Rooting Depth and Water Use of Different Sunflower Phenotypes

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SUMMARY

Field studies were conducted at three North Dakota environments to evaluate the depth of soil water extraction and water use of three sunflower (*Helianthus annuus* L.) hybrids. The hybrids which differed in phenotype and maturity were '894' which is typical in height and maturity of almost all sunflower currently grown in the major U.S. production areas, 'EX 47', an early maturing semidwarf, and 'Sunwheat 101', an early maturing dwarf. Grain yield, harvest index, biological water use efficiency and grain water use efficiency were similar among hybrids.

Differences were found in crop residue production and as expected plant height. Total water use differed significantly among hybrids with 894 using the greatest amount of water. The cumulative water use patterns of all three hybrids were similar even though they were not always in the same stages of phenological development. Approximately 70% of the total water use occurred by the end of anthesis. Depth of soil water extraction differed among hybrids and environments. The later the maturity of the hybrid the greater the depth of water utilization. Depth of soil water extraction was much greater at the drier environments. No significant correlation between rooting depth (depth of soil water extraction) and plant height was observed.

INTRODUCTION

The majority of U.S. sunflower production is located in the northern Great Plains with the highest concentration in central North Dakota. Almost all sunflower in this area is grown under rain fed conditions. Typical hybrids currently being grown would under normal growing conditions average between 1.5 and 2.1 m in height at maturity and are ready to combine harvest 95 to 105 days after emergence.

Recently private breeding programs have developed and released early maturing dwarf and semidwarf sunflower hybrids. These hybrids typically average 1.2 to 1.5 m and 0.8 to 1.2 m in height for the semidwarf and dwarf types respectively. Some of these hybrids mature 1-2 weeks earlier than most commercially grown hybrids. When early maturing hybrids are sown in mid May, the typical period for planting sunflower, they usually yield less than the more common taller and longer season hybrids. These early maturing hybrids, however, have potential in the overall production scheme as a late seeded replacement crop. Schneiter et al. (1992) reported that early maturing types could be sown as late as June 30 and still produce reasonable yields. These hybrids may also have potential as a second crop in more southern parts of the U.S. Harvesting problems in northern North Dakota occasionally occur because conventional hybrids mature late or because inclement weather late in the growing season delays harvest. In these situations the early maturing characteristic would be an advantage. In addition these hybrids, because of their shorter stature, may have reduced stalk breakage, reduced lodging and greater ease of harvest. The production of short stature types would also allow producers to delay their last cultivation.

The major factor limiting the production of all adapted crops in the northern Great Plains is water. Sunflower is especially well adapted for production in this semi arid area because of its extensive and deep root system. This characteristic allows the crop to yield well under water stress, which often causes significant yield reduction in many other crops. One of the concerns with the production of semidwarf and dwarf sunflower phenotypes is that if top growth is reduced, will rooting depth and soil water extraction patterns also change?

Previous research by Majid and Schneiter (1988) compared rooting depth of conventional and semidwarf sunflower hybrids of similar maturity. Results suggest that differences in rooting depth do occur among sunflower hybrids, but that differences are not related to plant phenotype. In these studies no correlation between plant height and depth of soil water extraction was observed.

The objectives of this research were to compare depth of soil water extraction (rooting depth) and water use of early maturing dwarf and semidwarf sunflower hybrids to that of a hybrid of typical height and maturity. This information would assist agronomists in making cropping recommendations to producers in situations where the crop is sown late or where potential drought conditions exist.

MATERIALS AND METHODS

Three diverse sunflower phenotypes were evaluated in field studies conducted during the 1990 and 1991 growing season at Prosper and during the 1991 growing season at Fargo. Both locations are in east central North Dakota. The three hybrids evaluated were '894', which is typical of sunflower genotypes currently being grown in the northern Great Plains, 'EX 47', an early maturing semidwarf, and 'Sunwheat 101', an early maturing dwarf. Soil types at Prosper are mostly Perella (fine-silty, frigid, mixed Typic Haploquolls) and Bearden (fine-silty, frigid mixed Aeric Calciaquolls). Soils at Fargo are mostly Fargo (fine, frigid, montmorillonitic Vertic Haploquoll) and Hegne (fine, frigid, montmorillonitic Typic Calciaquolls). Mean annual precipitation at both locations is approximately 560 mm with an average of 130 frost free days.

Research plots were established the first week in June using conventional farm equipment. In all instances the previous crop was small grain. Weeds were controlled using trifluralin (α,α,α, trifluro-2, 6-dinitro-N, N-dipropyl-p-toluidine) at a rate of 0.84 kg ha^{-1} (AI). This was supplemented with hand weeding when necessary. Experimental design was a RCB with four replications. Each plot consisted of three rows spaced 0.76 m apart and 5.4 m in length. In all instances recommended agronomic practices to optimize yield were followed. Sites were tested for essential nutrient levels and fertilizer applied according to recommended procedures (Dahnke et al., 1990).

A plant population of 44 000 plants ha^{-1} was established by over seeding and then removing excess seedlings at stage V4 (Schneiter and Miller, 1981). Immediately after seedling emergence, soil cores were removed and access tubes were inserted vertically into the soil profile to a depth of 2.3 m equidistant between two plants in the center row of each plot. Neutron probe (Campbell Pacific Model 1) readings at 0.15, 0.31, 0.61, 0.91, 1.22, 1.52, 1.83 m and 2.14 m depths into the soil profile were recorded at periodic intervals. Instrument readings were converted to volumetric soil moisture values using a calibration curve for the test site soil type. Total crop water use was determined as soil moisture depletion plus precipitation. Data were recorded at a nearby fallow site to determine the soil water status of non cropped land. Soil internal drainage and surface water runoff at the test site were considered negligible.

Additional data on stage of plant development and plant height were collected each time readings were taken. Additional performance data were obtained by harvesting the center row of the three row plot. Water use efficiency for grain and above ground biological yield were determined by dividing yield by the amount of water use.

RESULTS

Precipitation at Prosper during 1990 was above normal in June and below normal the rest of the growing season. Temperatures were near normal. Precipitation at Fargo in June 1991 was over 2.5 times normal but was below normal the rest of the growing season. Maximum temperatures were below normal while minimum temperatures were above normal the entire growing season. At Prosper during 1991, precipitation was below normal the entire growing season while temperatures were similar to those experienced at Fargo.

influences the total water requirement for crop development. It would appear that initial concerns about rooting depth of early maturing dwarf and semidwarf sunflower may be unfounded. Because of their early maturity and the ability of sunflower hybrids to adjust to varying degrees of soil water stress by increasing rooting depth, early maturing types appear to be equally well adapted to moisture stress as hybrids of typical height and maturity.

Table 1. Plant height, grain and residue yield, water use efficiency of grain and above ground biological production and harvest index of the sunflower hybrids. Values are an average of three North Dakota environments.

Hybrid	Plant height (cm)	Grain yield kg ha^{-1}	Residue yield kg ha^{-1}	Harvest index (%)	Water use efficiency Grain kg ha^{-1}	Water use efficiency Biological mm^{-1}
EX 47	129	2623	3540	42.6	7.5	17.6
Sunwheat 101	112	2773	3712	42.9	7.2	17.0
894	175	2905	5007	36.5	6.7	18.3
C.V.	5.5	9.3	11.1	5.1	13.2	12.2
LSD ($P \leq 0.05$)	14	NS[1]	388	NS	NS	NS

[1]NS = Not significant.

REFERENCES

Dahnke, W. C., C. Fanning, and A. Cattanach. 1990. *Fertilizing Sunflower.* North Dakota State Univ. Ext. Serv. Circ. SF-713 Rev. Fargo, ND. 2pp.

Majid, H. R., and A. A. Schneiter. 1988. Semidwarf and conventional height sunflower performance at five plant populations. Agron. J. 80:821-824.

Nelson, B. D. 1984. The effect of plant stage and root growth on the incidence of Sclerotinia wilt of sunflower. Phytopathology 74:813.

Schneiter, A. A., B. Cukadar, E. Zaffaroni, and H. Majid. 1988. Agronomic evaluation of semidwarf sunflower. p 363-368. *In* Proc. 12th Int. Sunflower Conference. Nova Sad, Yugoslavia. 25-29 July, 1988. International Sunflower Assoc., Toowoomba, Queensland, Australia.

Schneiter, A. A., S. Hussain, and B. L. Johnson. 1992. How late is too late. The Sunflower. February. p. 20-22. National Sunflower Association, Bismarck, ND.

Schneiter, A. A., and J. F. Miller. 1981. Description of sunflower growth stages. Crop Sci. 21:901-903.