Evaluation of the Quantitative and Qualitative Yield of Safflower

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Abstract: An experiment in the split plot design in the format of completely randomized blocks with four replicates was carried out in the city of Firuzkooh to study the effect of seeding date on safflower cultivars in the years 2009-2010. The experimental treatments included the seeding date as the major factor (four different dates 20 days apart from each other – February 28, March 20, April 9, and April 29) and the cultivar as the minor factor(the three cultivars of Sina, Isfahan 14, and Padideh). Results obtained show that yield and its components are significantly affected by delays in the seeding date –that is, the more the seeding date is delayed from the suitable seeding date, the more the yield is reduced. Safflower cultivars also show statistically significant differences due to their high production potential and also because of the degree of their adaptation to the weather in the area. As a whole, the cultivars can be seeded in Firuzkooh at the seeding dates of February 28 and March 29; and these two dates did not give significantly different results. Based on the results of this experiment, the cultivar Padideh was superior in many of the traits investigated, while the cultivar Isfahan 14 did not meet the necessary requirements to be recommended for Firuzkooh.

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1. Introduction

Edible oils are one of the main sources of providing energy for the vital processes of the human body and, due to their role in supplying the fat and vitamin requirements of the body, are considered among the most important needs of the human body after the carbohydrates. Considering the increasing trend of the consumption of edible oils in the country and the high cost of meeting the demand for them through imports, the expansion of the cultivation of oil crops adapted to the climatic conditions of the country, and also the expansion of research programs in these crops, merit attention. Safflower is a plant grown and developed in various countries of the world for a very long time. Its scientific name is *Carthamus tinctorius* L., and oil is extracted from its seeds. In the production of this crop, the goal is to obtain the highest yield by choosing the best seeding date and the suitable cultivars for each area, because these two factors are among the obstacles which challenged the cultivation of this crop in some areas. Most researchers agree on the considerable effect of seeding date on safflower yield, but each one of them, based on the conditions under which their experiments are conducted, have stated different reasons for this effect. The extent of reduction in yield due to delays in seeding date is not the same for early- intermediate-, and late-maturing cultivars. Yield stability in early–maturing cultivars at different seeding dates is more than those of intermediate – and late–maturing cultivars, probably because early–maturing cultivars are more likely than intermediate – and late – maturing varieties to complete their life cycle and the final stages of their development without facing unfavorable environmental conditions (Mundel et al., 1994).

Zimmerman (1992) stated that the yield of safflower is influenced by the cultivar planted and by the temperature and the relative humidity (and their mutual effects) at pollination time and after that; so that with an increase in temperature and humidity at the time of pollination there was a decrease in yield, because the number of seeds in each receptacle was severely reduced. Lueble et al. (1965) studied the effect of seeding date on seed yield, oil, and the water needs of spring safflower and reported that for each 4 – 6 week delay in seeding date (from January 16 to May 3), seed yield decreased by 160 to 366 kilograms per hectare; and in their study they found that there was also a reduction in the weight of one thousand seeds. The reason for the drop in the weight of one thousand seeds in the late seeding dates was the synchronism of the filling of seeds and the warm summer weather.

Ehdaee and Noormohammadi (2004) studied the effects of seven seeding dates on seed yield and other cultural traits of two safflower cultivars in Ahvaz in a two–year experiment, and showed that there was a statistically significant difference among seeding dates with respect to seed yield, the weight of one thousand seeds, and the percentage protein content of seeds. They specially found a severe drop in seed yield for late seeding dates. Safflower has very diverse cultivars which differ from each other in the color of flowers, plant height, shape of the leaves, shape of the stems, presence or absence of spikes, oil content, composition of oils, seed weight, and other traits (Zeinali, 2000).

2. Materials and Methods

An experiment in the shape of split blocks in the format of completely randomized blocks with four replicates was conducted in the city of Firuzkooh to study the effect of seeding date on safflower cultivars in 2009–2010. The experimental treatments included four seeding dates, 20 days apart from each other, as the major factor (February 28, March 20, April 9, April 29), and three cultivars (Sina, Isfahan 14, and Padideh) as the minor factor. Each plot consisted of four rows. The rows were four meters long and 50 centimeters apart. There was a distance of five centimeters between the seeds in each row. The plots were 0.8 meter apart, and the distance between replicates was two meters. The land used for the experiment, which had been fallow the previous year, was plowed using a reversible plowshare, the clods were crushed by disking, and the soil surface was leveled with a trowel. The soil was sampled at the depths of zero to 30 centimeters and the samples were analyzed before seeding to determine the nitrogen and phosphorus requirements of the crop. Based on the results of this analysis, 200 kilograms of ammonium phosphate (48% P_2O_5 and 18% N) per hectare of the land was broadcast on the soil and disked to be mixed with it. In addition, for each seeding date the equivalent of 150 kilograms of urea per hectare was applied as top dressing in each plot at the start of stem formation, following which the plots were irrigated. The seeds were disinfected with the fungicide Benomyl. The seeds were sown dry and by hand on ridges in rows at a depth of 3 – 4 centimeters. The rows were 50 centimeters apart and the distance between the seeds in each row was 5 centimeters. The method of seeding was as follows: at every four centimeters of each row, two seeds were sown one centimeter apart. After the germination of the seeds and the emergence of seedlings, one of the two seedlings at each hill was thinned out at the 3 – 4 leaf stage. During the growth and development of the crop, weeding was carried out by hand. Irrigation was first applied after seeding, and the time of this application of water was considered as the basis for the date of seeding. Up to the 2 – 3 leaf stage, Irrigation was repeated after each four days; and after that, irrigation water was applied every 7 to 10 days, based on the water needs of the crop, the temperature, and the weather conditions. Statistical calculations were performed using the SAS and Excel software; and Duncan′s multiple range test was used to compare means.

3. Results and Discussion

Results of analysis of variance (Table 1) show that the mutual effect of the seeding date and the cultivar planted was significant for the seed yield trait at the probability level of one percent level; so the highest seed yield was obtained for the cultivar Sina at the first seeding date, and the least seed yield was harvested for the cultivar Isfahan 14 at the second seeding date (Table 4). At the first seeding date, Isfahan 14 had the least seed yield, but this yield was not significantly different from those of the cultivars Padideh and Sina. In this study, when seeding was delayed from the first to the fourth seeding date, the yield of the cultivar Padideh decreased, but this cultivar was not significantly different from the cultivar Sina at the first seeding date. There was no significant difference among the cultivars at the fourth seeding date, while at the third seeding date the cultivar Sina had the highest yield. However, this yield was not significantly different from those of the other cultivars (Table 4). Studies carried out by other researchers (Dadashi and Khajehpoor, (2005); Rabiee et al., (2005); Arsalan et al., 1997) have also shown that the seeding date has a significant effect on seed yield. In the study conducted by Arsalan et al. (1997), the shorter growing season, which was caused by the delay in the seeding date, and the shorter plants, reduced the seed yield. The safflower cultivars were also significantly different at the level of one percent probability (Table 1) so that the cultivar had the highest yield at the mean seed yield of 496.2 grams per square meter, while the cultivar Isfahan 14 showed the lowest yield at the mean seed yield of 393.1 grams per meter (Table 3). The increase in the seed yield of the cultivar Padideh can be attributed to the higher biological yield, the bigger number of seeds in each plant, and the greater figure for the 100- seed weight. The mutual effect of the genotype and the seeding date was significant for the biological yield trait (Table 1), so that the cultivar Sina had the highest biological yield at the second seeding date, compared to the other cultivars, although it was not significantly different from the cultivar Padideh and Isfahan 14 at the first seeding date, and was not significantly different from the cultivar Padideh at the second seeding date (table 4). Dadashi and Khajehpoor (2002) also in their studies reported a significant mutual effect between the seeding date and the cultivar for the biological yield trait. As a whole, there was a significant difference among the dates of seeding at the five percent level of probability regarding the biological yield trait (Table 1). The first seeding date with the mean of 1652.4 grams per square meter and the fourth seeding date with the mean of 1299.9 g. per square meter had the most and the least biological yield, respectively (Table 2). Therefore, those plants will produce the highest yield that, in the conditions present during their growth, make the optimum use of the factors of production and store more photosynthates. Bagheri in his study carried out in Isfahan in 2006 found out that by delaying the seeding date from March 31 to April 24 the dry weight of each plant (grams per square meter) decreased at the stage when 75% of the plants had flowered. He attributed this to the increase in the rate of growth of plants caused by the high air temperature at that time of the year. No significant difference was found among the cultivars regarding biological yield (Table 3).

The harvest index, or the coefficient of transport, shows the efficiency of the distribution of the photosynthates produced in the plants among the seeds; and the way these products are distributed among plant parts determines the economic yield. Results of the analysis of variance showed (Table 1) that the seeding dates, the cultivars, and the mutual effects of the seeding dates and the cultivars were not significantly different; but comparison of the means of the treatments with Duncan′s multiple range test showed (Table 2) that the first seeding date was better than the rest in regard to harvest index. This suggests that the air temperature at the first seeding date was ideal for the transport of photosynthates from the point of production (source) to the point of consumption (target). Mirzakhani et al. (2003) also obtained similar results regarding harvest index in their study of safflower cultivars in the city of Arak. The mutual effect of the seeding date and the cultivar concerning the percentage oil content of seeds was not significant, but the effect of the seeding date on the percentage oil content of seeds was significant at one percent (Table 1). As a whole, the fourth seeding date produced the least percentage of oil content of seeds and was significantly different from the other seeding dates, except the third seeding date (Table 2). Alessi et al. (1981) reported that the percentage oil content of seeds was affected by the seeding date and that delays in seeding would cause a reduction in the percentage oil content of seeds, and hence would decrease the oil yield. Neither were the cultivars significantly different with respect to percentage oil content (Table 1The mutual effect of the date of seeding and the cultivar on the number of seeds in each plant was not significant (Table 1), but delays in seeding date caused a reduction in the number of seeds per plant (Table 2). This could be attributed to the increase in air temperature at the flowering and the pollinating stages, which occurred as a result of delays in seeding date and which disturbed the pollinating process. Arsalan et al. (1997), in their study of safflower cultivars, noticed that high temperatures at the flowering and the pollinating stages caused floret sterility, and hence decreased yield and its components. Dadashi and Khajehpoor (2005) stated that the reasons for the reduction in the number of seeds in spring safflower brought about by delays in seeding date were a decrease in the growing season of receptacles and an increase in temperature at flowering (which causes seed sterility). They reported that the reason for the increase in the number of seeds in plants of safflower seeded in very late spring was the reduction of temperatures at the growth and development stage of receptacles. Since the number of seeds per receptacle, together with the number of receptacles per plant, determine the total number of seeds, and as the total number of seeds also has a deciding role in determining yield; therefore, the number of seeds in each receptacle directly influences yield. As a whole, the biggest number of seeds per plant was achieved at the first, and the smallest number, at the third and fourth seeding dates (Table 2). The cultivars were significantly different from each other at the five percent probability level regarding the number of seeds per plant (Table 1). The biggest and the smallest number of seeds per receptacle belonged to the cultivars Padideh and Isfahan 14, respectively (Table 3). The bigger number of seeds per plant in the cultivar Padideh was probably due to its greater adaptation to the environmental conditions of the region the experiment was conducted in. Bagheri (1996) also observed that the number of seeds per plant is influenced by the cultivar planted. Results obtained from the analysis of variance (Table 1) show that there is no significant difference among seeding dates concerning the weight of one hundred seeds; but the cultivars studied were significantly different at the one percent probability level, so that the cultivar Padideh, with an average of 3.53, and the cultivar Isfahan 14, with an average of 3.05, had the highest and the lowest one hundred seed weights, respectively (Table 3). Results obtained by researchers regarding the effect of seeding date on seed weight are not consistent. In many studies, a reduction in seed weight due to delays in seeding dates has been reported (Ehdaee and Noormohammadi, 2004), but in some studies (Choolaki et al., 1993) the seed weight was not affected by the seeding date. Apparently, this trait has caused he insusceptibility of seed weight to seeding date through modifying the distribution of photosynthates among the seeds formed in the plants and through regulating the number of seeds per plant

(Zand and Koocheki, 2000). The mutual effect of the seeding date and the cultivar on the one hundred seed weight was not statistically significant (Table 1).

Table 1. Results of Analysis of Variance on the Effect of Seeding Date on the Traits of Safflower

		Mean Square (MS)					
Source of variance	df	Number of seeds per plant	Weight of 100 seeds(grams)	Seed yield (gr/m^2)	Biological yield (gr/m^2)	Harvest index (%)	Oil content (%)
Block	3	9387.4	0.01	9915.3	349335.3	21.5	1.4
Seeding date	3	89619.5**	0.12	35852.6**	37341.2*	11.6^{ns}	84.1**
The a error	9	4101	0.05	6416.1	95414.3	42.6	1.8
Cultivar	2	34490.3**	0.91**	54960.1**	149178.5^{ns}	57.1^{ns}	3.6^{ns}
Cultivar×Seeding date	6	9928.8^{ns}	0.04^{ns}	13202.7*	221105.4*	44.2^{ns}	1.2^{ns}
Residual error	6	2494.5	0.06	10549.5	44311.3	72.6	4.4
Coefficient of variation (%)		13.1	6.1	14.3	17.8	21.9	8.5

*, ** show significance at 5 and 1 percent respectively; ns means not significant

Table 2. The Simple Effect of the Seeding Date on the Traits of Safflower

Seeding date	Number of seeds per plant	Weight of 100 seeds(gr)	Seed yield(gr/m^2	Biological yield(gr/m^2	Harvest index (%)	Oil content (%)
February 28	593.4a	3.35a	535.07a	1652.4a	33.7a	33.8a
March 20	506.9b	3.36a	461.28ab	1450.6ab	32.5a	29.9b
April 9	441.4c	3.27ab	441.39b	1379.8ab	32.6a	28.9bc
April 29	394.1c	3.14ab	405.40b	1299.9b	31.2a	27.7c

Table 3. The Simple Effect of cultivar on the Traits of Safflower

cultivar	Number of seeds per plant	Weight of 100 seeds(gr)	Seed yield(gr/m^2)	Biological yield(gr/m^2)	Harvest index (%)	Oil content (%)
Padideh	593.4a	3.35a	535.07a	1652.4a	33.7a	33.8a
Isfahan 14	506.9b	3.36a	461.28ab	1450.6ab	32.5a	29.9b
Sina	441.4c	3.27ab	441.39b	1379.8ab	32.6a	28.9bc

Figures in each column which have common letters are not significantly different at the 5% level

Table 4. The Mutual Effect of the Seeding Date and the Cultivar on the Traits of Safflower

Treatment		Traits of Safflower Studied					
Seeding date	Cultivar	Number of seeds per plant	Weight of 100 seeds(gr)	Seed yield(gr/m^2)	Biological yield(gr/m^2)	Harvest yield (%)	Oil content (%)
February 28	Y 1	688^{a}	3.48^{a}	558.1^{a}	1542.25^{ab}	36.2^{a}	34.3^{a}
February 28	Y 2	480.8^{abc}	3.17^{a}	485ab	1722.5^{a}	28.9^{a}	33.9^{a}
February28	Y 3	611.5^{ab}	3.42^{a}	562a	1692.5^{ab}	35.9^{a}	33.4^{a}
March 20	Y 1	533.3^{ab}	3.56^{a}	491.3ab	1570^{ab}	31.2^{a}	29.8^{a}
March 20	Y 2	451.9^{abc}	3.17^{a}	348.4bc	1001.7^{c}	35^{a}	30.6^{a}
March 20	Y 3	535.4^{ab}	3.35^{a}	544a	1780^{a}	31.3^{a}	29^{a}
April 9	Y1	449.6^{abc}	3.64^{a}	428.1b	1425.5^{b}	31.1^{a}	29.2^{a}
April 9	Y 2	457.2^{abc}	3.04^{a}	388.1bc	1322.5^{bc}	29.8^{a}	29.4^{a}
April 9	Y 3	417.4^{abc}	3.12^{a}	507.8ab	1391.2^{bc}	36.9^{a}	28^{a}
April 29	Y 1	417.5^{abc}	3.44^{a}	407.2b	1474.7^{b}	34.4^{a}	27.8^{a}
April 29	Y 2	335.2^{abcd}	3.82^{a}	350.9bc	1290^{bc}	27.7^{a}	27.4^{a}
April 29	Y 3	429.5^{abc}	3.17^{a}	357.9bc	1135^{bc}	31.6^{a}	27.9^{a}

Figures in each column which have common letters are not significantly different at the 5% level.

3. Discussion and conclusions

Given the results obtained, the abundance of the species of the family Labiateae and also the abundance of species containing essence and tannin in the sub-region can be ascribed to the fact that these species are not grazed because stock mainly do not graze plants containing these compounds; and hence plants containing them have become more abundant. On the other hand, the abundance of the growth forms Hemicryptophyte and Trophyte appears logical since these plants are more resistant to adverse environmental conditions, especially grazing, and also because trophytes are adapted to short growing seasons common in the cold, mountainous rangelands.

Since the grazing pressure on rangelands is mainly due to economic incentives which exist for those who exploit rangelands, and because the region of Cherat has a tremendous potential for the production and multiplication of medicinal plants, attention to these huge resources can, besides preserving the diversity of life forms which is the basis for the survival of natural ecosystems, will be useful in improving the economic situation of livestock producers; and by correctly training them in properly exploiting these plants, and also through cultivating and multiplying these species it is possible to reduce the pressure of excessive exploitation of the vegetative cover. Results obtained from the study of the curative features of these plants show that there is an abundance of plants with astringent and purgative effects which, considering the prevalence of diseases of the digestive system in the rural parts of the sub-region of Lasem, signifies the importance of identifying these species and the need for the pasture exploiters to become acquainted with these plants. Moreover, the abundance of plant species effective in purifying blood and in strengthening the heart, and the familiarity of the local residents with these plants, has resulted in fewer incidences of cardio-vascular diseases among these people. Furthermore, since flowers are the part most used in these species, and because flowers play the major role in apiculture, it is possible to prepare the grounds for the development of apiculture, which has been practiced in the region before, along with the cultivation and multiplication of medicinal plants, so that, while preserving the ecologic values of the sub-region, multiple use of these diverse rangelands and improving the economic situation of the local people and domestication of the existing plant species can be achieved. Therefore, familiarizing the pasture exploiters with the existing medicinal species and training them in the format of medicinal plants, as a practical strategy in raising the spirit of cooperation among them will create jobs and economic profits for pasture exploiters and will also greatly help in sustaining this natural ecosystem.

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