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SOIL WATER USE COMPARISON OF EIGHT SUNFLOWER CULTIVARS[1]

By

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Abstract

Soil water use by sunflower (Helianthus annuus L.) cultivars Peredovik, 894, 8944, Cargill 204, Cargill 5011, Cargill 5012, Cargill 30311 and Cargill 30312 was monitored throughout the 1977 growing season in the Red River Valley of the Northern Great Plains. The three sites selected as replications of the study were of two different soil types but approximately equal amounts of soil N, P, and K at planting. Neutron moderation equipment was used to determine available water removal patterns. Precipitation and irrigation measurements were combined with soil water data to determine seasonal plant water use. Seed yields were measured at maturity and water use efficiencies calculated for the eight cultivars.

Soil water removal patterns and total water use were essentially the same for all cultivars averaged across sites. Seed yield, oil percent and oil yield differed by cultivar. Water use efficiency, as seed yield per cm of water used by the plant, reflected seed yield differences among the cultivars. The cultivars Peredovik and Cargill 204 were consistently highest in seed yield, oil yield and water use efficiency.

Introduction

Economical crop production involves proper management of resources such as soil water. Knowledge of seasonal plant water requirements can be beneficial in planning crop rotations. Water use by many crops has been under investigation for some time (2,3). A relative newcomer to crop production in the Northern Great Plains (4) is sunflower (Helianthus annuus L.). Although considered to be a drought tolerant crop (1,5), little data are available to quantify seasonal water use by sunflower.

Cultivar selection is another aspect of crop production that relates to best economic return. Selection is often on the basis of previous yield performance. Cultivar water requirements are usually overlooked or information is not available.

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The objectives of this study were to examine total water use by eight sunflower cultivars in addition to determining soil water removal patterns and water use efficiencies of the same cultivars.

Methods and Materials

The study was conducted at three locations in the Red River Valley of the Northern Great Plains in 1977. Physical characteristics of the study sites are presented in Table 1. All three sites were located on soils of relatively recent glacio-lacustrine origin. The prevailing cultural practices for this region include continuous dryland cropping. The climate is sub-humid-continental and the limited amount of irrigation being used is supplemental as a crop water source. The frost free period is approximately 130 days, with seasonal and annual precipitation averaging 30 cm and 49 cm, respectively, for the past 75 years.

TABLE 1. Physical Characteristics of Three Northern Great Plains Study Sites.

Site	Soil Taxonomic Name, Series, and Texture	Site Location	Water Holding Capacity, 0-2 m Profile	
			Total[1]	Available[2]
			---------- cm	----------
1	Sandy, mixed, frigid Aeric Calciaquoll Ulen fine sandy loam	Glyndon, MN	22.0	13.0
2	Sandy, mixed, frigid Aeric Calciaquoll Ulen fine sandy loam	Dilworth, MN	28.6	17.2
3	Coarse-loamy, mixed Pachic Udic Haploboroll Embden fine sandy loam	Hunter, ND	60.9	31.5

[1] Total water holding capacity = cm water held in profile at 1/3 bar soil moisture tension.

[2] Available water holding capacity = cm water held in profile between 1/3 bar and 15 bar soil moisture tension.

Eight sunflower cultivars selected for study are described in Table 2. The primary justification for selection of these cultivars was availability within existing replicated yield trials being conducted by Cargill, Inc. Planting dates were 9 May, 17 May, and 20 May at sites 1, 2, and 3, respectively. Each cultivar was planted in four row plots 6.2 m long with 72.2 cm row spacings. Plant populations were thinned to approximately 44,500 plants per hectare. Soil nitrogen, phosphorus and potassium levels were similar at all sites and adequate for seed yield of at least 2200 kg per hectare (6).

TABLE 2. Description of Cultivars for Which Water Use was Determined.

Cultivar	Description
Peredovik	Open pollinated (U.S.S.R. standard source)
894	F-1 hybrid (U.S.D.A.) - (CMS HA89 x RHA294)
8944	3-way hybrid - (CMS HA89 x HA234) x RHA294
Cargill 204	F-1 hubrid (closed pedigree)
5011	Experimental single cross hybrid (Cargill, Inc.)
5012	Experimental single cross hybrid (Cargill, Inc.)
30311	Single cross hybrid (Cargill 205, Cargill, Inc.)
30312	Experimental single cross hybrid (Cargill, Inc.)

Neutron probe access tubes were installed in one of the center rows of each four row plot after seedling emergence. Soil samples were collected at this time for laboratory determination of total available water to the 2 m depth. Pressure plate and membrane apparatus were used to determine the soil moisture percentage of these soils at 1/3 and 15 bar soil moisture tension (SMT). Available water was calculated as the difference between the 1/3 bar and 15 bar SMT moisture percentages (Table 1).

Neutron moderation equipment was used weekly from installation of access tubes until harvest to detect changes in soil moisture to a depth of 2 m. The moisture data were used to calculate total water use by the sunflower cultivars. Rain guages were installed at all sites. Irrigation amounts at site 2 were also recorded. It was assumed no deep percolation occurred at any site and no runoff was observed.

Sunflower heads in the center 3 m of the two center rows of each plot were bagged after pollination for protection from birds. The 1.5 m at either end of these rows plus the outside row on either side served as border. The bagged heads were harvested at maturity and oven dried at 50 C. Dry heads were threshed and the seeds cleaned before being weighed.

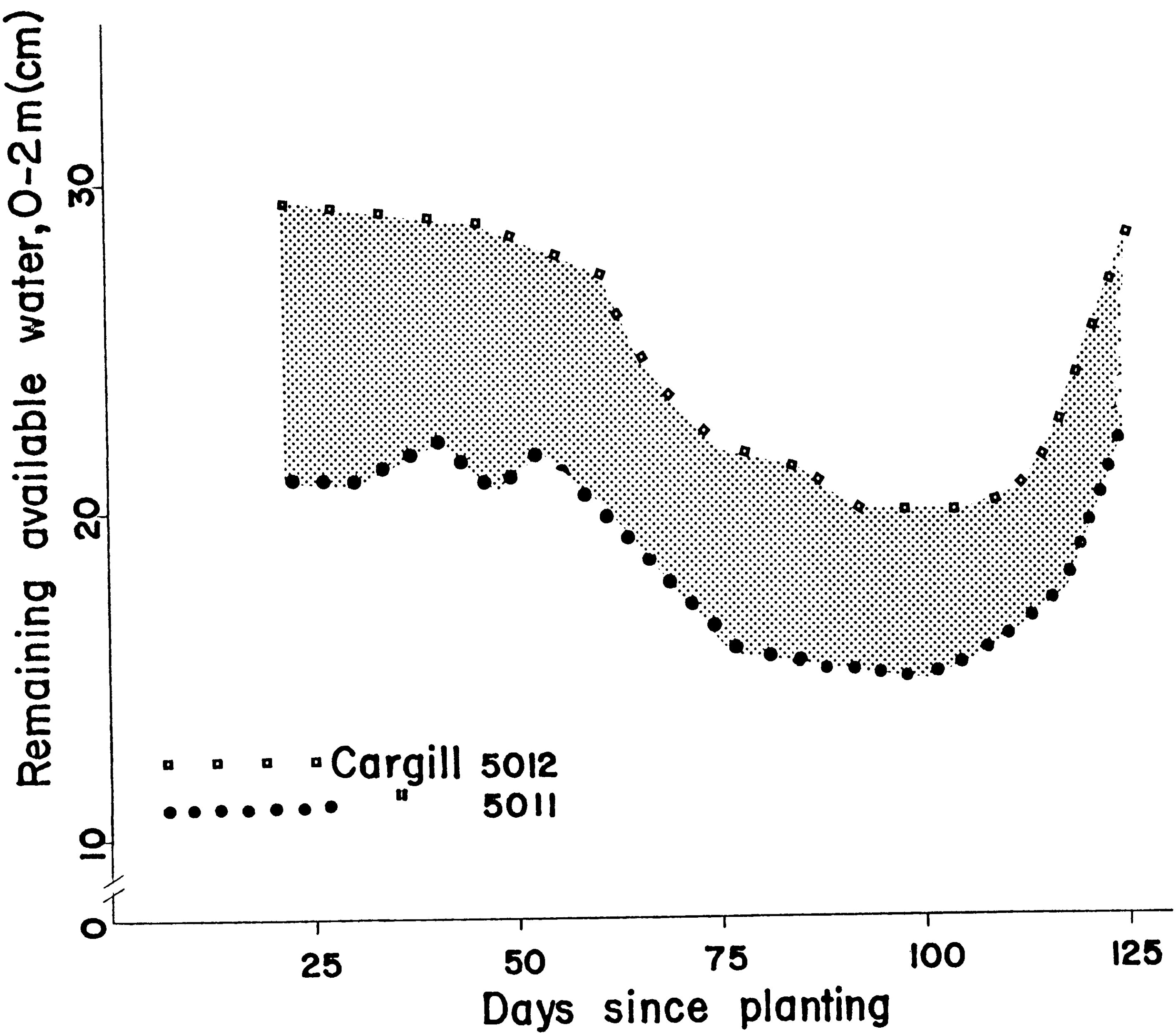
Oil percentage was determined by the nuclear resonance technique for seed yields from 3 additional replicated plots of each cultivar adjacent to the study area.

Results and Discussion

Water Removal Patterns and Water Use

The amount of available water remaining in the 2 m profile beneath cultivars C. 5012 and C. 5011 at various times throughout the growing season is illustrated in Figure 1. The shaded area between the two lines represents the range of available moisture remaining in the profile for all cultivars studied. The moisture data were obtained from averages of all three sites. The figure indicates that the degree of moisture removal was essentially the same for all cultivars. The range between the cultivars was attributed to field variation and differences in available water at the time measurements were initiated.

FIGURE 1. Range in Remaining Soil Water in 0-2 m Profile for Eight Sunflower Cultivars.



Total available water in the soil profile at planting was greater for some cultivars but remained consistently higher throughout the growing season, resulting in similar patterns of removal for all cultivars.

Approximately 50 days after planting there was a marked decrease in total available water as the period of maximum plant growth and water use was initiated. For a period of 8 weeks this rate of depletion continued while the sunflowers completed the vegetative and flowering stages and matured. At maturity, the total available water increased as plant water use ceased and the soil profile was recharged due to precipitation.

Total water use was calculated as the sum of precipitation in soil water storage from planting until harvest. At site 2 water use also included irrigation. Cumulative seasonal water use for each cultivar at all sites was averaged (Table 3). No differences between individual cultivar water use within sites were found although average water use for all eight cultivars varied for each site. Total water use for sites 1, 2 and 3 averaged 25.26, 35.45 and 36.70 cm, respectively (Table 4). All sites received approximately equal precipitation. However, the greater available water holding capacity of the soil at site 3 allowed the cultivars to utilize more stored soil water; thus total water use was greater here. Total water use at site 2, where 7.9 cm of irrigation water were applied, approached that of site 3.

TABLE 3. Summary of Average Yield and Water Use Data by Eight Sunflower Cultivars in 1977*.

Cultivar	Seed Yield (10% H_2O)	Oil Percent** (10% H_2O)	Oil Yield	Water Use	Water Use Efficiency
	kg/ha	%	kg/ha	cm.	kg/ha/cm
Peredovik	2949 a	43.1 b	1271 a	32.8 a	90 a
Cargill 204	2819 ab	41.7 c	1176 ab	33.4 a	84 ab
Hybrid 894	2414 abc	41.2 c	995 abc	33.0 a	73 ab
Cargill 30311	2320 abc	45.1 a	1046 abc	32.0 a	73 ab
Cargill 30312	2308 abc	45.6 a	1052 abc	33.6 a	69 b
Cargill 5012	2142 bc	45.5 a	975 abc	34.0 a	63 b
Hybrid 8944	2131 bc	41.0 c	874 bc	30.5 a	70 ab
Cargill 5011	1894 c	43.5 b	824 c	30.4 a	62 b

Within each column, values followed by the same letter are not significantly different at the 5% level, according to Duncan's multiple range test.

* Each reported value is the average of three sites.

** Two site x 3 rep/site averages.

Yields and Water Use Efficiency

Average seed yield, oil percent and oil yield for each cultivar are presented in Table 3. Average seed yields differed significantly among cultivars with Peredovic and Cargill 204 consistently producing the largest yields at all locations. Average seed yields by site (Table 4) were 1856, 2491, and 2770 kg/ha for sites 1, 2, and 3, respectively.

Oil percent, averaged for sites 1 and 3, is significantly different among cultivars. The ranking of oil percent is not the same as the seed yield ranking. Cultivars with high seed yields were not necessarily high in oil percent. However, Peredovik and Cargill 204 were top performers in terms of both seed and oil yield.

Water use efficiency was calculated as seed yield per cm of water use and averaged for each cultivar (Table 3). Differences in water use efficiency are a reflection of differences in seed yield due to the nonsignificant differences in total water use. Peredovik was more efficient than the other cultivars in terms of water use.

No significant differences were found in water use efficiency when averaged for all cultivars at each site (Table 4). Approximately 73 kg/ha of seed were produced per cm of water used at all locations in 1977. Greater water use was measured at sites 2 and 3 but average water use efficiency was nonvariable due to the larger seed yields produced.

TABLE 4. Average Total Soil Water Use, Seed Yields and Water Use Efficiency of Eight Sunflower Cultivars at Each Site.

Site	Planting Date	Seasonal Precipitation	Irrigation	Soil Water Depletion	Total[1] Water Use	Seed Yield	Water Use Efficiency
		cm				kg/ha	kg/ha/cm
1	9 May	20.7	-	4.6 a[2]	25.3 a	1856 a	73 a
2	17 May	21.0	7.9	6.6 a	35.5 b	2491 b	70 a
3	20 May	22.9	-	13.8 b	36.7 b	2770 b	75 a

[1] Subsurface drainage and surface runoff were nonsignificant at all three sites.

[2] Values in any column followed by the same letter are not significantly different at the 5% level (Duncan's MRT).

Conclusions

No differences in available water removal patterns or total water use were observed among eight sunflower cultivars. Most cultivars selected for study in this experiment may have been too genetically similar for detection of differences in cultivar water use. Soil physical properties influenced water use. With a greater amount of available water for plant use, seed yields and water use increased. Application of irrigation water on a soil type with a somewhat limited water holding capacity resulted in increased seed yields and water use.

Seed yields, oil percents and oil yields were different among cultivars. Peredovik and Cargill 204 cultivars produced largest seed and oil yields.

Water use efficiency differences among cultivars were consistent with seed yield variability since total water use was the same for all cultivars. Peredovik was most efficient for seed production in terms of water use.

Previous yield performance as the basis for selection of sunflower cultivars for seed production should be adequate. In this study water use efficiency directly reflected seed production as total water use was no different among cultivars.

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