Indian Journal of Fundamental and Applied Life Sciences ISSN: 2231-6345 (Online)
An Open Access, Online International Journal Available at http://www.cibtech.org/jls.htm
2014 Vol. 4 (2) April-June, pp.628-632/Vahid et al.
Research Article

THE EFFECT OF DENSITY, VARIETY, AND PLANTING DATE ON YIELD AND YIELD COMPONENTS OF SAFFLOWER

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ABSTRACT
More than 90 percent of Iranian domestic need for oil is imported. *Carthamus tinctorius* L., one of the native plants in Iran, is tolerant to drought and salinity. Its seeds contain 35% high-quality oil and 15% protein. To study the effect of density, variety, and planting date on yield and yield components of safflower, an experiment was carried out using split-plot design with four replications at Islamic Azad University, Bojnord Branch, Iran in fall 2005. Date of planting was the main factor (a1=September 23, a2=October 2, a3= October 12, a4= October 22) and varieties (b1=LRV51.51, b2= Zargsan and b3=295) and densities (c1=4, c2=9, c3=12, c4=15 centimeters) were the sub-factor. The results showed that there was an interaction effect among planting date, variety and density. The highest seed yield (2679 kg.) was produced with September 23 planting time, LRV 51.51 and 4 centimeter density. The first planting date yielded the highest average oil seed compared to the other planting dates, 715 kg/ha. Among the varieties LRV51.51 produced the highest amount of oil. There was a correlation between plant seed yield and oil yield(r=0.89) and the number of seeds per pod(r=0.8).

Keywords*: Safflower, Seed Yield, Oil Yield, Correlation, Important Traits*

INTRODUCTION
Oilseeds are the second major food supply sources after cereals in the world. Minimum oil consumption per capita in Iran is about 15 Kg and currently 900,000 tons of oil is demanded in the country. To compensate for this severe shortage, it is vital to focus more efforts on enhancing the yield per unit area and to pay more attention to new varieties and appropriate exotic varieties (Omidi,1991).
Safflower (*Carthamus tinctorius* L) is one of our oldest domesticated crops. It is a major oil seed crop. Iran, with an annual 240 mm of rainfall, is classified as a dry region in the world. Safflower, one of the native and valuable oil seeds in Iran, an oil importing country, is tolerant to drought and salinity, which makes the crop an important one. Its seeds contain 35% high-quality oil and 15% protein. The petals, colored orange, are used mainly as the condiment in food preparation. In studying best planting time of safflower in southern Iran, S. Motelipour (2001) expressed that the highest seed yields (1276 kg/ha)and oil(330 kg/ha) were obtained when it was planted in oct.22. The sooner the planting time, the more rapidly it emerged, and plant height increased. Jelali (2001) showed that double row planting had higher seeds per head and consequently increased seed yield. According to the path analysis, seed yield was determined by head diameter, heads/plant and seeds/head since these characters had highly positive significant direct effects on seed yield (Arshan, 2007). Ozel *et al.*, (2004) showed that the most suitable sowing date and intrarow spacing for safflower on Harran Plain were November and 5 cm, respectively In the study of yield components, leaf pigment contents, patterns of seed filling, dry matter, LAI and LAID of some safflowerr (*Carthamus tinctorius* L.) genotypes in Iran, Mokhtassi, (2007) expressed that Zarghan-279 (with the greatest LAID) had 25% longer LAID than LRV.51.51 (with the lowest LAID). Also, higher dry matter accumulation, HI, seed weight/pod, 1000-seed weight and pod diameter were found to be closely related to high-yield genotypes.

MATERIALS AND METHODS
In fall 2011, an experiment was carried out using split-plot design with four replications at Islamic Azad University, Bojnourd Branch, Iran. Date of planting was the main factor (a1=September 23, a2=October

2, a3= October 12, a4= October 22) and (b1=4, b2=9, b3=12,) and varieties (c1=LRV51/51, c2=Zarghan and c3=295) and density (were the sub-factors. Experiment plot consisted of rows of 4-m long and 0.5 m apart. Data on yield per plant and yield component were obtained by calculating the mean of five randomly selected plants in each plot. Some important collected data were plant height, number of secondary branches, oil yield per plant, number of heads, the number of seed per heads, and100 seed weight.

RESULTS AND DISCUSSION

There were significant different among main factors(planting times, different density and varieties) at 5% level for seed yield. The highest seed yield belonged to the first planting time (sep.22) with 2679 kg/ha and 4-cm density with 20704 kg/ha (Table 1). Four-cm density caused the uniform growing on the rows, which made light to have a better distribution within the canopy. The results were in accord with Azary (2001) that showed with the decreasing the space between plants the seed yield increased. LRV.51/51(C1) had the highest seed yield because of its numerous pods (Table1). In the evaluation of domestic and exotic safflower genotypes, a wide range of genetic variety has been reported for different traits including maturity, plant height, and grain yield (Yazdi-samadi, 1979). It seems that the difference between the genotypes in yield components leads to their difference in grain yield and the correlation between yield components confirms that. Urage and Weyessa (1991) reported that traits such as number of branches, plant height, head diameter, and growth volume were the most important features that were indirectly involved in grain yield determination. **Omidi Tabrizi,A.H (2000**)showed that LRV.51/51(C1) had the most plant height and sub branch**.** The interaction between planting time and variety was significant. The highest seed yield was obtained from LRV.51/51 and Oct. 12 planting time(Table2) with 2812 kg/ha.

Table 1: Mean comparison of major factors for seed yield

Variety (kg)		Density(cm)		Planting time	
2821(kg)	C1	2704(kg)	B1	2679(kg)	A1
2626(kg)	C2	2642(kg)	B2	2644(kg)	A2
2499(kg)	C3	2628(kg)	B3	2628(kg)	A3
				2557(kg)	A4

Table 2: Interaction between planting time and variety

2812 a	a_1c_1
2687 ab	a_1c_2
2660 ab	a_1c_3
2655 ab	a_2c_1
2632 ab	a_2c_2
2616 ab	a_2c_3
2610 ab	a_3c_1
2607 ab	a_3c_2
2597 b	a_3c_3
2586 b	a_4c_1
2584 b	a_4c_2
2478 c	a_4c_3

Mean in each column having at least one common letter are not significantly different at 5% level according to duncan's multiple range test Oil yield

The highest seed yield was obtained from four cm and Oct. 12 planting time with 2844 kg/ha (Figure1)

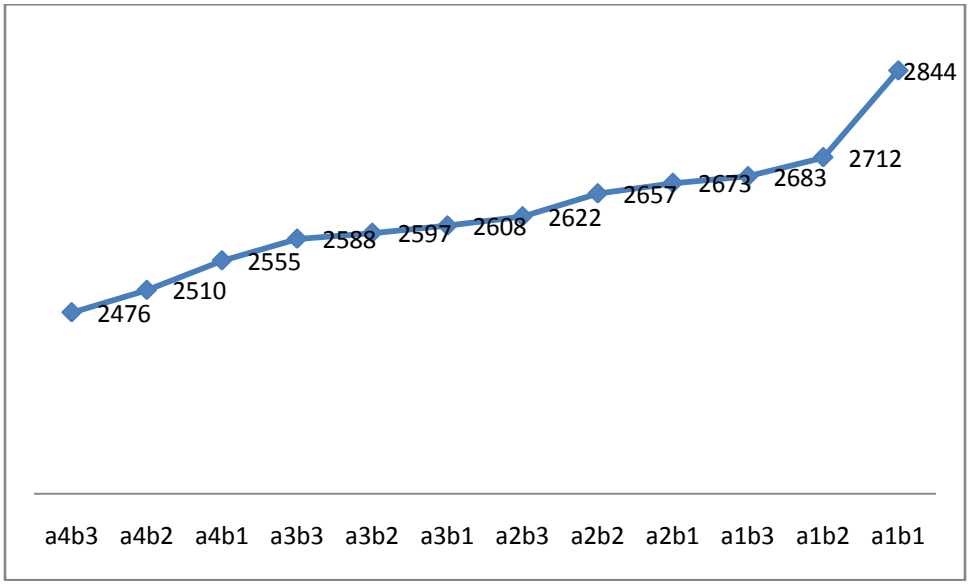

Figure 1: Interaction between planting time and density

The percentage of oil was also an important quality to be investigated. The percentage of oil seed was affected by genotype. The results indicated that, there were a significant different interaction between planting time and variety for oil percentage. The highest oil seed percentage was obtained from LRV.51/51 and Oct. 12 planting time (Table3).

Table 3: Interaction between planting time and variety

27.75 a	a_1c_1
27.42 ab	a_1c_2
27.25 ab	a_1c_3
27.08 ab	a_2c_1
27.00 ab	a_2c_2
26.83 ab	a_2c_3
26.75 ab	a_3c_1
26.75 ab	a_3c_2
26.75 ab	a_3c_3
26.58 b	a_4c_1
26.58 b	a_4c_2
26.58 b	a_4c_3

Mean in each column having at least one common letter are not significantly different at 5% level according to duncan's multiple range test Oil yield

The highest oil seed belonged to the first planting time (sep.22) with 715 kg/ha and 4-cm density with 736kg/ha. The highest oil seed was obtained from LRV.51/51 with 721 kg/ha which probably shows high percentage of skin, and less oil content in the embryo of this genotype. Seed filling period as another effective factor in the increase of oil amount. The identification of the variety with high oilseed yield has been one of the purposes of this study, thus LRV51/51 variety can be considered as the superior variety because of its higher grain yield, for oil yield is the product of grain yield and oil percentage and it's a function of these two factors. The results indicated that the interaction between planting time and variety,

and density were not significant for plant height, number of secondary branches. The results indicated that the interaction between planting time and variety also planting time and density, for oil yield, was significant. In spite of the fact that oil yield of LRV51/51 variety has been more than that of others, the interaction between vareity and density, Zarghan and 4-cm density, the highest oil seed was obtained with755kg/ha (Table 4).

Table 4: Interaction between variety and density

755 a	b_1c_2
735ab	b_1c_1
715 ab	$b_1 c_3$
715ab	b_2c_2
712ab	b_2c_1
693 b	$b_2 c_3$
690b	b_3c_2
677b	b_3c_1
673c	$b_3 c_3$

Mean in each column having at least one common letter are not significantly different at 5% level according to duncan's multiple range test

Correlation among Traits

The correlation of yield and the yield components with each other are shown in Table5.

There was a high correlation among yield and number of secondary branches(r=0.59), oil yield per plant (r=0.89), number of heads (r=0.80), and the number of seeds per head (r=0.51). The positive significant correlation between grain yield and oil yield shows that grain yield is the most important factor to increase oil yield in safflower oil plant. It has been reported that there was a positive significant correlation between grain yield and the number of heads per plant, the number of branches, biomass, and harvest index (Acharya, 2004; Baradaran, 2001: Zahedi, 2004). Based on the results, there was a positive correlation between number of heads per plant and the number of secondary branches (r=0.85).

The correlation between yield per plant, and the number of heads per plant was also reported by Ashri (1971).

Table 5: Correlation Coefficient of yield and yield component in exotic and domestic varieties of safflower

	Seed yield	Oil yield	Number of heads	Number of seed per heads	Number of secondary branches	1000 seed weight	days to maturity
Seed yield	-						
Oil yield	0.89**	-					
Number of heads	0.80**	0.031	-				
Number of seed per heads	0.51**	0.07	0.65**	-			
Number of secondary branches	0.59**	0.21	0.85**	0.141	-		
1000 seed weight	0.07	0.17	0.126	0.07	0.13	-	
days to maturity	-0.02	0.16	0.71**	0.15	0.67**	0.02	-

** and ** represent statistically significant at 1 and 5 percent*

Conclusion

Based on the results, LRV51/51 has the highest yield, among the studied varieties. It is recommended that these varieties are used in the in the region and regions with similar climate. LRV51/51 was ranked first in having traits which correlate highly with yield, which were oil yield per plant, and the number of heads per plant. The highest seed yield (2679 kg/ha) was produced with September 23 planting time, and 4 centimeter density.

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