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Performance of some Safflower (*Carthamus tinctorius* L.) Varieties Sown in Late-autumn and Late-spring

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Abstract : This study was conducted to evaluate the effects of late-spring and late-autumn sowing times on oil content, seed yield and some yield components of three safflower (*Carthamus tinctorius* L.) varieties at Field Crops Department, Agricultural Faculty of Ankara University. Yenice, Dinçer and Remzibey-05 safflower varieties were sown on 19 November 2004 and 20 May 2005. According to results of this research; plant height 111.47 and 59.93 cm, capitula number per plant 15.57 and 8.58, secondary branch number per plant 6.26 and 5.07, seed number per capitula 30.18 and 28.67, a thousand seed weight 35.62 and 38.24 g, seed yield 200.74 and 112.30 kg/da, harvest index 30.09 and 30.46 %, oil content 26.75 and 22.14 % and oil yield 53.87 kg/da and 23.03 kg/da were recorded in late-autumn and late-spring sowing, respectively. The highest seed yield and, oil content and yield were obtained from cv. Dinçer and cv. Dinçer and cv. Remzibey-05, respectively. The effect of late-autumn sowing on plant height, capitula number, secondary branch number, seed yield, oil content and oil yield were positive and significant statistically. The increasing ratio of these characters in late-autumn sowing according to late-spring sowing was 86.14%, 81.38%, 5.68%, 80.00% , 21.03% and 119.10%, respectively.

Key Words: Safflower, *Carthamus tinctorius* L., late sowing, yield, oil content.

Geç-Güzlük ve Geç-Yazlık Ekilen Bazı Aspir Çeşitlerinin (*Carthamus tinctorius* L.) Performansı

Özet: Bu çalışma, üç aspir (*Carthamus tinctorius* L.) çeşidinin yağ içeriği, tohum verimi ve bazı verim öğeleri üzerine geç-güzlük ve geç-yazlık ekim zamanlarının etkilerini değerlendirmek amacıyla Ankara Üniversitesi, Ziraat Fakültesi, Tarla Bitkileri Bölümü'nde yürütülmüştür. Yenice, Dinçer ve Remzibey-05 aspir çeşitleri 19 Kasım 2004 ve 20 Mayıs 2005 tarihlerinde ekilmiştir. Araştırma sonuçlarına göre; geç-güzlük ve geç-yazlık ekimlerde sırasıyla, bitki boyu 111.47 cm, 59.93 cm; bitkide tabla sayısı 15.57,8.58; bitkide yan dal sayısı 6.26, 5.07; tablada tohum sayısı 30.18, 28.67; 1000 tohum ağırlığı 35.62 g, 38.24 g; tohum verimi 200.74 kg/da, 112.30 kg/da, hasat indeksi %30.09, %30.46; yağ içeriği %26.75, %22.14 ve yağ verimi 53.87 kg/da, 23.03 kg/da olarak kaydedilmiştir. En yüksek tohum verimi Dinçer çeşidinden, en yüksek yağ oranı ve verimi ise Dinçer ve Remzibey-05 çeşitlerinden alınmıştır. Bitki boyu, tabla sayısı, yan dal sayısı, tohum verimi, yağ içeriği ve yağ verimi üzerine geç-güzlük ekimin etkisi olumlu ve istatistiki olarak önemli bulunmuştur. Bu söz konusu karakterlerin geç-yazlık ekime göre geç-güzlük ekimdeki artış oranları sırasıyla %86.14, %81.38, %5.68, %80.00, %21.03 ve %119.10 olmuştur.

Anahtar Kelimeler: Aspir, *Carthamus tinctorius* L., geç ekim, verim, yağ içeriği.

Introduction

Safflower (*Carthamus tinctorius* L.,) (Asteraceae) is an annual oilseed crop and its seed oil contents are between 20 to 40%. Safflower has been grown commercially for its edible oil and natural dye sources in the world (Işığıgür et al., 1995; Gecgel et al., 2007). Since safflower is more drought and salt tolerant than some other oil seed crops, it is especially suited for dry and salty areas where other oil seeds are difficult to grow (Weiss, 2000). Also, low production costs and low water and nutrient needs of safflower appeal to farmers as an alternative to various crops. However, safflower yield is generally lower than the yield of other oil crops. For this reason, it is needed to develop hybrid safflower varieties that can be produced inexpensively, yield at least 25% better than present open-pollinated types, and maintain oil contents of 45% or above (Baydar and Gökmen, 2003).
Today, Turkey imports about 50% of vegetable oil consumed. That alternative oil crops are introduced in present production system should be evaluated as one of solutions to problems related to shortage in oil production and import a considerable amount of edible oil. Safflower included in late-autumn oilseed crops is one of the alternative ones, particularly in dry lands of Central Anatolia and surrounding regions which have insufficient precipitation.

Sowing time is a major agronomic factor affecting both seed and oil yield in safflower (Tomar, 1995; Gür and Özel, 1997; Sergek, 2001; Gecgel et al., 2007). Therefore, determining optimum sowing time and selecting suitable variety for growing regions are necessary to obtain safflower with high yield and quality. The objective of this study was to evaluate the effects of late-autumn and late-spring sowing times on oil content, seed yield and some yield components of three safflower varieties (a spiny type and two spineless types).

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Materials and Methods

This research was carried out at the experimental fields of Field Crops Department at Agricultural Faculty of Ankara University (32° 51' E; 39° 57' N; 860 m above sea level) during 2004-2005. The characteristics of experimental area were as follows: clay and loam, pH 7.96, lime 4.91%, clay 40.40%, sand 28.54%, silt 31.02%, organic matter 1.12%, total nitrogen 0.113%, phosphor 16.66 ppm and, potassium 405 ppm. Temperature, rainfall, and relative humidity during the crop cycle, and total and mean values of these meteorological data for two sowing times are presented in Table 1.

Table 1. *Time course of some climatic parameters in two experimental years*

Years	Months	Average temperature (°C)	Relative humidity (%)	Rainfall (mm)
	November	7.2	66.8	35.2
2004	December	2.3	72.8	8.7
	January	3.5	69.4	19.3
	February	2.5	67.0	27.4
	March	6.1	65.0	67.6
2005	April	11.6	58.9	78.6
	May	16.6	58.3	86.7
	June	19.5	54.7	37.1
	July	25.0	51.1	11.9
	August	25.4	51.7	0.1

Three safflower varieties were used as the study material such as Yenice (spineless, orange colored), Dinçer (spineless, red colored) and Remzibey-05 (spiny, yellow colored). All varieties which developed at Anatolia Agricultural Research Institute have become adapted well to dry land conditions of Central Anatolia. They were sown on 19 November 2004 and 20 May 2005, with 30 cm row spacing. Intra row spacing was stabilized at 10 cm (average 130 plants/m^2) by thinning (17 May 2005 for late-autumn sowing and 6 July 2005 for late-spring sowing). Irrigation was applied only on 1 July 2005 in all trial area. Weed control was made by manual weeding in the inter row and in the row. Harvest was made by hand on 19 August 2005 for late-autumn sowing and 31 August 2005 for late-spring sowing.

Twenty plants per plot were selected as randomly and were harvested separately. The evaluated parameters in these selected plants were: plant height (cm), capitula number per plant, secondary branch number per plant, seed number per capitula, a thousand seed weight (g), seed yield (kg/da), harvest index (%), oil content (%) in seed samples with shells using Soxhlet apparatus, and oil yield (kg/da).

Results and Discussion

Some development stages and, variety and sowing time effects on investigated characteristics of safflower varieties Yenice, Dinçer and Remzibey-05 is presented in Figure 1 and Table 2, respectively.

Plant development

Cultivars developed a number of leaves in 80 days (late-autumn) and 17 days (late-spring) after sowing (DAS).The period between rosette stage and stem elongation lasted 99 days in late-autumn sowing and 40 days in late-spring sowing. Dinçer and Remzibey-05 cultivars flowered 220 and 66 DAS in late-autumn and late-spring sowing, respectively. The other cultivar (Yenice) commenced flowering 234 DAS (late-autumn) and 73 DAS (late-spring). Safflower cultivars planted in late late-autumn and late late-spring required 273 days and 103 days to harvest, respectively (Figure 1).

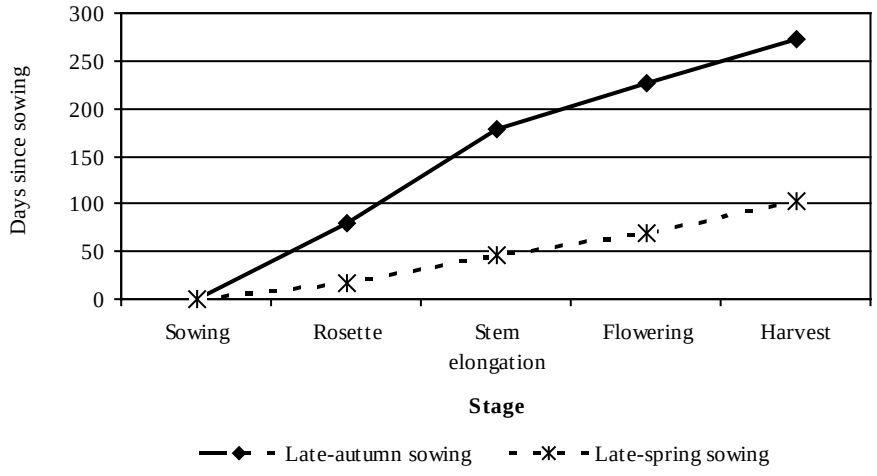

Figure 1. Some development stages of safflower varieties

Table 2. *Performance of safflower varieties*

Character	Sowing time	Varieties			Mean
		Dinçer	Remzibey-05	Yenice	
Plant height (cm)	Late-autumn	103.63 ^{b*}	95.20 ^{c}	135.53 ^{a}	111.47 ^{a}
	Late-spring	58.12 ^{b}	49.83 ^{c}	71.68 ^{a}	59.93 ^{b}
	Mean	80.90 ^{b}	72.59 ^{c}	103.61 ^{a}	
	LSD $_{(0.05)}$	V: 5.708	ST: 4.660	V x ST: 8.072	
Capitula number/plant	Late-autumn	15.32	17.88	13.52	15.57 ^{a}
	Late-spring	8.32	8.80	8.62	8.58 ^{b}
	Mean	11.82	13.34	11.07	
	LSD $_{(0.05)}$		ST: 1.869		
Secondary branch number/ plant	Late-autumn	6.08	6.52	6.17	6.26 ^{a}
	Late-spring	4.49	4.98	5.75	5.07 ^{b}
	Mean	5.29	5.75	5.96	
	LSD $_{(0.05)}$		ST: 0.688		
Seed number per capitula	Late-autumn	29.11	30.97	30.47	30.18
	Late-spring	29.90	26.58	29.54	28.67
	Mean	29.51	28.77	30.01	
A thousand seed weight (g)	Late-autumn	38.43	35.12	33.31	35.62
	Late-spring	41.99	39.58	33.16	38.24
	Mean	40.21 ^{a}	37.35 ^{a}	33.24 ^{b}	
	LSD $_{(0.05)}$	V: 3.652			
Seed yield (kg/da)	Late-autumn	208.74	193.78	199.70	200.74 ^{a}
	Late-spring	125.04	98.08	113.78	112.30 ^{b}
	Mean	166.89	145.93	156.74	
	LSD $_{(0.05)}$		ST: 25.885		
Harvest index (%)	Late-autumn	34.05	40.28	24.95	33.09
	Late-spring	32.37	32.69	26.31	30.46
	Mean	33.21 ^{a}	36.48 ^{a}	25.63 ^{b}	
	LSD $_{(0.05)}$	V: 6.816			
Oil content (%)	Late-autumn	26.68	30.27	23.30	26.75 ^{a}
	Late-spring	24.18	22.98	19.25	22.14 ^{b}
	Mean	25.43 ^{a}	26.63 ^{a}	21.28 ^{b}	
	LSD $_{(0.05)}$	V: 3.971	ST: 3.242		
Oil yield (kg/da)	Late-autumn	55.69	59.30	46.62	58.87 ^{a}
	Late-spring	30.61	22.60	21.89	25.03 ^{b}
	Mean	43.15	40.95	34.26	
	LSD $_{(0.05)}$		ST: 10.971		

V: Variety, ST: Sowing time

* There was no statistical difference among the same letters

Plant height

The effects of variety, sowing time and variety x sowing time interactions on plant height were significant (P<0.01, P<0.05 and P<0.01, respectively). The plant height of cv. Dinçer, cv. Remzibey-05 and cv. Yenice was higher 45.51 cm, 45.37 cm and 63.85 cm, respectively in late-autumn sowing than in late-spring sowing. That plant height was affected by differences variety and sowing time was reported by Gür and Özel (1997) and Sergek (2001). The plant height in safflower varieties depends primarily on the planting date and plant spacing. Late planting and lower populations reduce plant height, and its full height vary between 0.46 m and 1.5 m (Kafka et al., 2000).

Capitula number per plant

Capitula number per plant was significantly affected (P<0.01) by sowing time only. While capitula number per plant was mean 15.57 in late-autumn sowing, this value was mean 8.58 in late-spring sowing. In addition, it was found that capitula number was correlated with secondary branch number, seed yield and oil content, and these correlations were significant statistically at 0.05 level (Table 3). Sergek (2001) sowed that the capitula number of Yenice, Remzibey-05 and Dinçer cultivars sown in April were 10.29, 11.03 and 9.75, respectively.

Table 3. *Correlation coefficients among the characters in safflower varieties*

Characters	1[a]	2	3	4	5	6	7	8
1	-							
2	0.696	-						
3	0.775	0.847*	-					
4	0.600	0.527	0.520	-				
5	-0.608	-0.346	-0.771	-0.452	-			
6	0.884*	0.899*	0.775	0.610	-0.334	-		
7	0.286	0.831*	0.429	0.367	0.168	0.652	-	
8	0.725	0.967**	0.741	0.583	-0.202	0.953**	0.846*	-

*) *P<0.05*

[a] 1 (plant height), 2 (capitula number per plant), 3 (secondary branch number per plant), 4 (seed number per capitula), 5 (a thousand seed weight), 6 (seed yield), 7 (oil content), and 8 (oil yield)

Secondary branch number per plant

The effect on secondary branch number per plant of sowing time was statistically significant (P<0.01). The secondary branch number per plant varied between 4.49 of cv. Dinçer in late-spring time and 6.52 of Remzibey-05 in late-autumn sowing. Wide plant spacing and early planting dates increase branching and capitula formation. For example, a plant sown in November reached to 1.9 m tall with over 50 capitula, while the same variety planted in April only reached 0.45 m with 3-5 capitula (Kafka et. al., 2000).

Seed number per capitula

No statistically significant effects of variety, sowing time and variety x sowing time interactions on seed number per capitula were recorded. Except for cv. Dinçer, seed number per capitula of cv.Remzibey-05 and cv.Yenice were higher (4.39 and 0.93, respectively) in late-autumn sowing than in late-spring sowing. Generally, the seed number per capitula in safflower ranged from 17 to 39 (Abel, 1975; Sergek, 2001). Also, Berglund et al. (1998) stated that each branch will usually have from one to five capitula (flower heads) containing 15-20 or more seeds per head.

A thousand seed weight

The effect on a thousand seed weight of sowing time was insignificant. However, observed differences among cultivars were found significant (P<0.01) statistically. A thousand seed weight was 33.16-41.99 g and while the highest value was obtained from cv. Dinçer, the lowest value was recorded in cv. Yenice. According to the results of previous researches, a thousand seed weight of safflower cultivars varied between 33.47 g and 42.66 g (Gürbüz, 1986; Gencer et al., 1987; Sarıkaya, 1989; Bayraktar and Ülker, 1990; Sergek, 2001).

Seed yield

The effect of sowing time on seed yield was statistically significant (P<0.01). The seed yield varied between 98.08 kg/da and 208.74 kg/da. The seed yield in late-autumn sowing was found higher of 88.44 kg/da than late-spring sowing. It was observed that there was a significant (P<0.05) and positively effect correlation between plant height and seed yield (Table 3). Plant height of all cultivars sown in late-autumn was taller

than late-spring, and this condition affected directly seed yield of cultivars investigated. That the significant effect of variety and sowing time on seed yield was found was recorded by Tomar (1995), Gür and Özel (1997) and Sergek (2001). Sergek (2001) reported that the seed yields of Yenice, Remzibey-05 and Dinçer cultivar planted in April under Ankara conditions were obtained 172.25, 159.78 and 149.63 kg/da, respectively

Harvest index

The effect of sowing time on harvest index was not observed. But, the effects of cultivars were found significant (P<0.05) statistically. Except for cv. Yenice, the harvest index in cv. Dinçer and cv. Remzibey-05 were higher of 1.68 % and 7.59 %, respectively in late-autumn sowing than late-spring sowing. Harvest index values obtained were similar to the values (24.52-33.18 %) reported by Dinlersöz (1996), and higher than the values 22.50-29.20 % and 22.60-29.46 %, respectively) given by Zope et al. (1994) and Sergek (2001).

Oil content

Oil content was influenced (P<0.01) by sowing time and (P<0.05) variety. A significant sowing time x variety interaction for oil content was not observed. It was determined that oil content increased average 4.65 % in late-autumn sowing. While the lowest increasing content (2.50 %) was recorded in cv. Dinçer, the highest increasing content (7.29 %) was obtained in cv. Remzibey-05 having the highest mean oil content, followed by cv.Yenice (4.05 %). In other words, oil content of cv. Dinçer was affected slightly by sowing time. Oil content ranged from 23.30 to 30.27 % in late-autumn sowing and from19.25 to 24.18 % in late-spring sowing. Contrary to our findings, Naughtin (1975) and Gür and Özel (1997) observed that oil content was not affected by sowing time. But, Gecgel et al. (2007) reported that Montola-2001 and Centennial safflower varieties were sown on 12 October (autumn) and on 16 March (late-spring), and oil content for the Montola-2001 variety was higher in late-spring sowing (mean 32.42 %)

than that observed in autumn sowing (mean 31.40 %). However, oil content for the Centennial variety was usually higher in autumn sowing (mean 34.56 %) than observed in late-spring sowing (mean 32.74 %).

Oil yield

Oil yield results from seed yield and oil content in seed. As shown Table 3, the correlation coefficients indicated that oil yield was positively correlated with capitula number per plant (r= 0.967) and seed yield (r= 0.953) at 0.01 level, and oil content (r=0.846) at 0.05 level. Similarly, Özel et al. (2004) reported that the trend of the oil yield values had a positive correlation with the variations in seed yield and oil content in their study. The effect of sowing time on oil yield was statistically significant. Contrary to oil content; recorded differences oil yields from three cultivars was not significant. The mean oil yields of cv. Yenice, cv. Dinçer and cv. Remzibey-05 were found 34.26 kg/da, 43.15 kg/da and 40.95 kg/da, respectively. Statistically significant effect ($P<0.01$) of sowing date on oil yield was obtained. The oil yield from late-autumn sowing was approximately twice higher than the one from late-spring sowing (Table 2). The oil yield in cv. Dinçer, cv. Remzibey-05 and cv. Yenice were higher of 25.08 kg/da, 36.70 kg/da and 24.73kg/da, respectively in late-autumn sowing than late-spring sowing. Our results were in good agreement with those of Özel et al. (2004).

Seed yield, yield characters (plant height, capitula number and secondary branch number) which affected positively seed yield, oil content and oil yield were affected positively by late-autumn sowing. The increasing ratio of seed yield, oil content and oil yield was mean 80.00 %, mean 21.03 % and mean 119.10%, respectively (Table 4).

Table 4. *Changing content of investigated characters in late-autumn sowing according to late-spring sowing (%)*

Characters	Varieties			
	Dinçer	Remzibey-05	Yenice	Mean
Plant height	78.30	91.05	89.08	86.14
Capitula number/ plant	84.13	103.18	56.84	81.38
Secondary branch number/plant	35.41	30.92	7.30	24.54
Seed number /capitula	-2.64	16.52	3.15	5.68
A thousand seed weight	-8.48	-11.27	0.45	-6.43
Seed yield	66.94	97.57	75.51	80.00
Oil content	10.34	31.72	21.04	21.03
Oil yield	81.93	162.39	112.97	119.10

Conclusion

Seed yield, oil content and oil yield were affected by sowing time, and these data from three varieties were higher in late-autumn sowing. It has been observed that safflower planted in early late-autumn in Central Anatolia completes rapidly the rosette stage and then, develops stems. Once the stems in safflower have begun to develop, this plant becomes more sensitive to low temperatures. For this reason, planting dates after mid-November for Central Anatolia can be recommended in order to obtain high yield from safflower. In addition; the highest seed yield and oil content were obtained from cv. Dinçer and cv. Dinçer and cv. Remzibey-05, respectively. In other words, these two cultivars exhibited better performance than cv. Yenice in both sowing time.

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