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Effects of Winter and Spring Sowing on Yield Components of Safflower Genotypes

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***Abstract*—**The research was conducted with three replications as "Randomized Block Design" in Konya-Turkey ecological conditions. In the study, 16 of promising safflower lines (A8, E1, F4, F6, G16, H14, I1), and 1 cultivar (Dinçer) were evaluated in 2008-09 growing season. Some of the yield components such as plant height (cm), first branch height (cm), number of branches per plant, 1000 seed weight (g), seed yield (kg ha^{-1}), oil content (%), oil yield (kg ha^{-1}) were determined. Winter sowing showed higher values than spring sowing. The highest values were taken from Dinçer for plant height (86.7 cm), E1 (37.5 cm) for first branch height, F6 for number of branch (11.6 per plant), I1 for number of head (24.9 per plant), A8 for 1000 seed weight (51.75 g), Dinçer for seed yield (2927.1 kg ha^{-1}), oil content (28.79 %) and also for oil yield (87.44 kg ha^{-1}) respectively.

Keywords—Oil yield, Safflower, Sowing time, Yield components

I. Introduction

FOR many areas worldwide, winter-hardy safflower (*Carthamus tinctorius* L.) provides to important management alternatives for farmers in worldwide. Fall-sown safflower leads to earlier spring growth and development, and also potentially higher yield than spring-sown safflower. Earlier crop development in the spring when temperatures are lower and moisture is more plentiful; promotes more efficient water usage [1]. Winter safflower is a crop which is able to fulfill these requirements. It is a crop that produces high quality oil for edible purposes while efficient to high water usage [2]. Autumn sowing of safflower is enable to autumn and early spring plant development, so that it is potentially increasing seed yield compared with spring sowing [3]. Safflower is considered that most heat and drought tolerant of the alternative agronomic crops which is commercially available [4]. Safflower, as a dicotyledon, is potentially an excellent rotation crop with winter annual monocotyledons such as wheat in semiarid regions [5]. The aim of this research is to investigate the effects of winter and spring sowing on seed and oil yield of safflower genotypes in Konya, Turkey conditions.

II. Material And Methods

The research was conducted with three replications as "Randomized Block Design" in Konya-Turkey ecological conditions. Average altitude of the research area was 1050 m above the sea.

In research area, November 2008 - August 2009 total precipitations are 327.3 mm. Average temperatures to August 2009 from November 2008 are 8.7, 1.3, 2.4, 4.0, 5.9, 11.5, 16.2, 22.3, 24.1 and 23.2 ^{o}C, respectively. As for minimum temperature are -4.1, -16.3, -16.5, -11.4, -5.2, 0.2, 3.0, 10.7, 13.2 and 8.4 (respectively, to August 2009 from November 2008).

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The soil was clay loam, pH 8.03, phosphorous, potassium, iron, zinc, organic matter and $CaCO_3$ contents of 55.9, 17.9 kg ha-1, 14.74, 0.32 ppm and 37.6, 2.25% respectively. In research area there was not salinity problem.

In the study, collected and selected seeds from Konya natural vegetation and the lines which were evaluated by Dr. Rahim ADA, a total of 16 safflower promised lines (A8, E1, F4, F6, G16, H14, I1), and 1 cultivar (Dinçer) were grown in 2009-10 growing season. Pure lines were derived through self-pollination of individual plants of each genotype.

A total of 40 kg/ha of P_2O_5 and 30 kg/ha of nitrogen were applied before sowing and 20 kg/ha of nitrogen was applied as a top dressing at the start of stem elongation. Weeds were controlled by hand.

The experiment was started with sowing in November and continued in April in 2008-09 growing season. Each genotype was sown in plots with 4 rows, 4 m of longitude, with spacing of 50 cm between rows. On August 2010 plant harvests were made. Each plot was harvested as leaving 50 cm on both row ends to eliminate border effects.

Samples of each plot were obtained to determine plant height (cm), first branch height (cm), number of branches per plant (number), 1000 seed weight (g), seed yield (kg ha^{-1}), oil content (%) and oil yield (kg ha^{-1}).

Cluster and variance analysis of were done by using JUMP statistic program.

III. Results

Means of plant height, first branch height, number of branch, 1000 seed weight, seed yield, oil content and oil yield of genotypes were given in Table 2 and as figure, for seed yield (Figure 1), oil content (Figure 2) and oil yield (Figure 3). In the winter sowing trial, all genotypes were lost due to their poor germination and cold damage in the late autumn. However, some plants passed winter successfully, that was mainly due to no germination or little cold damage in autumn. Similar results have been reported by Alizadeh [6], for winter planting of safflower.

In the research, all the investigated characteristics in terms of different sowing time showed statistically significance except first branch height. The results of winter sowing were higher than spring sowing (Table I).

In winter sowing, the means of plant height, branch number, head number, 1000 seed weight, seed yield, oil content and oil yield were found 95.9 cm, 10.5 number $plant^{-1}$, 31.4 number $plant^{-1}$, 44.46 g, 2749.9 kg ha^{-1}, 28.80 % and 795.3 kg ha^{-1} respectively. Spring sowing showed 54.7 cm, 6.81 number $plant^{-1}$, 11.23 number $plant^{-1}$, 38.43 g, 1418.5 kg ha^{-1}, 25.39 % and 367.4 kg ha^{-1} respectively for those characteristics.

According to the mean values which were given in Table 2, the highest mean were taken from Dinçer cultivar (86.7 cm) for plant height, E1 line (37.5 cm) for first branch height, F6 line for (11.6 number $plant^{-1}$) number of branch, I1 line (24.9 number $plant^{-1}$) for number of head, A8 line (51.75 g) for 1000

TABLE I
ANALYSIS OF VARIANCE FOR SAFFLOWER GENOTYPES WHICH WERE SOWN IN WINTER AND SPRING

Source	DF	Plant Height	First Branch Height	Branch Number	Head Number	1000 Seed Weight	Seed Yield	Oil Content	Oil Yield
Common	47	-	-	-	-	-	-	-	-
Replication	2	22.2306	53.104	0.47396	12.2765	2.28521	180.482	0.25315	24.6393
Sowing times (A)	1	20439.4**	293.041	167.253*	4896.48**	435.608*	212714**	139.367**	21973.5**
Error 1	2	63.0565	96.3065	2.46896	6.90437	5.48687	263.076	1.33185	11.6166
Genotypes(B)	7	501.548**	71.3195*	21.5986**	51.3227**	245.177**	14490.8**	13.953**	1407.05**
(AxB)	7	147.442*	11.0632	3.47667**	17.619	23.4918**	3788.37	2.05724	299.706*
Error 2	28	47.06	23.3066	0.7929	10.769	2.478	1691.5	1.4055	123.74

*P < 0.05; **P < 0.01

TABLE II
SOME FEATURES OF SAFFLOWER GENOTYPES WHICH WERE SOWN IN WINTER AND SPRING

Sowing Times	Genotypes	Plant Height	First Branch Height	Branch Number	Head Number	1000 Seed Weight	Seed Yield	Oil Content	Oil Yield
Winter	Dinçer	110.8	35.0	12.1	27.7	48.53	3670.8	29.46	1081.1
	A8	107.7	37.3	13.3	34.4	53.27	3456.2	27.81	961.2
	E1	100.40	39.3	9.6	34.9	38.63	2313.2	29.60	684.1
	F4	87.3	34.9	8.1	31.1	45.67	2866.7	30.04	861.7
	F6	96.0	32.2	14.2	31.9	44.90	3115.4	29.83	928.8
	G16	82.3	36.1	8.4	30.7	47.30	2268.7	28.07	636.3
	H14	81.4	31.3	7.3	26.1	34.87	1957.2	25.30	496.1
	I1	101.6	32.1	11.3	34.6	42.47	2351.1	30.30	713.0
	Mean	**95.9**	**34.8**	**10.5**	**31.4**	**44.46**	**2749.9**	**28.80**	**795.3**
Spring	Dinçer	62.5	33.9	6.3	15.0	40.20	2183.4	28.12	614.3
	A8	62.4	31.5	7.9	11.1	50.23	1532.1	25.09	377.8
	E1	65.7	35.6	6.9	14.2	34.93	1754.9	25.20	450.3
	F4	48.7	31.2	5.6	7.0	44.03	949.5	24.99	248.2
	F6	61.4	29.3	9.0	11.1	39.90	1499.3	26.16	396.8
	G16	51.2	30.0	5.7	10.4	41.13	1452.6	24.28	351.3
	H14	45.1	25.2	5.3	5.8	28.90	633.2	22.79	144.9
	I1	40.4	22.1	7.8	15.3	28.10	1343.1	26.52	355.4
	Mean	**54.7**	**29.9**	**6.81**	**11.23**	**38.43**	**1418.5**	**25.39**	**367.4**
Average	Dinçer	86.7	34.5	9.2	21.3	44.37	2927.1	28.79	847.7
	A8	85.1	34.4	10.6	22.7	51.75	2494.2	26.45	669.4
	E1	83.1	37.5	8.2	24.6	36.78	2034.1	27.40	567.2
	F4	68.0	33.0	6.8	19.0	44.85	190.8.1	27.52	554.9
	F6	78.0	30.8	11.6	21.5	42.40	2307.4	28.00	662.8
	G16	66.8	33.0	7.1	20.5	44.22	1860.7	26.18	493.8
	H14	63.3	28.3	6.3	16.0	31.88	1295.2	24.04	320.5
	I1	71.0	27.1	9.6	24.9	35.28	1847.1	28.41	534.2
	Mean	**75.3**	**32.3**	**8.7**	**21.3**	**41.441**	**2084.2**	**27.10**	**581.0**

Lsd values: **Plant height**, genotypes: 10.94, genotypes x sowing times:11.47; **First branch height**, genotypes:5.79; **Branch number**, genotypes:1.421, genotypes x sowing times: 2.09; **Head number**, genotypes: 5.235; **1000 seed weight**: 2.511, genotypes x sowing times:3.552; **Seed yield**, genotypes:65.61; **Oil content**, genotypes: 1.891; **Oil yield**, genotypes: 17.75, genotypes x sowing times: 25.10.

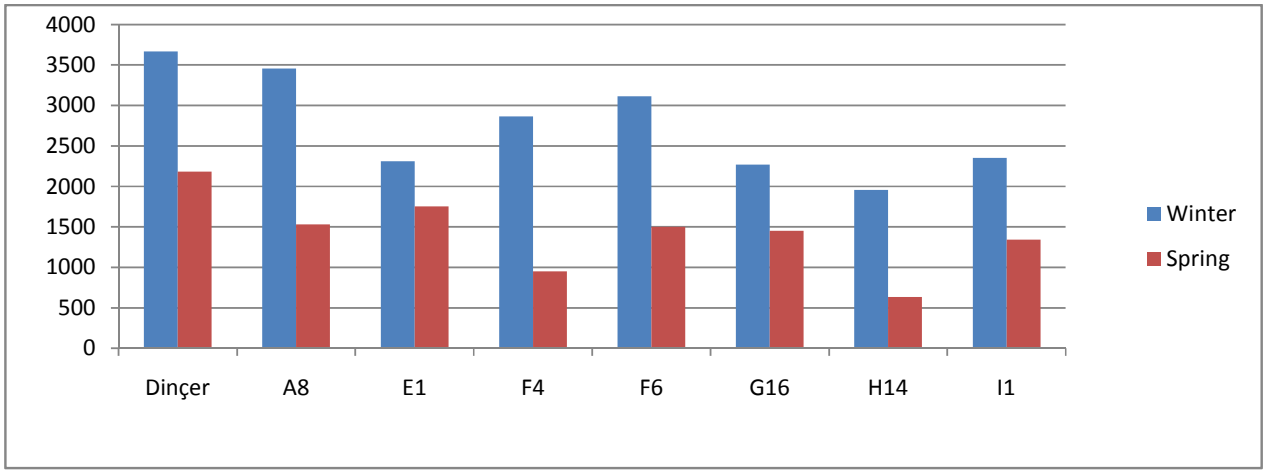

Fig. 1 Seed yields in sowing winter and spring of safflower genotypes (kg ha^{-1})

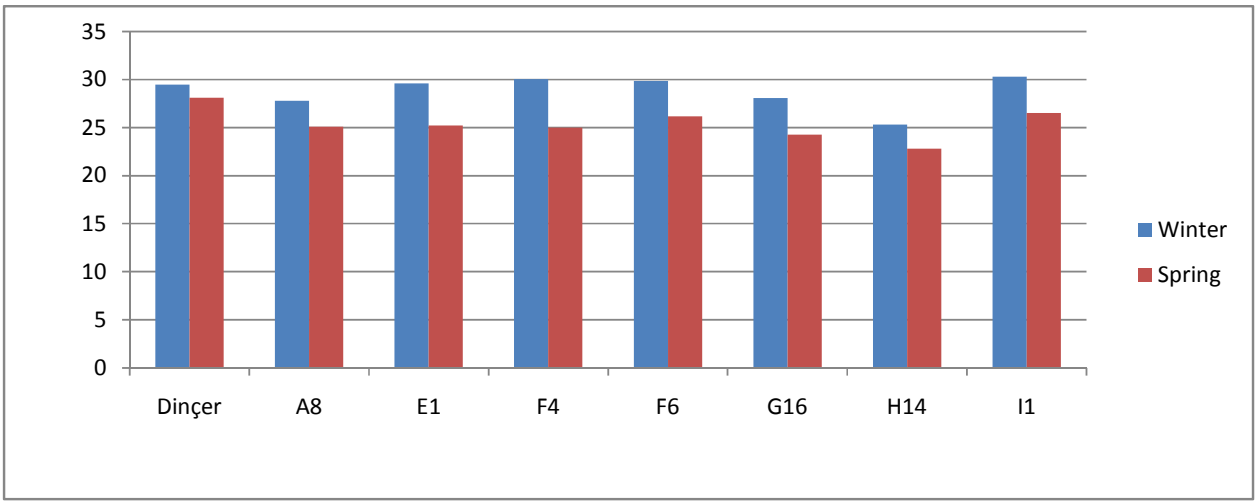

Fig. 2 Oil contents in sowing winter and spring of safflower genotypes (kg ha^{-1})

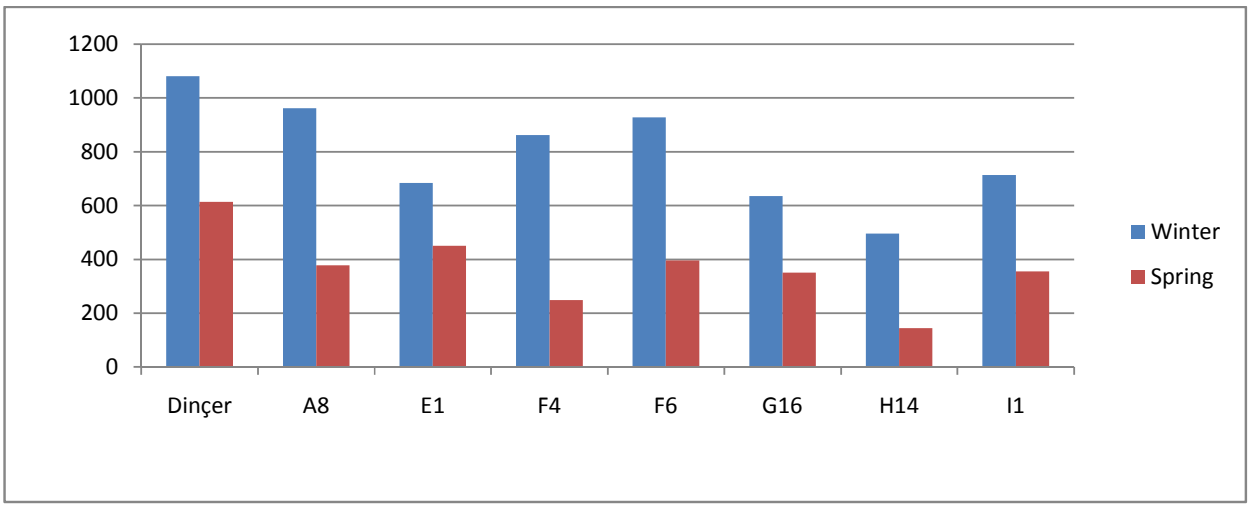

Fig. 3 Oil yields in sowing winter and spring of safflower genotypes (kg ha^{-1})

seed weight, Dinçer cultivar (2927.1 kg ha^{-1}) for seed yield, (28.79 %) oil content and , (874.4 kg ha^{-1}) for oil yield. Whereas, the lowest values were obtained from H14 line (63.3 cm) in plant height, I1 line (27.1 cm) in first branch height, H14 line (6.3 number $plant^{-1}$) in number of branch, H14 line (16.0 number $plant^{-1}$) in number of head, H14 line (31.88 g) in 1000 seed weight, H14 line (1295.2 kg ha^{-1}) in seed yield, H14 line (24.04 %) in oil content and again H14 line (320.5 kg ha^{-1}) in oil yield.

Oil yield by means of sowing times x genotype interaction was statically important at $P<0.05$ level. The highest oil yield were taken from Dinçer cultivar (108.11 kg ha^{-1}) in winter sowing, the lowest were obtained from H14 (14.49 kg ha^{-1}) line in spring sowing.

IV. Discussions

Plant height is affected by climate and cultural techniques [7]. Safflower was showed that winter sowing had more positive effects on plant height compared to spring sowing [8]. Kıllı and Küçükler [4], Bayraktar [9] reported that plant height was varied between 105.0-112.5 and 42.67-64.83 cm in safflower. These results also supports to the results of that research. It was reported for safflower that, first branch height varies 20.00-46.01 Zarei et al. [1]; 56.3-115.4 cm, Kızıl et al. [10]; branch number changes between 4.09 and 7.89 per plant Özel et al. [11]; 6.6-7.4 per plant Bayraktar, [12]; 7.06-8.42 per plant, Öztürk and Özkaynak, [13]; head number changes from 4.9 to 6.1 per plant Orange et al. [14]; from 12.5 to 39.6 per plant Pahlavani et al. [15]; between 12.78 and 15.09 per plant Badiger et al. [16]; for 1000 seed weight it varies 36.19-36.21 g Koç and Altınel, [17]; 46.7-41.55 g Bayraktar, [9]; from 30.80-42.50 g Emami et al. [18]. Differences and similarities between the results of the previous studies mentioned above and also in this study might be related with the genetically structure of the genotypes, climate and soil conditions. A study where was made in Ankara-Turkey ecological conditions showed that, fall/winter sowings gave higher seed yield than spring sowings [9, 19], however, no significant differences found in yield among different sowing dates in Syria [20]. Therefore, determining optimum sowing time and selecting suitable variety for growing regions are necessary to obtain safflower with higher yield and more quality [21]. In previous studies related to safflower, Özturk et al. [22]obtained seed yield as 1320.7 kg ha^{-1} from Dinçer cultivar in Konya-Turkey ecological conditions. Şakir and Başalma [23] reported that, seed yield changed from 2283.3 to 2505.8 kg ha^{-1} in safflower cultivars. Safflower oil can show differences in response to sowing time which can be a major factor as affecting both oil quality and fatty acid composition [24]. Therefore, determination of optimum sowing time is important critically [25]. Oil content had been obtained from the researchers: Cosge et al. [25] 23.14-26.64 %, Camas et al [26] found as 24.09-27.27 %, Cosge and Kaya [21] observed between 22.14-26.75 % in safflower genotypes.

Özel et al. [11] reported similar results that; the trend of the oil yield values had a positive correlation with the variations in seed yield and oil content. In previous studies in safflower, oil yield were obtained 603.9-823.6 kg ha^{-1} [19], 253.0-541.0 kg ha^{-1} [27], 263.0-1038.0 kg ha^{-1} [8]. The investigated result for oil yield is also in accordance with previous data.

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