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Effects of sowing dates on yield and yield components of different spring safflower (*Carthamus tinctorius*) cultivars as a double crop in Yasouj, Iran

Mostafa Alinaghizadeh[1], Mohsen Movahhedi Dehnavi[2], Hushang Faraji[2], Ashkbus Dehdari[2], Mohamad Azimi Gandomani[1]

[1]MSc. Student, Department of Agronomy and Plant Breeding, Faculty of Agriculture, Yasouj University, Yasouj, Iran. E-Mail: m.a.naghizadeh@gmail.com
[2]Assistance Professor, Department of Agronomy and Plant Breeding, Faculty of Agriculture, Yasouj University, Yasouj, Iran

Abstract
In order to study the effects of sowing dates on yield and yield components of spring safflower, as double crop, an experiment was carried out in 2007 at the research field of agricultural college of Yasouj University. The experimental design was a factorial with randomized complete block with three replications. Four sowing dates (May 16, June1, June 16 and July 2) as a first factor and four cultivars (Arak 2811, Esfahan 14, IL111 and PI) as second factors, were used. May 16 and June 16 sowing dates had Minimum (1129 kg ha^{-1}) and Maximum (1372 kg ha^{-1}) grain yield respectively. Significant interactions were seen between cultivars and sowing dates for most of measured characters, cultivars of Esfahan 14 at July 2 sowing date and IL111 at May 16 sowing date showed the highest and the lowest grain yield, oil yield, grain numbers per plant and grain numbers per head respectively. Generally with respects of these results was suggested the Esfahan 14 cultivar at July 2 sowing date as the best option for double cropping of spring safflower in Yasouj region. However, because of the coinciding the harvest date of Esfahan 14, at July 2 sowing date, with the sowing date of some winter crops, such as canola, the June 16 sowing date for all cultivars suggested as second option.

Key words: Double Cropping - safflower - sowing date, yield components

Introduction
Sowing two or more crops in a year can cause the effective usage of natural sources in agriculture and more benefits in economic outcome, and it has been considered. Selection of short growing period genotypes that have other suitable characters is very important for double cropping. A suitable combination of genotype and sowing date is the most important factor in acquiring economic yield. Similar results reported in some plant like sunflower (4) and safflower (3) in case of interaction between genotype and sowing date on grain yield and some physiological properties. Yasouj is one of the areas in Iran that has the capability for safflower cultivation. Because there were no reports on suitable safflower sowing date, this research was carried out to study the effect of sowing date on spring safflower cultivars as a double crop in Yasouj.

Material and method
The experiment was carried out in 2007 cultivation year at the research field of agricultural college of Yasouj University. The experimental design was a factorial with randomized complete block with three replications. Four sowing dates (16 May, 1 June, 16 June and 2 July) as a first factor and four cultivars (Arak 2811, Esfahan 14, IL111 and PI) as second factors were used. Each plot included five rows and each row was eight meters length and row space was 50 cm. Plant density was 40 plants m^{-2} for all cultivars. The mentioned land at 2006 cultivation year was fallow. 70 kg N ha^{-1} was distributed at stem elongation and then irrigated. In this experiment, characteristics such as grain yield, oil yield, oil percent, biological yield, harvest index, number of grain per head, number of fruitful head per plant and plant height, were determined. Final harvest was made on three m^2 of three middle rows of each plot and grain yield was measured. Grain oil was extracted with petroleum banzine as solvent. The statistical analysis carried out

with SAS software and mean comparisons was made based on Duncan`s Multiple Range Test ($p<0.05$).

Results:

Grain yield

Significant interaction was seen between sowing date and cultivar for grain yield ($p<0.01$). So that the highest and the lowest grain yield were seen in Esfahan 14 at fourth sowing date and IL 111 at first sowing date respectively. Delaying from first to third sowing date resulted in increasing grain yield in IL111 cultivar, but more delaying from third to fourth sowing date caused severe reduction of grain yield. Also, sowing delay increased grain yield of Esfahan 14 cultivar (table 2). Generally the third sowing date produced the highest grain yield (table 1). Among safflower cultivars, Esfahan 14 and IL111 cultivar had the highest and the lowest grain yield respectively (table 1).

Oil yield

There was significant interaction between sowing date and cultivar on oil yield ($p<0.01$), so that Esfahan 14 cultivar at fourth sowing date had the highest oil yield and IL111 cultivar at first sowing date had the lowest oil yield (table 2). At first sowing date PI and Arak 2811 cultivars had the highest oil yield. At fourth sowing date Esfahan 14 cultivar produced the highest oil yield and there was significant difference between Esfahan 14 and other cultivars (table 1). Generally the third sowing date produced the highest oil yield and the first sowing date had the lowest oil yield, but no significant differences were not seen among first, second and fourth sowing date. Esfahan 14 cultivar and IL111 cultivar produce the highest and the lowest oil yield respectively (table 1).

Oil percent

Significant interaction was seen between sowing date and oil percent ($p<0.01$), so that Arak 2811 cultivar at first and second sowing date had the most oil percent and IL111 at first and third sowing date had the lowest oil percent. In general third sowing date had the lowest oil percent (table 1).

The number of fruitful head per plant

Significant interaction was seen between sowing date and cultivar for number of fruitful head per plant ($p<0.01$). So that IL111 cultivar at first and second sowing date had the highest and the lowest fruitful head per plant respectively (table 2). At first sowing date PI cultivar produce the most fruitful heads. In second sowing date Esfahan 14 cultivar and IL111 had the highest fruitful heads. At third sowing date the situation was so that, Esfahan 14 cultivar produce the lowest fruitful heads per plant. At fourth sowing date the differences between cultivars from the view of mentioned property reduced and only Arak 2811 cultivar had high number of fruitful head (table 2). In general the second sowing date was better in fruitful head number per plant and among the rest sowing date there was no significant difference (table 1). Also Arak 2811 cultivar and IL111 cultivar were better compared with Esfahan 14 and PI cultivars (table 1).

The grain number per head

Significant interaction was seen between sowing date and cultivar for grain number per plant ($p<0.01$). So that the highest and the lowest grain number in head was seen in Esfahan 14 cultivar at fourth sowing date and IL111 cultivar at first sowing date respectively (table 2). At third sowing date Esfahan 14 and PI cultivars produced the highest grain number per head (table 2). The grain number per head affected by sowing date severely, So that, the highest grain number per head belonged to third and fourth sowing date respectively and the lowest was belonged to the first and second sowing date (table 1). Esfahan 14 and IL111 cultivars had the highest and the lowest grain number per head respectively (table 1).

Biological yield

Significant interaction was seen between genotype and sowing date for biological yield ($p<0.01$). So that, Arak 2811 cultivar at first and fourth sowing date had the highest and the lowest biological yield respectively (table 1). Apparently this cultivar was more sensitive to weather changes at difference sowing dates. At third sowing date Arak 2811, Esfahan 14 and IL111 cultivars produced higher biological yield compared to PI. At fourth sowing date Esfahan 14 cultivar produced higher biological yield compared other cultivars (table 2). In general third sowing date and fourth sowing date had higher and lower biological yield respectively (table 1). There were no significant differences between cultivars.

Harvest Index

Significant interaction was not seen between genotype and sowing date for harvest index but compared to other attendances (table 1) has shown that fourth and first sowing date met the highest and the lowest harvest index respectively. This means that environment temperature at fourth sowing date had the best condition for translation photosynthesis material from sink to sours. PI and Arak 2811 cultivars had the highest and the lowest harvest index respectively (table 1).

Plant Height

There was no significant interaction between genotype and sowing date with respect to plant height. The third sowing date with 65.68 cm average plant height had the highest plant height. Reduction of plant height at first, second and fourth sowing date compared to third sowing date was 13.1%, 10.3% and 10.9% respectively. Eafahan 14 cultivar, with 64.9 cm average plant height had higher plant height compared to other cultivars (table 1). The study of plant height changes in different cultivars showed that reduction of plant height in Arak 2811, IL111 and PI cultivars compared to Esfahan 14 is 7.6%, 12.7% and 10% respectively (table 1).

Table1. Mean comparison of main effects of measured characters*

treatment	Harvest index (%)	Oil yield (kg/ha)	Biological yield (kg/ha)	Grain yield (kg/ha)	Oil (%)	plant height (cm)	number of fruitful head	number of grain per head
Sowing date								
May 16	34.8^{b}	280.4^{b}	3342.5^{ab}	1129.5^{b}	24.5^{a}	57^{b}	3.4^{b}	22.4^{b}
June 1	37.7^{ab}	288.6^{b}	3145.5^{b}	1164.9^{b}	24.3^{a}	58.8^{b}	3.7^{a}	24.7^{b}
June 16	38.7^{ab}	325.8^{a}	3636.8^{a}	1372.9^{a}	23.7^{b}	65.6^{a}	3.4^{b}	28.3^{a}
July 2	41.2^{a}	290.7^{b}	2918.6^{b}	1209.1^{b}	24.6^{a}	58.4^{b}	3.4^{b}	27.9^{a}
cultivar								
Arak 2811	34.8^{b}	281.9^{b}	3424.8^{a}	1165^{cb}	24.9^{a}	59.9^{b}	3.6^{a}	24^{bc}
Esfahan 14	38.8^{ab}	316.1^{a}	3344.2^{a}	1291.5^{a}	24.6^{a}	64.9^{a}	3.3^{b}	30.5^{a}
IL111	37.2^{ab}	274^{b}	3094.8^{a}	1141.6^{c}	23.3^{b}	56.7^{b}	3.6^{a}	22.3^{c}
PI	41.5^{a}	313.4^{a}	3179.8^{a}	1278.3^{ab}	24.3^{a}	58.4^{b}	3.5^{ab}	26.4^{b}

*- treatments with the same letter are not significant at the 5% statistical level.

Table2. Mean comparisons of interaction effects of measured characters*

Treatment		Biological yield (kg/ha)	Oil yield (kg/ha)	Grain yield (kg/ha)	Number of grain per head	number of fruitful head	Oil (%)
May 16	Arak 2811	4056.1^{a}	319.1^{abc}	1255.5^{bcde}	23.1^{def}	3.4^{b}	25.4^{a}
	Esfahan 14	2962.9^{cd}	286.7^{bcd}	1154.8^{def}	26de	3.4^{b}	24.8^{abcd}
	IL111	2792.5^{cd}	184.7^{e}	809.9^{g}	18.3^{f}	2.8^{c}	22.8^{fg}
	PI	3558.4^{abc}	327.2^{ab}	1297.6^{bcd}	22.2^{def}	4^{a}	25.1^{abc}
June 1	Arak 2811	3093.9^{bcd}	258.6^{d}	1010.7^{fg}	24.3^{de}	3.2^{b}	25.5^{a}
	Esfahan 14	3048.7^{bcd}	291.7^{bcd}	1166.7^{def}	23.8^{de}	4^{a}	25^{abc}
	IL111	2860.1^{cd}	284.8^{bcd}	1230.2^{cde}	23.5^{de}	4.2^{a}	23.1^{efg}
	PI	3579.3^{abc}	299.3^{bcd}	1252^{bcde}	27.1^{cd}	3.4^{b}	23.8^{def}
June16	Arak 2811	3868.1^{a}	319.3^{abc}	1323.7^{abcd}	25.8^{de}	3.9^{a}	24.1^{cde}
	Esfahan 14	3783.6^{ab}	318.7^{abc}	1310.6^{bcd}	34^{ab}	2.6^{c}	24.3^{bcd}
	IL111	4017.3^{a}	328^{ab}	1464.6^{ab}	21.8^{ef}	4^{a}	22.3^{g}
	PI	2878.1^{cd}	336.1^{ab}	1392.6^{abc}	31.5^{bc}	3.3^{b}	24.1^{cde}

July2	Arak 2811	2681^{d}	264.8^{cd}	1069.8^{ef}	22.8^{def}	3.8^{a}	24.7^{abcd}
	Esfahan 14	3581.4^{abc}	374.2^{a}	1533.9^{a}	38.4^{a}	3.3^{b}	24.3^{bcd}
	IL111	2709^{d}	267.2^{cd}	1061.6^{ef}	25.6^{de}	3.3^{b}	25.1^{abc}
	PI	2703^{d}	285.3^{bcd}	1171^{def}	24.8^{de}	3.3^{b}	24.3^{bcd}

*- treatments with the same letter are not significant at the 5% statistical level.

Discussion

With respect to table 2 it is obvious that delaying from second to fourth sowing date resulted in increasing of grain number per head in Esfahan 14 cultivar. This is because of delaying in sowing date and so decreasing the temperature resulted in better pollination at this cultivar. Arslan *et al*, (1997) reported that high temperatures at flowering and pollination stages resulted in fruitless of small flowers and reduction of yield and yield components. At third sowing date due to higher plant height, biological yield, grain number per head and suitable environmental growing conditions , safflower cultivars could produce high grain yield, compared to first, second and fourth sowing date. With view to studies carried out by researchers sowing date has significant effect on grain yield (5). With respect to direct correlation between oil yield and oil percent and grain yield and significant and positive correlation between grain yield and oil yield ($r= 0.96^{**}$, data not shown) shows that at third sowing date, high oil yield is related to high grain yield. Also as table 1 shows, we see that the third sowing date has the highest plant height and biological yield. This is because the air temperature decreased at this sowing date and plant growth period got longer and consequently plant growth, height and biomass increased. Abble (1976) reported that sowing date effect on plant height was significant. With respect to these results, effect of sowing date on most qualities was significant. Also significant interactions were seen between cultivars and sowing dates for most of the measured characters. So regarded to all aspects, because of the coinciding the harvest date of Esfahan 14, at July 2 sowing date, with the sowing date of some winter crops, such as canola the June 16 sowing date for all cultivars suggested as second option.

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