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Effect of Sowing Dates on Yield and Yield Components of Spring Safflower (*Carthamus tinctorius* L.) in Isfahan Region

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Abstract: In order to study the effect of sowing dates on the yield and yield components of two safflower varieties, an experiment was conducted at Agriculture Research Station of Isfahan Kabotar Abad in 2004. A split plot layout within randomized complete block design with three replications was used in the experimentation. Eight sowing dates were in the main plots, consist March 6, March 21, April 6, April 21, May 6, May 21, June 6 and June 21 and two varieties (Isfahan 14 and I.L111) were in the sub plots. The results showed that the number of seed per capitulum and seed yield were decreased significantly as the sowings dates were delayed. The Isfahan 14 variety in comparison with I.L111 produced more fertile capitulum in square meter and also, respectively seed per capitulum. The second sowing date (March 21) produced the highest seed yield (2306.2 kg ha^{-1}), whereas the 7th sowing date (June 6) produced the lowest seed yield (622 kg ha^{-1}). The effect of variety for seed yield was not significant. Farmers in the Kabotar Abad of Isfahan and in other areas with similar conditions are recommended to plant the Isfahan 14 variety on March 21.

Key words: Safflower, sowing date, variety, yield, yield components

INTRODUCTION

Safflower, one of the world's oldest oil seed crops, has been grown commercially for edible oil and natural dye sources around the world. India, the USA, Mexico, Australia and Ethiopia are the largest producers of safflowers for oil and these countries account for about 85% of the world's safflower production (FAO, 2002).The other important countries growing safflower are China, Kazakhistan, Argentina, Uzbekistan and the Russian Federation.

As 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). The world average yield of safflower is much lower (0.72 t ha^{-1}) than those reported for soybean (2.34 t ha^{-1}), rapeseed (1.51 t ha^{-1}), groundnut (1.37 t ha^{-1}) and sunflower (1.14 t ha^{-1}).The seed contain 30% oil, 20% protein and 35% crude fiber. The seeds are also a rich source of minerals (Zn, Cu, Mn and Fe), vitamins (Thiamine and B-caroten) and the tocopherols (α, β and γ) (Velasco *et al*., 2005). Safflower leaves, petals and seeds have tremendous medicinal and therapeutic significance and petals are also used for extracting dye for coloring cloths and foodstuffs (Carvalho *et al*., 2006). The yield of safflower can be divided into several components. Seed weight, plant height, first branch height, number of branch, capitulum diameter, number of seed per capitulum and number of capitulum per plant are the main parameters which are determined at different experiments (Gonzalez *et al*., 1994; Pascual-Villalobos and Albuquergue, 1996; Omidi-Tabrizi, 2000; Bagheri *et al*., 2001). However, Chaudhary (1990) showed that the number of seed per capitulum, number of capitula per plant and 1000 seed weight could be used for selection of high seed yielding varieties as primary selection criteria in an investigation with 50 safflower lines. In a study with three safflower cultivars, Camas and Esendal (2006) estimated the heritability for capitulum and 1000 seed weight were 21, 69 and 81%, respectively and reported that 100 seed weight could be used to succeed in selection in early generation. However, further experimental data are required to support these positive results. To some up, the main objective of the present study was to examine the adaptation ability, grain yield, yield components of two commercial safflower cultivars in Isfahan, Iran conditions.

MATERIALS AND METHODS

The experiment was conducted at Kabotar Abad research station Isfahan, Iran with longitude 51° 39′ and

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altitude 32° 28' from March to November 2004. The study field had a loam soil. This location in an arid area (according to the De Martonne climate classification) characterized by warm and dry summers, moderate winter and 150 mm annual rainfall. A split plot layout within randomized complete block design with three replications was used. Planting dates were in the main plots March 6, March 21, April 6, April 21, May 6, May 21, June 6, June 21 and two varieties (Isfahan 14 and I.L111) were in the sub plots. Prior to seeding 30 kg urea ha^{-1} and 90 kg^{-1} ammonium phosphate were broadcasted and incorporated in to the soil. Seeds were hand-planted and the amount of seed was 20 kg in a hectare sparse was performed before the stem elongation period and the final density was 400,000 plants.

The field was frequently irrigated to avoid visible symptoms of drought stress. Weeds and insects were effectively controlled. Plant samples were taken approximately every week. At each sampling date, five randomly selected plants per replication and genotype were cut at ground level and depends on phonological stage were separated into stem, capitula and finally seeds. All samples were dried at 75°C to constant weight and then weight. Final harvest consisted of 3 m of centre row of each plot. The following yield components were measured: capitulum diameter, seed weight per capitulum, number of seeds m^{-2}, number of capitula per plant, number of seeds per capitulum and 1000 seed weight. All statistical analyses were performed using SAS software (SAS, 1996). Mean separation test was performed using Duncan's multiple range test at 1 and 5% levels (Little and Hills, 1978).

RESULTS AND DISCUSSION

The effect of the sowing dates was not significant for the fertile capitulum numbers (Table 1). The March 21 date produced most fertile capitulum numbers but the difference was not significant when compared to other sowing dates (Table 2). Since the number of fertile capitulum per square meter stem from the number of fertile capitulum in plants, if the sowing date does not have significant effect on fertile capitulum number in plants, the number of fertile capitulum per square meter will not be significant. The effect of variety on number of fertile capitulum per square meter was significant at 0.01% probability level. Isfahan 14 variety produced more fertile capitulum number than I.L111 and their difference was significant (Table 1). The interaction effect of variety and sowing date for fertile capitulum number in square meter was significant at 0.05% probability level (Table 1). In all dating except March 21 and April 6 there was not a significant difference between the two varieties. However these two date trends have changed. While Isfahan 14 variety in March 21 produced the most fertile capitulum number per square meter, in April 6 (only after 15 days) it produced a lower number of fertile capitulum than I.L111 which means that different varieties have a different reaction to environment changes which comes from interaction between sowing date and variety (Fig. 1). The effect of sowing date on seed on the capitulum was significant (Table 1). Although, the sowing date of April 6 produced the highest yield, the June 6 produced least (Table 2). Mirzakhani (2002) claims that the low number of capitulum in plants in the late sowing dates caused an increase in the number of seeds per capitulum.

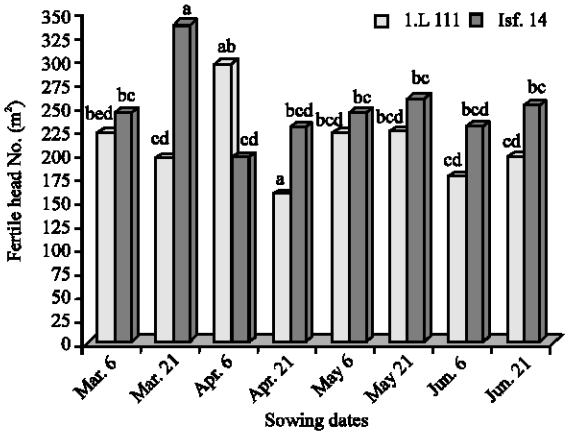

Fig. 1: Interaction effect between sowing date and variety for fertile head number (m^2)

Table 1: ANOVA analysis yield and yield components

Source of variation	df	Square mean character: Seed yield (kg ha^{-1})	Fertile capitulum No. (m^2)	Seed on the capitulum	1000 seed weight (g)
Replication	2	1019897.0**	12261.0	12.5	0.37
Sowing date	7	176139.8**	3405.5	99.2**	2.40*
Error	14	115030.9	3131.1	26.8	2.50
Variety	1	162052.5	16133.3**	217.2**	1633.80**
Sowing date×Variety	7	263589.7	6899.04*	16.2	5.50
Error	16	115711.3	1834.2	11.4	4.20

*, **Significant at 5 and 1% probability levels, respectively

Table 2: Means comparison of sowing date and variety on yield and yield components*

Treatments	Seed yield (kg ha^{-1})	Fertile capitulum No. (m^2)	Seed on the capitulum	1000 seed weight
Sowing dates				
6 Mar.	1965.6ab	232.0a	22.7bc	45.0a
21 Mar.	2306.2a	266.7a	28.6ab	47.0a
6 Apr.	2172.3a	245.3a	32.5a	43.6a
21 Apr.	1268.2c	193.3a	25.0bc	39.4a
6 May	1547.2bc	234.7a	26.7ab	32.0b
21 May	1562.3bc	241.3a	28.0ab	30.0b
6 Jun.	622.0d	201.3a	19.2c	23.0c
21 Jun.	1315.2c	221.3a	24.0bc	26.0c
Variety				
I.L111	1665.5a	211.2b	23.7b	41.7a
Isfahan 14	1549.0a	247.8a	28.1a	30.1b

*All means followed by the same letter(s) in column are not significantly different at the 5% probability level

Adisarwanto and Knight (1997) suggests that early sowing, when combined with good conditions and a long growing season, leads to profuse growth and the number of seeds per pod increased. The effect of variety on seed on the capitulum was significant (Table 1). Significantly the Isfahanl 4 variety produced the most number of seeds on the capitulum than I.L111 (Table 2). Two good reasons for the interaction of different varieties on sowing dates are considered to be genetic discrepancy and adaptability to the environment. Mirzakhani (2002) reported Jila with 34.95 and UC-1 with 27.21 produced the highest and least number of seeds on the capitulum, respectively which, results from the differences in the period of seed filling and inappropriate environmental conditions. The interaction between sowing date and variety was not significant (Table 1).

The sowing date was significant for the 1000 seed weight (Table 1). The sowing date of June 6 produced the least weight for 1000 seed and its difference was significant with other sowing dates except for June 21. The cause of the low weight for the 1000 seed may be due to the following factors: The high number of seeds in each capitulum, the number of capitulum in each plant and the plant height. These factors affect the higher number of seeds in each plant and in the result, the 1000 seed weight is decreased. Bagheri *et al.* (2001) reported there is percentage 85 g (approximate) weight decrease due to each 12 days delay. Mirzakhani (2002) believes that increase or decrease in one of the yield components is concerned with increase or decrease of other yield components. He reported that although the number of capitulum in plants and the number of seeds per capitulum in the late dates had decreased, the 1000 seed weight had not decreased because among the yield components the 1000 seed weight had the least effect in the face of appropriate environment conditions. The effect of variety on the 1000 seed weight was significant at the 0.01% probability level (Table 1). The I.L111 variety produced the most weight for the 1000 seed which was a significant effect with regards to the Isfahan 14 variety (Table 2). Bagheri *et al.* (2001) reported the average weight of 100 seed as 3.9 g. The Zarghan 279 and jila varieties were highest with the 4.19 g and the Varamin 295 variety was least number of weight with 3.5 g. The effect of sowing dates on seed yield was significant at 0.01% probability level (Table 1). The sowing date of March 21 and June 6 with 2306.2 and 622 kg ha^{-1} produced the highest and the least seed yields, respectively. Appropriate vegetative growth length, having enough photosynthesis surfaces, having maximum yield components and not facing pollination, flowering and stage on seed filling with high temperatures as well as limited growth conditions are reasons for catching the high yield in contrast to the next sowing dates. Mirzakhani (2002) reported there was a significant difference between the average of the yield seed in the 3 sowing dates. The highest yield, 3062 kg ha^{-1} related to April 26 and the least yield seed, 1612 kg ha^{-1} related to the sowing date of May 25. He claims that on the sowing date of April 26, the normal temperature was higher than the average temperature of 5°C. As a result, the plant continues the development and growth easily and it has a longer period for growth with respect to the other two sowing dates. Having the optimum temperature, it is likely to the suitable environmental condition. The effect of the variety on the yield was not significant (Table 1). This significant difference between the two varieties may indicate the adaptability of the two varieties with to climatic conditions of the experiment location, which were able to use the appropriate environmental conditions and had admissible yield.

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