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Planting Date Effects on Growth, Yield, and Oil of Irrigated Sunflower[1]

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ABSTRACT

Interest in sunflower (*Helianthus annuus* L.) as an oilseed crop has greatly increased in the Southern Great Plains since 1974. To effectively manage sunflower for oil production and oil quality, information is needed concerning the effect of various agronomic practices. The objective of this research was to determine the effect of planting date on growth, yield, oil percent, and oil fatty acid concentration of irrigated sunflower. Sunfower 'Hybrid 896' seed was planted at about 2-week intervals from late March to late July or early August from 1975 to 1978 on Pullman clay loam (fine, mixed, thermic Torrertic Paleustoll). Time from planting to emergence was influenced by soil temperature, and ranged from 19 days with early plantings to 5 days with late plantings. The time from planting to the 50% ray flower stage decreased with delayed plantings, except for the last four plantings for which the average was about 59 days. Seed yields were not significantly different with plantings from late March to mid-June. Yields decreased with plantings after 21 June. Seed soil percent was relatively constant with early plantings, but decreased with plantings after about 29 May; oil yield/ha also decreased with plantings after that date. The oleic and linoleic acid concentrations of the oil were strongly affected by planting date because the different planting dates resulted in seed development during periods of different temperatures. Early-planted sunflower matured during hot weather, and the oil had oleic and linolecic acid concentrations of 43 and 45%, respectively. Oil from late-planted sunflower, which matured during cooler weather, had oleic and linoleic acid concentrations of around 15 and 75% respectively.

Additional index words: ***Helianthus annuus*** **L., Oleic acid, Linoleic acid.**

INTEREST in sunflower (*Helianthus annuus* L.) as an oilseed crop for the Southern Great Plains began to increase in 1974. In some cases, early planting is desirable to shift the time of field work away from other crops. In other cases, sunflower is planted as a catch crop after hail has destroyed another crop, or when other crops are not planted because of the lack of timely rainfall.

Rainfall has little effect on the optimum planting date for irrigated sunflower. However, temperatures during seed development strongly influence the fatty acid concentration of sunflower oil (Canvin, 1965; Harris et al., 1978; Johnson and Jellum, 1972; Keefer et al., 1976). The oleic and linoleic acid concentrations of sunflower oil generally increase and decrease, respectively, as temperature during seed development increases. The relative concentrations of these acids, which comprise about 85 to 90% of sunflower oil, are important with respect to use of the oil for cooking and food purposes. Oil high in oleic acid is preferred for deep-fat frying or cooking snack foods that require storage before consumption. Oil high in linoleic acid, a polyunsaturated acid, is preferred for salad oils and margarine (Robertson et al., 1979).

The objective of this research was to determine the effect of planting date on growth, yield, oil percent, and oil fatty acid concentration of irrigated sunflower in the Southern Great Plains.

MATERIALS AND METHODS

The research was conducted from 1975 to 1978 on Pullman clay loam (fine, mixed, thermic Torrertic Paleustoll) at Bushland, Texas. Bushland is in northern Texas at about 35° north latitude and 102° west longitude. Elevation is 1,180 m and precipitation averages 470 mm annually. The frost-free period averages 190 days, with 18 April and 28 October being the average dates of last and first frost, respectively.

The research plots were on furrow-irrigated land with uniform 0.3% slope. To facilitate irrigation, the first planting was made at the uppermost position on the slope and successive plantings were made at adjacent downslope positions. Plots were 20 m long and 4 m (four 1-m spaced rows) wide. Four plots were used for each planting.

Before planting sunflower, the field was plowed to form ridges and furrows; trifluralin [α,α,α-trifluoro-2,6-dinitro-*N*,*N*-dipropyl-*p*-toluidine] in 1975 and 1976, and profluralin [*N*-(cyclopropylmethyl)-α,α,α-trifluoro-2,6-dinitro-*N*-propyl-*p*-toluidine] in 1977 and 1978 were applied for weed control[3]; and anhydrous ammonia was chiseled into the furrows at a rate of 112 kg/ha of N, except in 1977 when the soil contained adequate residual N.

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[3] This paper reports the results of research only. Mention of a pesticide does not constitute a recommendation by the USDA for use nor does it imply registration under FIFRA as amended.

Table 1. Growth, yield, and oil factors of irrigated sunflower as affected by planting dates at Bushland, Texas, 1975 to 1978.

Planting	Days from planting to		Physiological maturity date	Plant height	Seed yield	Test weight	Seed oil	Oil concentration	
Range of dates	Emergence	50% ray flower stage						Oleic acid	Linoleic acid
				cm	kg/ha	g/liter		%	
21-23 March	19	91	4 Aug.	120	2,160 a*	400 a*	46.3 ab*	43.0	45.2
3-6 April	12	82	8 Aug.	120	2,050 a	380 c	45.3 abc	43.1	45.2
17-26 April	11	78	11 Aug.	130	1,975 a	390 b	44.3 bc	44.8	43.3
1-10 May	9	71	22 Aug.	140	2,140 a	380 c	47.3 a	39.9	48.4
15-24 May	8	64	2 Sept.	140	2,150 a	350 d	44.2 c	37.1	50.9
29 May-7 June	8	62	12 Sept.	140	1,830 ab	320 g	41.0 d	35.0	52.7
12-21 June	7	59	22 Sept.	130	1,820 ab	330 f	41.4 d	31.5	56.2
26 June-4 July	7	60	6 Oct.	120	1,480 bc	340 e	39.5 d	23.8	60.6
15-19 July	7	57	25 Oct.	130	1,170 c	320 g	40.2 d	15.4	71.6
28 July-1 Aug.	5	59	11 Nov.	130	580 d	280 h	34.6 e	16.3	70.1

* Values in a column followed by the same letter or letters are not significantly different at the 5% level (Duncan Multiple Range Test).

The sunflower was planted at about 2-week intervals from late March to late July or early August. The planting dates are shown by groups in Table 1. Sunflower 'Hybrid 896' seed was planted about 5 cm deep with unit planters in single rows per ridge to obtain about 64,000 plants/ha or a plant spacing of about 15 cm. Soil temperature at planting depth was monitored at three positions in the plot area for about 4 weeks after planting, except in a few cases they were stopped after seedling emergence. Air temperature was measured at a weather station about 2.5 km from the plot area.

The sunflower was irrigated through gated pipe for uniform germination and emergence, and as often as necessary during the growing season to avoid visual water stress symptoms (afternoon wilt). When sunflower moth (*Homoeosoma electellum* Hulst) populations warranted control, the sunflower was sprayed with methyl parathion [*0,0*-dimethyl *0*-(*p*-nitrophenyl) phosphorothioate] at a 0.6 kg/ha rate.

Data were obtained for emergence, flowering, and physiological maturity date (heads yellow with bracts turning brown); plant height; seed yield, test weight, and total oil percent; and oil fatty acid concentrations. Plant heights were measured at full flowering. At or after physiological maturity, head samples for yield were hand-harvested from a 3-m length of the two center rows of each plot, dried, and threshed with a stationary thresher. Seed yields were adjusted to 9% moisture. Total oil percent was determined by the nuclear magnetic resonance (NMR) technique (Granlund and Zimmerman, 1975) on whole seed dried at 70 C. The fatty acid concentration of oil was determined at a commercial laboratory by the gas chromatography method, except in 1978 when the linoleic and oleic acid concentrations of the oil were estimated by the refractive index method (Goss, 1978). All analyses were made on duplicate samples from individual plots, except for fatty acid concentration for which the samples from different plots were composited into one for each planting date in 1975, 1976, and 1977; Data were analyzed by the analysis of variance technique. To establish relationships between planting dates and various sunflower factors, the planting dates were converted to a Julian date basis. Relationships were then calculated by simple linear and quadratic regression analysis techniques.

RESULTS AND DISCUSSION

Time from Planting to Seedling Emergence and Ray Flowers

Time from planting to seedling emergence ranged from 4 to 25 days as a result of different planting dates, and averaged from 5 to 19 days (Table 1). When 3-day average soil temperatures were above 10 C after planting, seedlings generally emerged within 10 days. They emerged more slowly when temperatures dropped below 10 C. Emergence was slowest (25 days) when the average soil temperature remained below 10 C during the entire period from planting to emergence. Sunflower planted after about 1 May generally emerged within 10 days. Slower emergence increases the possibility of insect, disease, rodent, and bird damage to seeds and seedlings.

Average time from planting to the 50% ray flower stage was 91 days for the first planting and decreased with delays in planting to an average of about 59 days for the last four plantings.

Plant Height

Plantings from early May to early June resulted in taller plants than either earlier or later plantings. The trends, however, were not consistent (Table 1). The reason for the height fluctuations is not apparent.

Seed Yield

Average seed yields were not significantly different for the first seven plantings, but yields progressively decreased for the sixth through the tenth planting with some of the differences being statistically significant (Table 1). For the tenth planting, the sunflower did not mature before frost in some years. In 1978, yields were lower with early planting dates than with later plantings because the early-planted sunflower were more severely infested by stem weevils (*Cylindrocopturus adspersus* LeConte) than were the later-planted sunflower.

Seed Test Weight

Seed test weight decreased irregularly from first to last planting (Table 1). Test weight, an indicator of seed density, was closely related to seed oil percent. The equation for the average relationship between test weight (y) and oil content (x) was $y = -110.5 + 10.84x$, with an r value of 0.921 ($P = 0.001$).

Seed Oil Percent and Oil Fatty Acid Concentration

Seed oil percent, which was closely related to seed test weight, generally was highest with the early plantings and progressively decreased with later plantings (Table 1). Because seed yield and oil percent remained relatively constant with the first five plantings, oil yield/ha also remained relatively constant with these plantings. However, plantings after about 29 May

Table 2. Relationships between planting dates on a Julian basis (x) and various sunflower growth, yield, or oil factors (y).

Dependent variable (y)	Equation	Correlation coefficient	Level of significance
Planting to emergence (days)	$y = 40.22 - 0.373x + 0.00101x^2$	−0.813	0.001
Emergence to ray flowers (days)	$y = 121.95 - 0.740x + 0.00198x^2$	−0.912	0.001
Planting to ray flowers (days)	$y = 162.87 - 1.121x + 0.00301x^2$	−0.954	0.001
Plant height (cm)	$y = 70.06 + 0.887x - 0.0030x^2$	+0.318	NS†
Seed yield (kg/ha)	$y = 51.86 + 36.76x - 0.1597x^2$	−0.723	0.001
Seed test weight (g/liter)	$y = 420.60 - 0.091x - 0.0025x^2$	−0.805	0.001
Seed oil (%)	$y = 42.24 + 0.097x - 0.0006x^2$	−0.651	0.001
Oleic acid concentration (%)	$y = 30.48 + 0.312x - 0.0018x^2$	−0.897	0.001
Linoleic acid concentration (%)	$y = 56.66 - 0.287x + 0.0017x^2$	+0.890	0.001

† NS — Not significant.

sharply decreased oil yield because both oil percent and seed yield decreased with planting after that date. The decrease in oil percent for later plantings contradicts the findings of Anderson et al. (1978), who found no correlation between planting date and oil percent for plantings from September to May in Australia.

Concentrations of oleic and linoleic acids in sunflower oil were strongly influenced by planting date (Table 1). The concentrations were affected little by plantings between late March and late April, but changed rapidly thereafter with oleic acid decreasing and linoleic acid increasing for later plantings. Similar trends in oil concentration for sunflower planted during spring and summer were reported by Johnson and Jellum (1972) in Georgia and by Keefer et al. (1976) in Australia. The major factor influencing oil concentration was temperature at the time of seed development (Canvin, 1965; Harris et al., 1978; Keefer et al., 1976).

The earliest planted sunflower in this study flowered in about 90 days (about 20 June), which resulted in seed development during the period of highest average mean temperatures at this location (unpublished records). Later plantings resulted in flowering and seed development during periods of progressively lower average mean temperatures.

Relationships Between Planting Dates and Sunflower Growth, Yield, or Oil Factors

Although the relationships were calculated using simple linear and quadratic regression analyses, only quadratic relationships are shown (Table 2) because, in each case, the correlation coefficient was higher for the quadratic than for the simple linear relationship. The relationship between planting date (x) and the different sunflower factors (y) was significant at the 0.001 level in all cases, except for plant height, which was not significant. Although considerable year-to-year variations can be expected, the high correlation coefficients indicate that the effects of planting dates on Hybrid 896 sunflower factors can be predicted quite accurately for the Southern Great Plains.

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