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Effect of Planting Density on Yield and Yield Components of Safflower Cultivars in Spring Planting

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***Abstract*—**This study carried out to determine the effect of plant densities on some agronomic characteristics of four safflower cultivars in spring planting. The experiment was conducted at Yazd, Iran- using a factorial in a randomized complete block design with four replications. Cultivars were including Arak, IL, Asteria and Local and plant densities were 10, 13.3, 20 and 40 plant/m2. Number of seeds/head, number of heads/plant, HI, 1000-seed weight and seed yield significantly decreased as planting density increased. With increasing planting density, LAI, plant height, first branch height and biological yield increased. The highest seed yield was obtained in 13.3 plant/m^2 (2167 kg/ha). There were significant differences between cultivars. Local cv. had higher seed yield than the other cultivars mainly due to higher heads/plant and seeds/head.

***Keywords*—**safflower, plant density, cultivar

I. Introduction

SAFFLOWER (*Carthamus tinctorius* L.) is an annual, broadleaf oilseed crop of the Compositae adapted mainly to dry land and irrigated cropping systems. It originated in southern Asia and is known to have been cultivated in China, India, Iran and Egypt. It has been grown for centuries, primarily for its colorful petals to use as a food coloring and flavoring agent, for vegetable oils and also for preparing textile dye. Safflower is an important oilseed crop with 35-40% oil. Research linking health and diet has increased the demand for the oil, which safflower has the highest poly unsaturated/saturated ratios of any oil available. It is nutritionally similar to olive oil, with high levels of linoleic acid, but much less costly.In Iran the safflower cropped area has increased over last few years and reached about 10000 ha during 2008 whereas during 1997 it was 200-300 ha [2].[7] concluded flowering time in plant densities (100000, 125000, 200000 plant/ha) is different on safflower. 100000 plant/ha flowered earlier than the others. Reference [3] reported maximum seed yield in safflower happen at the highest plant density (40 plant/m^2) and maximum oil yield observe at 20 plant/m^2. Reference [4] concluded with increasing planting density number of branches/plant, seeds/head, heads/plant and seed yield (one plant) significantly decreased.The purpose of the present study was to evaluate optimum plant density in yield of safflower varieties in Yazd, Iran at spring.

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II. Materials and Methods

This experiment was carried out at the Khatam city, Yazd-Iran (longitude 54, 48', latitude 29, 32' and altitude 1546 m above sea level). The meteorological data of the region are representing in table I. The soil has sandy-clay texture (table II).

The experiment design was set up as factorial in a randomized complete block with four replications, with four cultivars (Arak, IL, Asteria and Local) under four plant densities (10, 13.3, 20 and 40 plant/m^2). Cultivars were planted in March 2007. All seed-beds were prepared with conventional tillage. Fertilizer was applied based on soil testing. For the experiment, 150 kg/ha P, 200 kg/ha K and 100 kg/ha N (at two times) were supplied. The plots were 7 rows, 0.5 m apart and 8 m long. After emergence, manual thinning was used to obtain normal density. Weeds were controlled by manual weeding before stem elongation. Observations were carried out on 5 central rows and 0.5 m from both ends of the rows was left as it represented the border effect. Plant harvests carried out on August 2007. Collected data included: seed yield, biological yield, harvest index, plant height, number of head per plant, number of branches per plant, number of seed per head, 1000-seed weight, LAI and first branch height.

The data of experiment were analyzed by SAS software for comparison of the mean values by the Duncan test.

III. Results and Discussion

A. Morphological Traits

The plant densities were significant on the plant height and the number of lateral branches per plant (table III). Higher plant height and branches/plant were reports at 40 (63.79 cm) and 10 plant/m^2 (16.59), respectively. Reference [3] reported there are significant differences between different plant densities.

The number of lateral branches and plant height showed significant difference amongst cultivars (table 3). Asteria cv. (18.09) and Arak cv. (18.03) produced higher branches/plant than the others and Local cv. (66.82 cm) had higher plant height than the other cultivars. The obtained results are comparable with by [1] and [3].

B. Yield Components

The primary yield components of safflower are number of head per plant, number of seed per head and seed weight. Even though yield components are under genetic control (cultivars), they do respond with various degrees of flexibility

to plant density. The analysis of variance indicates that number of seeds/head and heads/plant decreased by increasing plant densities.

Significant differences in heads/plant observed between plant densities and cultivars. Maximum number of heads/plant were produced by 10 (15.04) and 13.3 (14.48) plant/m^2. Local cv. (16.39) produced a significantly higher heads/plant than the other cultivars. Significant differences were found in the number of seeds/head between cultivars and plant densities (table 3). 10 (41.47) and 13.3 (40.83) plant/m^2 produced more seeds/head than the others.

Seed weight was significantly influenced by changed the plant densities from 10 to 40 plant/m^2. Environmental conditions such as interplant competition can adversely influenced seed development by inhibiting photosynthesis and other metabolites required during the seed filling stage. The highest seed weight (1000-seed weight=34.98g) was obtained in 10 plant/m^2. Cultivars were significant on the 1000-seed weight. IL cv. produced a significantly higher 1000-seed weight than the others.

C. Seed Yield

There was significant difference in seed yield between plant densities (table 3). Average seed yield ranged from 1602 kg/ha (40 plant/m^2) to 2167 kg/ha (13.3 plant/m^2). Cultivars had significant differences. Local cv. (2449 kg/ha) produced a significantly higher seed yield than the other cultivars. Similar results have been reported in safflower ([5] and [6]).

IV. Conclusion

It is conclusion from this present study that planting density on safflower mainly decreases seed yield in spring planting by reduction of 1000-seed weight, branches/plant, heads/plant and seeds/heads. Local cultivar and 13.3 plant density/m^2 produced highest seed yield than the other treatments.

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TABLE I
METEOROLOGICAL DATA OF THE EXPERIMENTAL REGION IN 2007

Month	Maximum temperature (°c)	Minimum temperature (°c)	Rainfall (mm)
March	24	-2.4	6.6
April	28.4	0.6	34.4
May	35.6	7.6	0.8
June	41.6	11.8	0
July	41.6	18.6	0.9
August	39.4	13.8	0

TABLE II
RESULT OF SOME CHEMICAL AND PHYSICAL ANALYSIS OF EXPERIMENTAL FIELD SOIL

Depth (cm)	P (ppm)	K (ppm)	N (%)	Organic matter (%)	EC (dS/m)	pH	Texture
0-30	6	140.8	0.059	0.693	3.353	7.61	Sandy-clay

TABLE III
MEAN COMPARISON EFFECT OF PLANT DENSITIES AND CULTIVARS ON AGRONOMIC TRAITS

Treatment	LAI	1000SW	PH	FBH	BP	HP	SH	HI	BY	SY
Plant density										
10	0.61d	34.98a	56.64d	30.93d	16.59a	15.04a	41.47a	30.81b	6434c	1985b
13.3	0.79c	33.84b	57.40c	32.00c	16.00a	14.48b	40.83b	33.58a	6447c	2167a
20	1.17b	31.77c	60.08b	36.68b	14.51b	12.46c	39.97b	27.51c	7207b	1961b
40	2.32a	30.07d	63.79a	41.16a	13.38c	10.91d	38.25c	20.28d	7919a	1602c
Cultivars										
Arak	0.33d	28.86bc	63.29b	30.84c	18.03a	14.11b	38.47b	22.31d	7116c	1549d
Asteria	1.63b	28.19c	61.72c	43.92b	18.09a	13.84b	37.33c	25.06c	7148b	1755c
IL	1.02c	44.20a	46.06d	20.00d	9.25c	8.56c	42.31a	30.06b	6562d	1961b
Local	1.91a	29.41b	66.82a	46.01a	15.19b	16.39a	42.41a	34.75a	7181a	2449a

LAI: leaf area index, 1000SW:1000-seed weight (g), PH: plant height(cm), FBH: first branch height(cm), BP: number of branches/plant, HP: number of heads/plant, SH: number of seeds/head, HI: harvest index, BY: biological yield(kg/ha), SY: seed yield(kg/ha)