	de	28.5	hı	29.9	gh
GW 9023	34.7	b	28.9	ghı	31.8	cd
PI 306924	31.3	de	28.4	hıj	29.8	h
Yenice	**28.5**	**hı**	**25.3**	**k**	**26.9**	**ı**
Kazak Pop.	31.1	de	33.3	c	32.2	bc
GW 9305	33.6	c	28.8	ghı	31.2	cde
Centennial	35.1	b	29.2	gh	32.2	c
Montola 2000	**36.9**	**a**	**34.9**	**b**	**35.9**	**a**
Dinçer	29.1	ghı	30.5	ef	29.8	h
Syrian	31.7	d	29.7	fg	30.7	efg
GW 9005	33.4	c	28.8	ghı	31.1	def
Remzibey	30.7	e	28.2	ıj	29.5	h
GW 9003	32.9	c	27.5	j	30.2	fgh
Finch	33.4	c	30.8	de	32.1	cd
Mean	**32.4**	**a**	**29.5**	**b**		

* P <0.01; LSD: 0.9; Sx: 0.2; CV: 8.8

Table 5. A comparison of the effects of sowing time on oil yield (kg/da) Duncan's Multiple Range Test*

	Sowing time					
Varieties	Winter		Spring		Means	
Gifford	54.5	g	31.7	k	43.1	h

GW 9023	71.2	de	42.8	hıj	57.0	ef
PI 306924	101.4	a	38.6	ıj	70.0	ab
Yenice	**43.3**	**hı**	**26.5**	**ı**	**34.9**	**ı**
Kazak Pop.	84.0	c	**52.6**	**g**	68.3	bc
GW 9305	73.0	d	41.4	hıj	57.2	ef
Centennial	73.0	d	45.8	h	59.4	de
Montola 2000	62.3	f	44.9	h	53.6	fg
Dinçer	**103.8**	**a**	44.4	h	**74.1**	**a**
Syrian	66.7	ef	43.3	hı	55.0	efg
GW 9005	70.3	de	32.2	k	51.3	g
Remzibey	69.0	de	38.8	ıj	54.0	fg
GW 9003	89.2	b	38.1	j	63.7	cd
Finch	72.7	d	56.1	g	64.4	cd
Mean	**73.9**	**a**	**41.2**	**b**		

* P <0.01; LSD: 4.7; Sx: 1.2; CV: 14.9

Conclusion

In the light of such data obtained, it can be concluded that the most suitable sowing time for safflower cultivation under Tekirdag conditions winter sowing gave better results than other spring sowing for examinated traits in Dinçer safflower variety. According to the results of the study it was found that winter sown safflower varieties that annual precipitation is suitable.

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