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ORIGINAL ARTICLE

Sowing Date Effect on Spring Safflower Cultivars

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ABSTRACT
To assess the effect of different sowing dates on yield, yield components and oil content of safflower cultivars, an experiment was conducted on a randomized complete block design arranged in factorial split-plot form with four replications during 2010 spring growing season at the research field, located in Kazem Abad, Iran. The experimental treatments were sowing date in four level including D_1= 16 Mar., D_2= 30 Mar., D_3= 14 Apr. and D_4= 29 Apr. 2010 as factorial main plots and cultivar including V1: Sina, V2: Goldasht, V3: KW2 and V4: MEC11 as subplots. The following parameters were determined: number of heads per plant, number of seeds per head, 1000 seeds weight, seed yield, seed oil content and oil yield. The study indicated the effect of sowing date and sowing date×cultivar on seed yield was significant at P = 0.01. Sowing on 16 Mar. by average of 1558.65 kg ha^{-1} produced the highest rate of seed yield. Also the highest rate of seed yield produced by MEC11 and KW2 were sown on 16 Mar. by average of 1759.66 and 1728.29 kg ha^{-1}, respectively which had a significant preference in comparison to other cultivars. The highest number of heads per plant, 1000 seeds weight and oil yield obtained in 16 Mar. sowing date by average of 11.05, 37.62 g and 497.25 kg ha^{-1}, respectively and the highest number of seeds per head and seed oil content obtained in 16 Mar. and 30 Mar. sowing dates by average of 23.65, 23.06, 31.81% and 31.56%, respectively. Also the highest number of heads per plant by average of 12.24 produced by Sina, the highest number of seeds per head by average of 25.09 produced by MEC11, the highest 1000 seeds weight by average of 37.31 and 37.81 g produced by MEC11 and KW2, respectively and the highest seed oil content by average of 31.37% produced by KW2. The highest number of heads per plant produced by Sina was sown on 16 Mar. by average of 14.88. The highest seed oil yield produced by KW2 in D_1 by average of 570.33 kg ha^{-1}.
Key words: *Safflower, Carthamus tinctorius L.; Cultivar; Sowing date; yield; yield components; oil content*

INTRODUCTION

Safflower (*Carthamus tinctorius* L.) is a herbaceous annual broad-leaved plant and a member of the Asteraceae family which is the only cultivated species of *Carthamus* genus and the other species of this genus are wild [1]. From the genetic source point of view Iran have a rich genetic source of safflower in the word. Safflower cultivation was done commonly in many regions of eastern hemisphere especially in Middle east as it was cultivated in Egypt since 3500 years ago [2]. Among the native and well adapted oilseed crops to weather condition in Iran, safflower plays an important role specially for its tolerance to water shortage and salinity and also potentiality of spring and autumn planting and rotation with other crops due to its advantages. Therefore it is necessary to study on this crop and its potentialities and suggest the most appropriate management strategies. On the other hand due to increasing edible oil need of Iran, safflower could be an important industrial oil seed crop [3]. The choice of the appropriate sowing date is one of the key points in crop management to obtain high quality and quantity yield so suggestion of most appropriate sowing date to farmers increase their yield and profit and therefore their tendency to cultivation of a specific crop such as safflower.

Heidari Zadeh [4] reported postponing the sowing date in addition to temperature increase in developmental stages of germination to flowering which shortening this period cause to yield component production period encounter with high temperature and reduced the total plant dry weight although number of heads per plant, 1000 seeds weight and seed yield more affected by it in comparison to biomass yield . According to Abel [6] seed yield decrease by postponing the sowing date [6]. Pasban Eslam [5] studied on traits of spring safflower cultivars and reported these cultivars generally are smaller, have less growth period and produced less seed yield in comparison to autumn ones due to less growth period in spring planting . Bassil and Kaffka [7] reported seed oil content is one of the most important traits in safflower cultivars which strongly influence economically safflower production in a region . Omidi Tabrizi [8] showed safflower seed oil content

is influenced by many factors such as sowing date, cultivar and soil salinity and ranged between 20 and 45% . Also Mirza Khani [9] reported the effect of cultivar on oil yield is significant .

Therefore the main objective of this study is to assess the effect of different sowing dates on number of heads per plant, number of seeds per head, 1000 seeds weight, seed yield, seed oil content and oil yield of safflower cultivars.

MATERIALS AND METHODS

The experiment was carried out at the experimental farm in Kazem Abad, Iran (12°50′- 15°8′E, 35°45′- 35°51′N; 1253 m a.s.l) during the 2010 spring growing season. The soil type where the experiment took place was a clay loam soil. The experiment was conducted on a randomized complete block design arranged in factorial split-plot form with four replications. The experimental treatments were sowing date in four level including D_1= 16 Mar., D_2= 30 Mar., D_3= 14 Apr. and D_4= 29 Apr. 2010 as factorial main plots and cultivar including V1: Sina, V2: Goldasht, V3: KW2 and V4: MEC11 as subplots. Each experimental plot consisted of 4 rows, 6 m long with 50 cm spaced between rows. Among blocks 6 m distance was kept to prevent treatments mingling. According to soil analysis, P and N were applied at a rate of 50 kg P_2O_5 ha^{-1} and 75 kg N ha^{-1} pre-plant in the form of ammonium phosphate and urea, respectively, and were incorporated in the soil before sowing. Also N fertilizer applied in stemming and flowering stages at a rate of 50 and 25 kg N ha^{-1}, respectively in the form of urea. Seeds were planted according to sowing date treatments. Plant density was 40 seed m^{-2}. The plants were thinned after complete emergence in the 4-6 leaf stage. The final harvest was performed at physiological maturity stage.

The following parameters were determined: number of heads per plant, number of seeds per head, 1000 seeds weight, seed yield, seed oil content and oil yield. After eliminating the margin effect 6 plants were randomly harvested from middle of each plot. Number of heads and number of seeds per head counted in these plants. 1000 seed weight was determined by measuring the weight of 8 random samples which each of them consisted of 100 seed, from each plot and multiplying it by 10 in order to express it to 1000 seeds. Seed yield was determined by harvesting plants at physiological maturity stage from each plot with 14% humidity. Oil content of the seeds was determined with a NMR spectrophotometer and expressed on a percent basis, based on whole seed. Oil yield were determined by multiplying the oil content by the seed yield.

Analyses were performed using the SAS software. A factorial analysis of variance (ANOVA) was performed for all parameters. Duncan's Multiple Range Test (DMRT) (P = 0.05) was used to conduct mean comparison. In addition correlation coefficients among traits were determined.

RESULTS AND DISCUSSION

Number of heads per plant

The results of factorial analysis of variance revealed that the simple effect of sowing date and cultivar on number of heads per plant at P = 0.01 and the interaction effect of them on this trait at P = 0.05 were significant (table 1). Comparison of means showed that Sina by average of 12.24 produced the highest number of heads per plant and had a significant preference in comparison to other cultivars although there was not a prominent difference among the other cultivars and all of them placed in second class (table 2). Also the highest number of heads per plant obtained on D_1 by average of 11.05 which had a significant preference in comparison to other sowing dates. Both D_2 and D_3 placed in second class and D_4 placed in third class (table 2).

Study of interaction effect of V and D on number of heads per plant showed that the highest and lowest number of heads per plant produced by Sina in D_1 by average of 14.88 and KW2 in D_4 by average of 4.34, respectively (table 3).

According to Tomar [10] number of heads per plant significantly affected by sowing date and highest number of heads per plant obtain in earlier sowing dates. Mirza Khani *et al*. [11] reported the effect of sowing date and cultivar and the interaction effect of them on number of heads per plant is significant .

Number of seeds per head

The results of factorial analysis of variance revealed that the simple effect of cultivar on number of seeds per head at P = 0.01 and the simple effect of sowing date on number of seeds per head at P = 0.05 were significant but the interaction effect of them on this trait was not significant (table 1).

Comparison of means showed that MEC11 by average of 25.09 produced the highest number of seeds per head and placed in first class and Goldasht by average of 15.46 produced the lowest number of seeds per head and placed in third class. Both Sina and KW2 placed in second class (table 2). Also the highest number of seeds per head obtained in D_1 and D_2 by average of 23.65 and 23.06, respectively. Both D_3 and D_4 placed in second class (table 2).

Guo Yahai and Lian Lu [12] reported number of seeds per head is the most yield component affecting seed yield . According to Pasban Eslam (2006) there is a positive and significant correlation between number of seeds per head and seed yield [5]. Bahdani and Jami Al-Ahmadi [13] showed the significant difference among cultivars from the number of seeds per head point of view Tomar (1992) reported the reduction of number of seeds per head due to postponing of the sowing date [10].

1000 seeds weight (TSW)

The results of factorial analysis of variance revealed that the simple effect of sowing date and cultivar on 1000 seeds weight were significant at $P = 0.01$ but the interaction effect of them on this trait was not significant (table 1). Comparison of means showed that KW2 and MEC11 produced the highest 1000 seeds weight by average of 37.81 and 37.31 g, respectively and placed in first class as there was not a significant statistical difference between them. Both Sina and Goldasht placed in second class (table 2). Also the highest and lowest 1000 seeds weight obtained in D_1 and D_4 by average of 37.62 and 32.62 g, respectively. D_1, D_2, D_3 and D_4 placed in first, second, third and fourth class, respectively (table 2).

Bahdani and Jami Al-Ahmadi [13] showed the significant difference among cultivars from the 1000 seeds weight point of view. Khalili mousavi *et al*. [14] said that 1000 seeds weight strongly affected by environmental conditions. Heidari Zadeh and Khajeh Poor [15] reported 1000 seeds weight significantly affected by sowing date and reduced by postponing sowing date from autumn to late spring mainly due to high temperature during growth period in postponed sowing date. According to Tomar [16] in postponed sowing dates 1000 seeds weight mean is more affected and reduced in comparison to other traits mainly due to hot and dry winds and reduction of soil water storage in seed filling period [16].

Table 1- Factorial analysis of variance components for assessed traits

C.O.V	DF	NH/P	NS/H	TSW
Replication	3	3.483ns	15.447ns	0.89ns
Sowing date	3	42.188**	127.393*	72.307**
Error a	9	3.457	18.423	1.057
Cultivar	3	69.674**	258.386**	119.932**
Sowing date×Cultivar	9	6.540*	27.819ns	0.598ns
Error b	36	2.907	16.818	0.668
CV (%)		18.689	19.594	2.671

*, ** significant at 5 and 1% respectively, ns: not significant

Table 2- Effects and means comparisons (simple effect) of Sowing date and Cultivar on assessed traits

Treatment	Mean		
	NH/P	NS/H	TSW (g)
Sowing date			
16 Mar. 2010	11.05 a	23.65 a	37.62 a
30 Mar. 2010	8.97 b	23.06 a	36.00 b
14 Apr. 2010	9.38 b	18.73 b	34.56 c
29 Apr. 2010	7.09 c	18.27 b	32.62 d
Cultivar			
Sina	12.24 a	22.04 b	33.06 b
Goldasht	8.35 b	15.46 c	32.62 b
KW2	8.01 b	21.13 b	37.81 a
MEC11	7.88 b	25.09 a	37.31 a

Any two means not sharing a common letter differ significantly from each other at 5% probability

Table 3- Effects and means comparisons (interaction effect) of Sowing date and Cultivar on assessed traits

Treatment		Mean		
Sowing date	**Cultivar**	**NH/P**	**NS/H**	**TSW (g)**
16 Mar. 2010	**Sina**	14.88 a	22.25 abc	35.75 e
	Goldasht	8.76 cde	20.42 bcd	35.50 e
	KW2	10.67 bc	25.23 ab	40.00 a
	MEC11	9.88 cd	26.71 a	39.25 ab
30 Mar. 2010	**Sina**	12.80 ab	25.85 abc	33.75 fg
	Goldasht	7,59 de	19.05 cd	33.50 g
	KW2	8.26 cde	20.84 abcd	38.75 bc
	MEC11	7.25 e	26.49 a	38.00 cd
14 Apr. 2010	**Sina**	12.59 ab	21.95 abc	32.00 h
	Goldasht	7.50 de	11.40 e	31.75 hi
	KW2	8.80 cde	16.03 de	37.25 d
	MEC11	8.63 cde	23.70 abc	37.25 d
29 Apr. 2010	**Sina**	8.69 cde	18.07 cd	30.75 ij
	Goldasht	7.67 de	10.98 e	29.75 j
	KW2	4.34 f	22.40 abc	35.25 e
	MEC11	7.67 de	23.46 abc	34.75 f

Any two means not sharing a common letter differ significantly from each other at 5% probability

Seed yield

The results of factorial analysis of variance revealed that the simple effect of sowing date and the interaction effect of sowing date and cultivar on seed yield were significant at $P = 0.01$ but the simple effect of cultivar on this trait was not significant (table 4). Comparison of means showed that the highest and lowest seed yield obtained in D_1 and D_3 by average of 1558.65 and 1037.73 kg ha^{-1}, respectively. D_1 had a significant preference in comparison to other sowing date and placed in first class. D_2 placed in second class and both D_3 and D_4 placed in third class (table 5).

Study of interaction effect of V and D on seed yield showed that the highest and lowest seed yield produced by KW2 in D_1 by average of 1728.29 kg ha^{-1} and MEC11 in D_4 by average of 809.23 kg ha^{-1}, respectively (table 6).

Mirza Khani *et al*. (2010) reported the effect of sowing date, cultivar and the interaction effect of them on seed yield were significant at $P = 0.01$. They explained seed yield directly related to plant growth duration since in long plant growth duration the rate of radiation absorbed by plant increase and therefore seed yield enhanced [11].

Seed oil content

The results of factorial analysis of variance revealed that the simple effect of sowing date and cultivar on seed oil content were significant at $P = 0.01$ but the interaction effect of them on this trait was not significant (table 4). Comparison of means showed that KW2 produced the highest seed oil content by average of 31.37% and placed in first class. MEC11 placed in second class and Both Sina and Goldasht placed in third class (table 5). Also the highest seed oil content obtained in D_1 and D_2 by average of 31.81% and 31.56%, respectively and placed in first class as there was not a significant statistical difference between them. D_3 and D_4 placed in second and third class, respectively (table 5). Hashim and Schinter [17] reported seed oil percent strongly related to kernel percent. Mirza Khani [9] reported the effect of cultivar on seed oil content is significant at $P = 0.01$.

Seed oil yield

The results of factorial analysis of variance revealed that the simple effect of sowing date and the interaction effect of sowing date and cultivar on seed yield were significant at $P = 0.01$ but the simple effect of cultivar on this trait was not significant (table 4). Comparison of means showed that the highest seed oil yield obtained in D_1 by average of 497.29 kg ha^{-1}. D_1 had a significant preference in comparison to other sowing date and placed in first class. D_2 placed in second class and both D_3 and D_4 placed in third class (table 5).

Study of interaction effect of V and D on seed oil yield showed that the highest and lowest seed yield produced by KW2 in D_1 by average of 570.33 kg ha^{-1} and MEC11 in D_4 by average of 222.28 kg ha^{-1}, respectively (table 6).

Geegle *et al*. [18] reported different sowing dates influence the quality and quantity of oil safflower . Omidi Tabrizi *et al*. [19] showed there is a positive and significant correlation between seed yield and oil yield.

Table 4- Factorial analysis of variance components for assessed traits

C.O.V	DF	SY	SOC	SOY
Replication	3	112986.306ns	0.307ns	12178.085*
Sowing date	3	969571.725**	69.14**	153573.3**
Error a	9	38780.199	1.126	2689.811
Cultivar	3	40680.947ns	20.682**	5751.61ns
Sowing date×Cultivar	9	168963.769**	0.39ns	16141.00**
Error b	36	30612.265	0.338	2743.23
CV (%)		13.922	1.932	13.735

*, ** significant at 5 and 1% respectively, ns: not significant

Table 5- Effects and means comparisons (simple effect) of Sowing date and Cultivar on assessed traits

Treatment	Mean		
	SY (kg ha^{-1})	SOC (%)	SOY (kg ha^{-1})
Sowing date			
16 Mar. 2010	1558.65 a	31.81 a	497.29 a
30 Mar. 2010	1354.74 b	31.56 a	427.32 b
14 Apr. 2010	1034.73 c	29.75 b	307.59 c
29 Apr. 2010	1078.55 c	27.31 c	293.03 c
Cultivar			
Sina	1327.24 a	29.00 c	387.32 ab
Goldasht	1207.53 a	29.31 c	353.47 b
KW2	1247.08 a	31.37 a	396.06 a
MEC11	1244.83 a	30.75 b	388.36 ab

Any two means not sharing a common letter differ significantly from each other at 5% probability

Table 6- Effects and means comparisons (interaction effect) of Sowing date and Cultivar on assessed traits

Treatment		Mean		
Sowing date	Cultivar	SY (kg ha^{-1})	SOC (%)	SOY (kg ha^{-1})
16 Mar. 2010	**Sina**	1575.01 ab	31.00 b	487.73 bc
	Goldasht	1211.65 cdef	30.75 b	372.02 efgh
	KW2	1728.29 a	33.00 a	570.33 a
	MEC11	1759.67 a	32.50 a	559.06 ab
30 Mar. 2010	**Sina**	1416.25 bc	30.50 b	431.47 cde
	Goldasht	1300.75 cde	30.75 b	400.09 defg
	KW2	1402.50 bc	32.50 a	456.31 cd
	MEC11	1299.46 cde	32.50 a	421.41 cdef
14 Apr. 2010	**Sina**	1068.65 efg	28.25 cd	301.52 hij
	Goldasht	977.35 fgh	29.00 c	283.58 ijk
	KW2	941.96 gh	31.25 b	294.56 ijk
	MEC11	1150.96 defg	30.50 b	350.70 fghi
29 Apr. 2010	**Sina**	1249.05 cde	26.25 f	328.62 ghij
	Goldasht	1345.35 bcd	26.75 ef	358.20 efghi
	KW2	915.57 gh	28.75 c	263.02 jk
	MEC11	809.23 h	27.50 de	222.28 k

Any two means not sharing a common letter differ significantly from each other at 5% probability

Correlation coefficients

Study of correlation coefficients on assessed traits revealed that there are a positive and significant correlation between seed yield and number of heads per plant (r= 0.38**), number of seeds per head (r= 0.32**), 1000 seeds weight(r= 0.29*), seed oil content (r= 0.43**) and Seed oil yield (r= 0.97**) (table 7).

Table 7- Correlation coefficient among assessed traits

NH/P	**1**					
NS/H	0.2203 0.0803	**1**				
SY	0.3862 0.0016	0.2311 0.0661	**1**			
TSW	0.0372 0.7703	0.5390 < 0.0001	0.2997 0.0161	**1**		
SOC	0.1517 0.2316	0.4382 0.0003	0.4328 0.0004	0.8402 < 0.0001	**1**	
SOY	0.3644 0.0031	0.3216 0.0096	0.9729 < 0.0001	0.4794 < 0.0001	0.6235 < 0.0001	**1**
Traits	**NH/P**	**NS/H**	**SY**	**TSW**	**SOC**	**SOY**

*, ** significant at 5 and 1% respectively, ns: not significant

CONCLUSIONS

According to our results, MEK11 and KW2 produced the highest seed yield b average of 1759.67 and 1728.29 kg ha^{-1}, respectively in comparison to other cultivars when sowing in an appropriate date (mid March) although in postponed sowing date, Goldasht showed more stability in seed and oil yield among cultivars. Therefore Goldasht cultivar recommends in postponed sowing dates in a region like Kazem Abad. Since postpone on sowing date nearly decrease all cultivars yield so choosing an appropriate sowing date is as important as choosing an appropriate cultivar which seems mid March is the most appropriate selection in a region like Kazem Abad.

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