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MANAGEMENT PRACTICES FOR DRYLAND SUNFLOWER IN THE U.S. SOUTHERN GREAT PLAINS[1]

By

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Summary

Effects of seeding date, plant population and soil water content at seeding on seed yield, oil content, and oil composition were determined for the three years (1975-1977). Seeding date had the greatest effect on yield and reflected the effect of seasonal precipitation patterns. Drought stress reduced yields up to 70%. Yield response to increased soil water content at seeding averaged 99.4 kg/ha-cm. Plant populations in the range of 25 to 45 thousand plants/ha had little effect on yield, but high populations tended to increase oil content. Seeding date influenced oil content and composition with April seedings having a 5 to 8% higher oil content than July seedings. For early seedings, oleic acid content was high and linoleic acid content was low, whereas the opposite was true for late seedings. Linoleic acid contents ranged from 41 to 71%. Yield potential was enhanced when soil water content at seeding was high, indicating that sunflower would be adapted for use on conservation systems such as conservation bench terraces, or after fallow where additional soil water may be available.

Introduction

Dryland (rainfed) crop production is difficult in the central and western parts of the Southern Great Plains because rainfall is low and evaporation potential is high. Annual cropping often results in poor yields, thus water conservation practices such as fallowing and terracing were developed to stabilize production. Major crops in the area are winter wheat (Triticum aestivum L.) and grain sorghum (Sorghum bicolor L. -Moench); however, since 1975, oilseed sunflower (Helianthus annuus L.) has been grown, with over 100,000 ha in Texas in 1977 (Lilleboe, 1978). Significant production was also recorded in New Mexico, Oklahoma and Kansas.

Research was initiated in 1975 at the USDA Southwestern Great Plains Research Center, Bushland, Texas to (a) determine the effects of seeding date, plant population and soil water content at seeding on seed yield, oil content and oil composition of sunflower, and (b) develop management practices for dryland sunflower in the Southern Great Plains.

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[1] Contribution from Federal Research, Science and Education Administration, USDA, in cooperation with the Texas Agricultural Experiment Station, Texas A&M University.

Experimental Methods

The experiment had a split-split plot design with three replications and was conducted for three years, 1975-1977. The treatments were:

1. Soil water content at seeding -- The main plots were three levels of soil water content at seeding, designated as wet, medium and dry. Each water content plot was 61 by 152 m and contained seeding date and plant population subplots. Soil water contents were adjusted on the wet and medium treatments by sprinkler or furrow irrigation during March of each year. The only supplemental water applied during any growing season was 1.5 cm sprinkler applied to all plots on April 9, 1975 to aid seedling emergence. Soil water content for the initial seeding date each year is shown in Table 1.

TABLE 1. Soil Water Content on the Initial Seeding Date Each Year, 1975-77.

Seeding Date	Soil Water Treatment		
	Wet	Medium	Dry
	---------- cm[1] ----------		
April 7, 1975	21.6	19.0	14.7
April 8, 1976	13.5	9.7	5.6
April 11, 1977	14.2	7.6	4.8

[1] Plant available water in the 0- to 1.8-m soil depth.

2. Seeding date -- Seeding was begun each year in early April and continued at approximately 3 week intervals until early July. Each seeding date subplot was 61 by 4.3 m and contained plant population sub-subplots.

3. Plant population -- Plant populations were adjusted by hand thinning at the seedling stage to populations of 25, 35, and 45 thousand plants/ha in 1975 and 1976 and to 17, 25, 35, and 45 thousand plants/ha in 1977. Actual populations on many plots were less than desired because low seed zone water contents limited emergence on some seeding dates during all years. Rodents damaged plants on some plots in 1976 and 1977.

The experimental area was established on a dryland wheat field in 1975 and 1977 and on an adjacent fallow area in 1976. The soil was Pullman clay loam, a member of the fine, mixed, thermic family of Torrertic Paleustolls (order Mollisols). Oilseed Hybrid 896 was seeded with unit planters having double-disk openers in 1-m-wide rows at 73,000 seed/ha. Fertilizer was not applied in 1975 or 1977, since P and K were adequate and soil tests showed that 112 kg N/ha were available in the top 1 m of soil. In 1976, 67 kg/N/ha were applied preplant. Preplant applications of trifluralin controlled weeds and methyl parathion was sprayed as needed to control sunflower moth (Homoeosoma electellum Hulst) during the bloom stage. Soil water contents were determined gravimetrically from samples taken to 1.8-m depths at seeding and 2.4-m depths at harvest in 1975 and to 3-m depths at seeding and harvest in 1976 and 1977. Soil water was monitored throughout the growing season on selected plots by the neutron

method. Sunflower heads on some plots were covered with cloth bags to protect the seed from birds. Heads were hand harvested for yield determinations. Oil content was determined on an oven-dry basis using the nuclear magnetic resonance procedure. Oil fatty acid composition was determined by gas-liquid chromotography.

Results and Discussion

Plant Population

Populations did not significantly affect seed yield in 1975 or 1977 (Table 2). Significant yield differences were observed in 1976; however, the differences were small. None of the interactions between population, seeding date or soil water content at seeding was significant in 1975 or 1977, but the seeding date by population interaction was significant in 1976. These results generally agree with those of Mian and Gaffer (1971), who found no significant yield differences for populations between 24,000 and 43,000 plants/ha for dryland sunflower in Pakistan. They reported that 54,000 plants/ha was optimum. Alessi et al (1977) obtained highest seed and oil yields with 25,000 plants/ha at Mandan, North Dakota. Robinson et al (1976) obtained yield increases at Waseca, Minnesota, by increasing populations from 37,000 to 86,000 plants/ha, but found that populations did not affect yield at Morris and Lamberton, Minnesota. In Saskatchewan, Canada, Vijayalakshmi et al (1975) found that yields tended to be highest with a population of 25,000 plants/ha, but were not significantly different from those with 75,000 plants/ha.

TABLE 2. Effect of Plant Population on Sunflower Seed Yield.

Population	Sunflower Seed Yields		
	1975	1976	1977
No./ha	---------- kg/ha ----------		
17,000	--	--	756 a
25,000	1320 a[1]	337 ab	757 a
35,000	1310 a	408 a	697 a
45,000	1327 a	310 b	748 a

[1] Means within a column followed by the same letter were not significantly different at the 5% level (Duncan's multiple range test).

Sunflower can be grown over a wide range of plant populations with little effect on seed yield. In the Southern Great Plains, populations of 25,000 to 35,000 plants/ha should be adequate for dryland sunflower production.

Higher plant populations significantly increased seed oil content (approximately 1%) in 2 of 3 years as shown in Table 3. Robinson et al (1976) reported similar results in Minnesota.

TABLE 3. Effects of Plant Population and Soil Water Content at Seeding on Sunflower Seed Oil Content.

Population	Seed Oil Content		
	1975	1976	1977
No./ha	---------- % ----------		
17,000	--	--	44.4 a
25,000	42.4 a[1]	41.3 a	44.4 a
35,000	42.5 a	41.2 a	43.6 a
45,000	43.6 b	42.2 b	45.0 a
Soil Water Treatment			
Wet	42.3 a	40.9 a	44.7 a
Medium	42.8 ab	41.3 b	43.4 a
Dry	43.2 b	42.4 b	44.9 a

[1] Means within a column followed by the same letter were not significantly different at the 5% level. Populations and soil water treatment were analyzed separately (Duncan's multiple range test).

Seeding Date

The effects of seeding date on sunflower seed yield (Table 4) reflect the effect of drought stress on yield. Thus, yield was determined primarily by the amount and distribution of precipitation received during the growing season (Table 5). Water stress at any physiological development stage can reduce sunflower yield, but stress at flowering causes the greatest reduction (Robelin, 1967). In 1975, high yields resulted from April and May seedings. Sunflowers planted during these months were flowering in July when precipation was adequate. However, later seedings resulted in low yields because of drought stress during August. A contributing factor to lower yields with late seeding may have been head rot (Rhizopus oryzae), which occurred on all sunflowers seeded May 20 or later.

The growing season in 1976 was dry, which resulted in poor yields for sunflowers seeded on most dates. Timely precipitation significantly increased yields for May 18 seeded sunflowers.

The growing season in 1977 was dry in June and July but much wetter than average during Agusut. Thus, early-seeded sunflower suffered drought stress which reduced yield, but June- and July-seeded sunflower had high yields because moisture was adequate.

Unger et al (1976) reported that highest seed yields of irrigated sunflower at Bushland, Texas, were obtained with May seeding. Johnson and Jellum (1972) obtained highest seed and oil yields when sunflower was seeded before May 1 in Georgia. In Minnesota, Robinson (1970) obtained highest yields with early-May seeding. Yield reductions due to later seeding appear to be related to the rate of physiological development of sunflower, which is hastened by later seeding (alessi, et al, 1977; Robinson, et al, 1976; Johnson and Jellum, 1972).

TABLE 4. Effects of Seeding Date and Soil Water Content at Seeding on Sunflower Seed Yields, 1975-77.

Seeding Date	Yields[1] Soil Water Treatment			
	Wet	Medium	Dry	Mean
	kg/ha			
1975				
April 7	2070 a[2]	1780 a	1680 a	1850 a
April 24	1860 b	1780 a	1460 a	1700 b
May 20	1170 c	1240 b	1110 b	1180 c
June 16	560 d	570 c	550 c	560 d
July 15	600 d	760 c	650 c	670 d
1976				
April 8	220 c	100 d	190 bc	170 c
April 27	550 b	250 c	340 ab	370 b
May 18	980 a	580 a	440 a	660 a
June 11	550 b	470 a	180 bc	403 b
July 1	200 c	160 cd	90 c	157 c
1977				
April 11	960 c	640 d	330 a	640 c
April 27	610 d	430 e	300 a	450 d
May 23	900 c	810 c	330 a	670 bc
June 13	1650 a	1310 a	460 a	1140 a
July 5	1240 b	1120 b	0 b	790 b

[1] Each yield shown for 1975 and 1976 is an average of three reps and three plant populations. Each yield for 1977 is an average of three reps and four plant populations.

[2] Means in a column for each year followed by the same letter were not significantly different at the 5% level (Duncan's multiple range test). Data for each year were analyzed separately.

TABLE 5. Monthly Precipitation, April Through September, at Bushland, TX, USA.

Month	1975	1976	1977	36-Mo. Average
	cm			
April	3.0	6.5	3.4	2.8
May	3.5	4.7	7.1	6.9
June	6.1	2.7	4.2	7.7
July	11.7	3.4	2.1	6.8
August	2.6	6.4	17.9	6.8
September	1.9	6.2	2.7	4.3

Seeding date also influenced seed oil content and fatty acid composition (Table 6). Mean oil contents were 5 to 8% greater for early seedings than for July seeding. During two of the three years, oil content did not differ significantly for sunflower seeded at the three earliest dates. Thus, to obtain highest oil content, sunflower should be seeded by mid-May.

TABLE 6. Effect of Seeding Date on Oil Content and Oil Fatty Acid Composition of Dryland Sunflower Grown at Bushland, Texas, 1975-1977.

Seeding Date	Oil Content[1]	Fatty Acid Components[2]				
		Oleic	Linoleic	Palmitic	Stearic	Other
	%					
1975						
April 7	47.9 a[3]	43.0	46.3	5.3	4.6	0.8
April 24	44.3 b	43.2	45.2	5.4	5.0	1.1
May 20	37.8 e	35.9	51.6	6.6	4.9	1.1
June 16	41.2 d	27.9	59.9	6.4	4.6	1.2
July 15	42.7 c	14.1	70.9	6.4	7.4	1.2
1976						
April 8	45.4 a	43.8	42.8	6.2	6.6	0.6
April 27	44.6 a	36.4	49.8	6.3	7.0	0.5
May 18	44.3 a	33.4	53.3	5.4	6.2	0.6
June 11	34.3 c	22.9	63.2	6.0	7.2	0.6
July 1	39.3 b	24.2	62.4	6.0	6.7	0.4
1977						
April 11	46.1 a	45.7	43.2	5.9	4.0	1.2
April 27	46.5 a	47.7	41.2	6.0	4.2	0.9
May 23	47.4 a	44.6	44.3	6.0	4.0	1.1
June 13	43.7 b	39.6	49.3	6.1	4.0	1.0
July 5	38.2 c	43.4	45.6	5.7	4.1	1.2

[1] Determined by the nuclear magnetic resonance technique on moisture-free samples.

[2] Determined by gas-liquid chromatography.

[3] Means in a column followed by the same letter were not significantly different at the 5% level (Duncan's multiple range test). Data for each year were analyzed separately.

Kinman and Earle (1964) found that linoleic acid content of sunflower grown in the Southern U.S. could be increased by late seeding. Oil composition data in Table 6 support their finding. Oleic acid was high and linoleic acid was low for seed from early seeding. The opposite was true for late seeding. Linoleic acid contents ranged from 14 to 48%. Seeding date did not affect oil composition as much in 1977 as in the other two years of the experiment.

Soil Water Content at Seeding

The effects of soil water content at seeding on sunflower seed yield are shown in Table 4. The wet treatment resulted in seed yields significantly higher than the dry treatment in 1976 and 1977. The soil water contents at the first seeding each year are shown in Table 1. The differences in soil water contents between treatments at later seeding dates tended to decrease because of greater evaporation from the wetter treatments.

Seed oil content was influenced by the soil water content at seeding during two of the three years (Table 3). The wet treatment caused about a 1% lower oil content than the dry treatment.

Yield responses obtained with increasing soil water content at seeding are shown in Fig. 1. Yearly responses ranged from 47.2 kg/ha-cm in 1976 to 127.5 kg/ha-cm in 1975, with a response of 99.4 kg/ha-cm for all three years. The data show the yield potential of dryland sunflower in the Southern Great Plains can be enhanced by increasing the soil water content at seeding.

Figure 2 shows that sunflower can extract water and nutrients to depths of 210 cm. Thus, on deep soils with a high water-holding capacity, water stored at seeding can meet much of the water requirement of sunflower. The Pullman clay loam used in the experiment can potentially store 60 to 65% of the sunflower water use requirement; however, the actual amount of soil water available at seeding depends on precipitation, cropping sequences and conservation practices used. Average soil water content at seeding (0 to 1.8-m soil depth) in the semiarid Southern Great Plains can be increased as much as 9 cm by fallowing or by preventing storm runoff with terracing or land leveling (Jones, 1975).

FIGURE 1. Effect of Soil Water Content at Seeding on Sunflower Seed Yield.

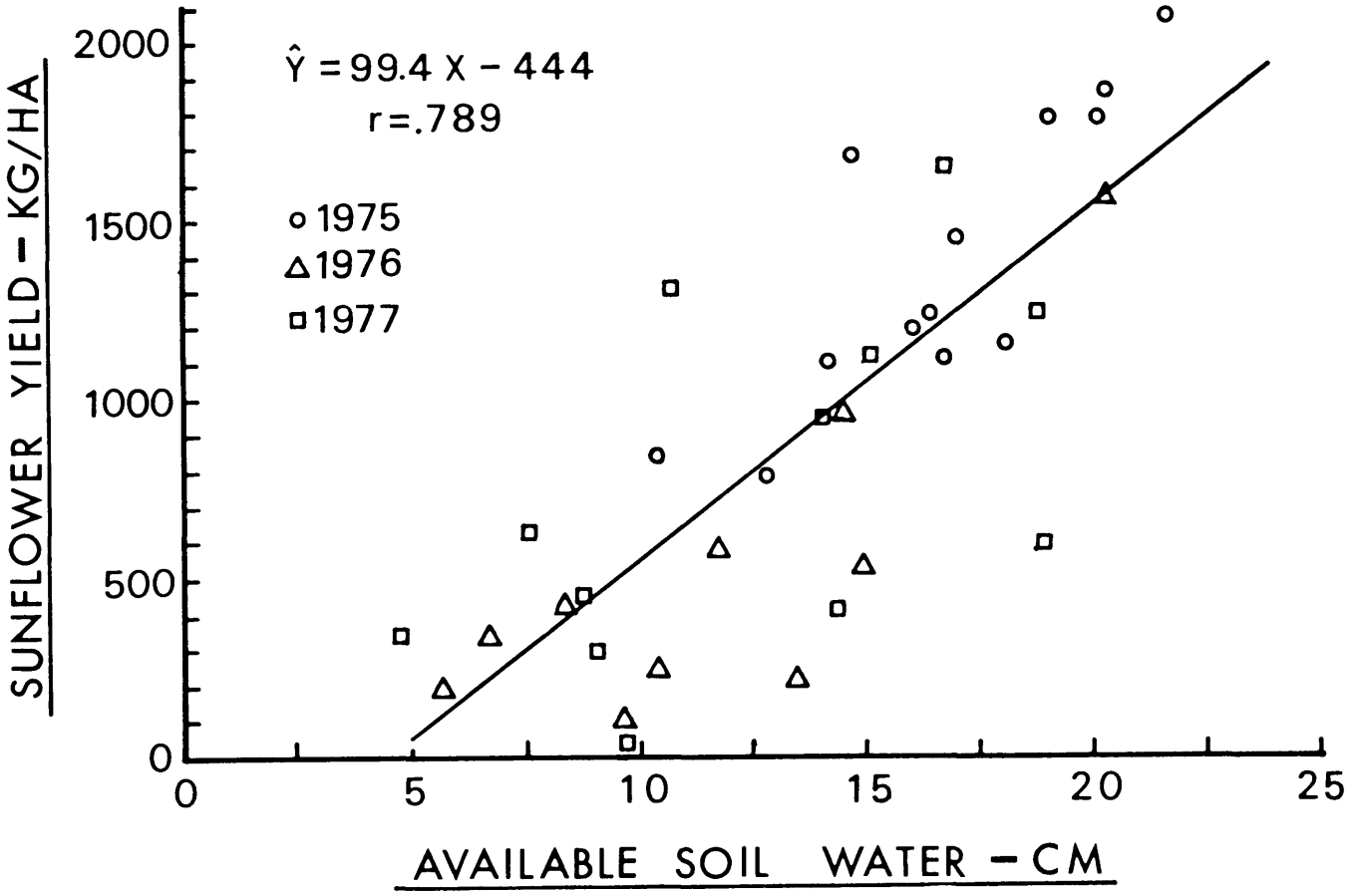
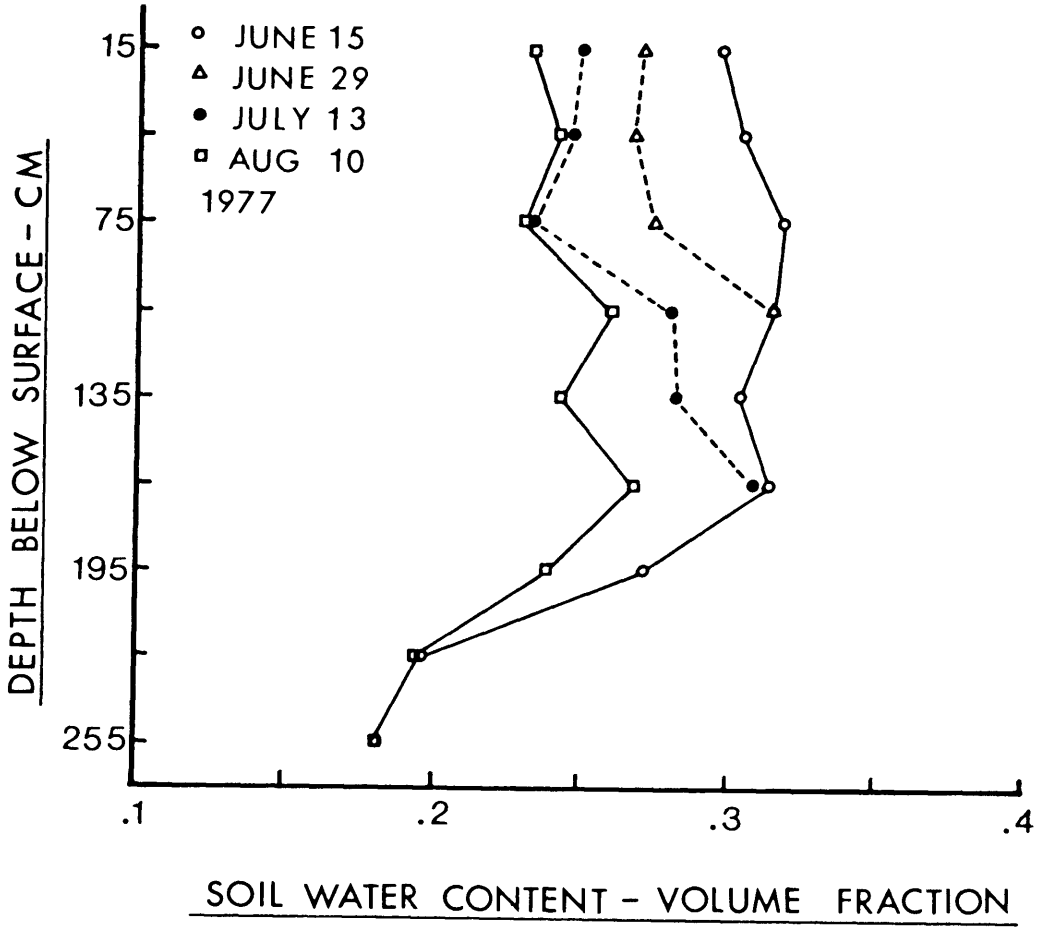


FIGURE 2. Extraction of Soil Water by Sunflower Seeded on April 11, 1977.



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