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Effects of Different Sowing Date and Intrarow Spacing on Yield and Some Agronomic Traits of Safflower (*Carthamus tinctorius* L.) Under Harran Plain's Arid Conditions*

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Abstract: This study was conducted to determine the suitable sowing date and intrarow spacing for safflower (*Carthamus tinctorius* L.) under Harran Plain's arid conditions during the 1998-1999 and 1999-2000 winter growing seasons. Four sowing dates (mid-October, early November, mid-November and early December) and 5 intrarow spacings (5 cm, 10 cm, 15 cm, 20 cm and 25 cm) were applied. Dinçer-118 was used as the safflower cultivar. Seed yield (1191.7-667.5 kg ha^{-1}), oil content (35.48-25.66%), oil yield (389.4-175.9 kg ha^{-1}), shell rate (50.37-39.33%) and 1000-seed weight (36.71-29.22 g) were investigated and all parameters measured were significantly affected by the treatments. The results obtained showed that the most suitable sowing date and intrarow spacing for safflower on Harran Plain were November and 5 cm, respectively.

Key Words: Safflower (*Carthamus tinctorius* L.), Sowing date, Intrarow spacing

Harran Ovası Kuru Koşullarında Farklı Ekim Zamanları ve Sıra Üzeri Aralıklarının Aspir (*Carthamus tinctorius* L.)'de Verim ve Bazı Tarımsal Karakterlere Etkisi

Özet: Bu çalışma, Harran Ovası koşullarında aspir (*Carthamus tinctorius* L.)'de uygun ekim zamanı ve sıra üzeri aralığını belirlemek amacıyla 1998-1999 ve 1999-2000 kışlık ürün yetiştirme dönemlerinde yürütülmüştür. Denemede, 4 farklı ekim zamanı (ekim ayı ortası, kasım ayı başı, kasım ayı ortası ve aralık ayı başı) ve 5 farklı sıra üzeri aralığı (5 cm, 10 cm, 15 cm, 20 cm ve 25 cm) uygulanmıştır. Aspir çeşidi olarak Dinçer-118 kullanılmıştır. Çalışmada, tohum verimi (1191.7-667.5 kg ha^{-1}), yağ oranı (% 35.48-25.66), yağ verimi (389.4-175.9 kg ha^{-1}), kabuk oranı (% 50.37-39.33) ve 1000-tohum ağırlığı (36.71-29.22 g) özellikleri incelenmiştir ve tüm incelenen özelliklerin uygulamalardan istatistiği olarak önemli derecede etkilendiği saptanmıştır. Bölgemiz kuru koşulları için en uygun ekim zamanının kasım ayı ekimi ve en uygun sıra üzeri mesafe ise 5 cm dir.

Anahtar Sözcükler: Aspir (*Carthamus tinctorius* L.), Ekim zamanı, Sıra üzeri aralıkları

Introduction

There is an increased demand for oil production in Turkey. In order to reduce deficiency in oil production and the level of oil and oilseed imported, oilseed crop production areas and oil yield should be increased or alternative oil crops should be introduced (Kolsarıcı et al., 2000). Winter oilseed crops including safflower have a potential to meet much of Turkey's oil demand. Regarding growth conditions, safflower is not selective and is more tolerant to drought and low temperatures (e.g., -12 °C) than other oil crops. In particular, in arid conditions, it can be planted in fallow areas (Karaca et al., 1989). The resistance of safflower to harsh climatic conditions makes it possible to be rotated with wheat, barley, lentils, chickpea and tobacco in arid areas. Therefore, it is fair to assume that safflower has a great potential for arid areas of the GAP (Southeastern Anatolia Project) region as an alternative plant to traditional winter crops.

The field and quality properties of safflower are largely determined by ecological factors and cultivation techniques. It was reported that the sowing date and intrarow spacing of safflower vary depending on ecological conditions (Alessi et al., 1981;

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Hadjichristodoulou, 1985; Gençer et al., 1987; Hadjichristodoulou, 1989; Rao et al., 1990; Pujari et al., 1993; Patel et al., 1994; Tomar, 1995; Patel et al., 1997; Samarthia and Muldoon, 1997). Gür and Özel (1997) reported that the highest yield for safflower was obtained from November sowings of the cultivar Dinçer-118. Therefore, in order to obtain safflower with high yield and quality, it is essential to determine the suitable growth conditions and cultivation techniques.

The aim of this study was to detemine the optimum sowing date and intrarow spacing for safflower under the arid conditions of Harran Plain.

Materials and Methods

Field trials were conducted in the 1998-1999 and 1999-2000 winter growing seasons at the GAP Koruklu Agricultural Research and Development Station, south of Şanlıurfa province.

Some climate data concerning the research area are given in Table 1 (KHGM, 2000).

In both growing seasons, the total rainfall was much lower than the long-term values and the pattern of rainfall in 1998-1999 and 1999-2000 was uneven (see Table 1).

Table 1. Some climate variables during the 1998-1999 and 1999-2000 growing seasons and long-term values.

		Temperature ºC			Precipitation	Humidity
Months	Years	Mean	Max.	Min.	(mm)	(%)
October	1998	19.0	34.8	3.7	-	43.0
	1999	18.8	39.9	2.3	7.0	54.2
	Long Term *	18.2	39.4	-1.2	19.9	42
November						
	1998	15.2	28.0	2.7	14.1	59.5
	1999	11.4	26.1	-6.3	6.6	51.1
	Long Term	9.9	31.0	-0.7	44.7	60
December						
	1998	8.7	18.9	-2.9	60.2	80.4
	1999	8.4	20.2	-4.6	18.5	66.4
	Long Term	5.8	22.6	-16.8	61.1	70
January	1999	7.4	17.6	-2.4	26.8	79.3
	2000	4.8	19.6	-7.5	76.9	80.5
	Long Term	4.8	19.8	-10.4	70.6	67
February						
	1999	7.9	19.6	-5.4	49.8	73.1
	2000	6.2	17.1	-6.9	21.3	65.6
	Long Term	5.8	25.8	-14.0	64.4	63
March						
	1999	10.8	24.4	-2.8	72.4	62.5
	2000	9.5	26.3	-4.0	25.9	61.9
	Long Term	9.7	27.0	-12.2	57.6	57
April						
	1999	16.0	32.1	3.0	17.8	61.1
	2000	17.2	30.2	2.0	41.5	65.9
	Long Term	15.0	34.8	-3.4	26.6	55
May						
	1999	23.9	39.2	7.6	1.0	37.4
	2000	22.1	35.5	6.2	3.5	45.0
	Long Term	21.8	43.0	1.0	22.3	41
June						
	1999	28.0	40.5	14.8	1.5	37.1
	2000	28.3	41.0	14.0	-	29.4
	Long Term	28.0	45.4	9.4	4.0	33
	1999				243.6	
TOTAL	2000				201.2	
	Long Term				371.2	

* Average of 21 years between 1979-1999 (KHGM, 2000)

The soil of the research field belonged to Harran I series and had A, B and C horizons, flat and/or flat-like slope, aluvial main material and a deep profile. According to soil analysis carried out prior to sowing in 1998, the soil of the research area had levels of chalk, pH, salt and organic matter of 17%, 7.84, 0.08% and 1.37%, respectively, and had a clay texture.

The experimental design was randomised complete block with a split-plot arrangement of treatments in 3 replicate blocks. Four sowing dates (mid-October, early November, mid-November and early December) were applied to whole plots, and 5 intrarow spacings (5 cm, 10 cm, 15 cm, 20 cm and 25 cm) were applied to sub-plots. In the trial, interrow spacing was chosen as 30 cm as reported by Gençer et al. (1987) and Patel et al. (1994, 1997). Dinçer-118 (with red flowers and unspiny) was used as the safflower cultivar and was supplied by the Anatolia Agricultural Research Institute (Eskişehir, Turkey). Sowings were performed on 15 October, 3 November, 17 November and 1 December in 1998; and on 15 October, 2 November, 16 November and 1 December in 1999. Plots had 6 rows and row length was 6 m. The sowings were performed in the rainfed plots and no irrigation was applied afterwards. Plants were thinned in February in both years. No effect of frost was observed. However, in the second year, at the rosette stage, *Delia* sp. (*Diptera: Anthomeyiidae*) caused harm by damaging the growing points of the plants. This led to tillering by means of new shooting from the leaf axil. No measure was taken for plant protection. Observations were carried out on 4 central rows, and 1 m from both ends of the rows was left as it represented the border effect. Nitrogen (60 kg ha^{-1}) and phosphorous (50 kg ha^{-1}) were applied. Half of the nitrogen and all of the phosphorous were applied prior to sowing, and the rest of the nitrogen was applied in March in both years. Plant protection practices were carried out when needed.

A 4.8 m^2 area was harvested on 3 July in both years by a plot combine machine when the plants were completely dried out. In each year, seed samples with the shells of each plot were milled and then the oil content was determined in 5 g by Soxhlet apparatus. Oil yield was calculated by multiplying oil content and the seed yield of each plot. Shell rate was determined in 5 g seed samples. Seeds were weighed and then germinated. After the completion of germination, shells were dried out at ambient conditions, weighed and proportioned to the seed sample weight prior to germination. In each plot, 4 groups of 100 seeds were weighed and their means were multiplied by 10, to calculate 1000-seed weight.

The results of each year were analysed separately according to the split plot design using the MSTAT-C program. Means were separated by the least significant difference (LSD) test at $P \leq 0.05$.

Results and Discussion

Seed Yield

As seen in Table 2, the seed yield varied between 1015.5 and 714.4 kg ha^{-1} in the 1998-1999 growing season and the highest yield was obtained from 17 November sowing with 5 cm intrarow spacing. In 1999-2000, these figures were between 1191.7 and 667.5 kg ha^{-1}, and the highest figure was obtained from 15 October sowing with 25 cm intrarow spacing. No statistically significant effect of sowing date on seed yield was obtained. This resulted from delayed emergence due to insufficient rainfall in early sowings (Table 1). In general, the highest seed yield was recorded with narrow intrarow spacings (5 cm). This may be attributed to increases in plant number per unit area. Similar results were reported by Alessi et al. (1981), Rao et al. (1990), Patel et al. (1994), Salera (1996) and Samarthia and Muldoon (1997). On the other hand, in the second year, the reason for obtaining higher yield with wider intrarow spacing may have been the increase in the number of plants per unit area as a result of tillering by *Delia* sp. The differences between seed yield in both years may have resulted from uneven and/or insufficient rainfall.

Our seed yield values were lower than those reported by Hadjichristodoulou (1985), Gençer et al. (1987), Hadjichristodoulou (1989), Rao et al. (1990), Pujari et al. (1993), Patel et al. (1994) and Gür and Özel (1997). This may have been a consequence of precipitation during the 2 growing seasons being lower than long-term values (Table 1), the cultivars used and other ecological conditions.

Oil Content

Oil content was not affected by treatments in the first year, but it was affected in the second year by intrarow spacing only. While, in the first year, the oil contents were 35.48-31.93% and the highest oil content was obtained from 3 November 5 cm intrarow spacing, in the second

Table 2. Means of seed yields (kg ha^{-1}) according to 4 sowing dates and 5 intrarow spacings in the1998-1999 and 1999-2000 growing seasons.

	Intrarow Spacings					
Sowing Dates	5 cm	10 cm	15 cm	20 cm	25 cm	Mean
			1998-1999 Growing Season			
15 October	854.7	714.4	789.4	905.0	781.2	809.0
03 November	1015.4	770.7	751.3	834.8	864.5	847.3
17 November	1015.5	788.5	803.3	854.8	822.6	857.0
01 December	957.4	818.3	841.3	796.8	735.8	829.9
Mean	960.8 a*	773.0 b	796.3 b	847.9 b	801.0 b	
LSD (5%)			93.52 (intrarow spacing)			
			1999-2000 Growing Season			
15 October	906.7 bcd	783.7 b-e	745.7 cde	824.0 b-e	1191.7 a	890.3
02 November	755.7 cde	791.0 b-e	987.7 ab	852.0 b-e	793.3 b-e	835.9
16 November	827.8 b-e	874.5 b-e	923.5 bc	689.5 de	667.5 e	796.6
01 December	868.3 b-e	785.7 b-e	803.7 b-e	732.0 cde	708.7 cde	779.7
Mean	839.6	808.7	865.1	774.4	840.3	
LSD (5%)			220.80 (sowing date x intrarow spacing)			

* Means followed by the same letter were not significantly different at the 0.05 probability level, according to the LSD test.
N.S.: Not significant

year, the oil contents were 34.81-25.66% and the highest oil content was obtained from 2 November 25 cm intrarow spacing (Table 3). On the other hand, the effect of intrarow spacing on oil content was significant and 25 cm intrarow spacing gave the highest (32.76%) oil rate in the second year. In general, the level of oil in the first year was higher than that in the second year. This may be attributed to the lower precipitation and occurrence of *Delia* sp. in the second year.

Oil content values obtained were similar to the values reported by Hadjichristodoulou (1989) and Patel et al. (1994), and higher than the values given by Gençer et al. (1987) and Gür and Özel (1997). These differences may have been a consequence of the cultivars used and ecological conditions.

Oil Yield

The effect of intrarow spacing on oil yield was significant in both years, but sowing dates and sowing date x intrarow spacing interactions were significant in the second year. As seen in Table 3, the oil yield varied between 362.0 and 220.0 kg ha^{-1} in the 1998-1999 growing season and the highest yield was obtained from 3 November sowing with 5 cm intrarow spacing. In 1999-2000, these figures were between 389.4 and 175.9 kg ha^{-1}, and the highest figure was obtained from 15 October sowing with 25 cm intrarow spacing. In general, the highest oil yield was recorded with narrow intrarow spacings. These results were in good agreement with those of other researchers (Alessi et al., 1981; Rao et al., 1990; Patel et al., 1994; Salera, 1996; Samarthia and Muldoon, 1997). In this study, the trend of the oil yield values had a positive correlation with the variations in seed yield and oil content.

Shell Rate

In both years, the effects of treatments on shell rate were insignificant ($P > 0.05$). The shell rate was 50.37-46.80% and the lowest shell rate was obtained from 3 November 5 cm intrarow spacing. In the second year, the shell rate was 49.67-39.33% and the lowest shell rate was obtained from 1 December 10 cm intrarow spacing (Table 4).

The shell rate values obtained were similar to the figures reported by Esendal (1973), and lower than the values given by Gençer et al. (1987). These differences may have resulted from the cultivars used and ecological conditions.

1000-Seed Weight

The effect on 1000-seed weight of intrarow spacing was insignificant in both years. Sowing dates significantly affected the 1000-seed weight only in the first year. As

Table 3. Means of oil contents (%) and oil yields (kg ha^{-1}) according to 4 sowing dates and 5 intrarow spacings in the 1998-1999 and 1999-2000 growing seasons.

Sowing Dates	Intrarow Spacings					
	5 cm	10 cm	15 cm	20 cm	25 cm	Mean
			OIL CONTENTS (%)			
			1998-1999 Growing Season			
15 October	33.45	31.93	33.61	33.97	33.29	33.25
03 November	35.48	33.98	33.51	34.38	33.15	34.10
17 November	33.76	34.23	32.53	35.16	34.51	34.04
01 December	33.47	33.12	34.29	33.22	33.80	33.58
Mean	34.04	33.32	33.48	34.18	33.69	
LSD (5%)			N.S.			
			1999-2000 Growing Season			
15 October	32.39	31.89	30.36	29.07	32.61	31.26
02 November	34.55	30.32	28.05	29.23	34.81	31.39
16 November	26.86	30.41	29.53	25.66	30.48	28.59
01 December	27.75	26.71	28.49	30.16	33.15	29.26
Mean	30.39 ab*	29.83 b	29.11 b	28.53 b	32.76 a	
LSD (5%)			2.751 (intrarow spacing)			
			OIL YIELDS (kg/ha^{-1})			
			1998-1999 Growing Season			
15 October	311.6	220.0	249.5	302.1	268.3	270.3
03 November	362.0	261.1	252.7	286.4	286.3	289.7
17 November	343.3	269.9	261.4	300.4	284.1	291.8
01 December	319.1	270.0	264.8	267.7	251.4	274.6
Mean	334.0 a	255.2 c	257.1 c	289.2 b	272.5 bc	
LSD (5%)			20.89 (intrarow spacing)			
			1999-2000 Growing Season			
15 October	294.0 b	250.0 b-f	226.6 c-g	239.5 b-f	389.4 a	279.9
02 November	261.0 b-f	242.1 b-f	277.0 bc	248.9 b-f	280.7 bc	262.0
16 November	211.4 efg	268.0 b-e	273.1 bcd	175.9 gh	198.9 h	225.5
01 December	240.7 b-f	206.0 fg	227.3 c-g	217.2 d-g	235.3 c-f	225.3
Mean	251.8	241.5	251.0	220.4	276.1	
LSD (5%)			56.89 (sowing date x intrarow spacing)			

* Means followed by the same letter were not significantly different at the 0.05 probability level, according to the LSD test.

N.S.: Not significant

Table 4. Means of shell rates (%) and 1000-seed weights (g) according to 4 sowing dates and 5 intrarow spacings in the 1998-1999 and 1999-2000 growing seasons.

Sowing Dates	Intrarow Spacings					
	5 cm	10 cm	15 cm	20 cm	25 cm	Mean
			SHELL RATES (%)			
			1998-1999 Growing Season			
15 October	50.37	48.66	51.19	50.23	48.24	49.74
03 November	46.80	47.08	46.92	49.23	49.73	47.95
17 November	46.96	47.37	47.14	48.23	48.13	47.57
01 December	47.77	48.37	51.33	46.82	47.54	48.37
Mean	47.98	47.87	49.15	48.63	48.41	
LSD			N.S.			
			1999-2000 Growing Season			
15 October	45.33	47.00	49.67	45.33	49.00	47.27
02 November	45.33	48.67	45.33	45.67	48.00	46.60
16 November	48.00	47.50	47.50	46.50	41.00	46.10
01 December	46.33	39.33	47.33	45.33	43.67	44.40
Mean	46.25	45.63	47.46	45.71	45.42	
LSD			N.S.			
			1000-SEED WEIGHTS (g)			
			1998-1999 Growing Season			
15 October	31.33	30.48	29.84	29.44	31.15	30.45 bc*
03 November	30.53	29.67	29.39	29.22	29.98	29.76 c
17 November	31.33	30.82	31.01	31.72	32.01	31.38 b
01 December	32.72	34.21	32.96	32.27	33.33	33.10 a
Mean	31.48	31.30	31.38	30.66	31.62	
LSD			1.568 (sowing dates)			
			1999-2000 Growing Season			
15 October	34.66	33.32	34.70	34.47	36.71	34.77
02 November	33.40	34.48	34.91	35.91	34.80	34.70
16 November	33.34	35.39	33.25	34.86	33.66	34.10
01 December	33.75	33.93	34.07	35.42	34.38	34.31
Mean	33.79	34.28	34.23	35.16	34.89	
LSD			N.S.			

* Means followed by the same letter were not significantly different at the 0.05 probability level, according to the LSD test.
N.S.: Not significant

seen in Table 4, 1000-seed weight varied between 34.21 and 29.22 g in the 1998-1999 growing season and the highest value was obtained from 1 December sowing with 10 cm intrarow spacing. In 1999-2000, these figures were between 36.71 and 33.25 g, and the highest 1000-seed weight was obtained from 15 October sowing with 25 cm intrarow spacing. The values of 1000-seed weight significantly increased as sowing date was delayed in the first year (Table 4). In general, the second year the values were higher than the first year values. This may have been due to the decrease in the head number per plant (Özel et al., 2001).

Our 1000-seed weight values were similar to or lower than the values reported by Esendal (1973), Hadjichristodoulou (1985), Gençer et al. (1987), Hadjichristodoulou (1989) and Gür and Özel (1997). This may have been a consequence of precipitation during the 2 growing seasons being lower than long-term values (Table 1), the cultivars used and other ecological conditions.

Conclusions

Despite the drought tolerance of safflower, the low water level was the most limiting factor for seed yield in this study. This resulted in lower seed yields in both years.

In the arid conditions of the GAP region, sowing can be performed from mid-October to early December. However, in the early sowings, due to insufficient rainfall, there is a risk of seed viability loss. Furthermore, since the highest yield was obtained from 5 cm intrarow spacing, this intrarow spacing is recommended.

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