

UTILIZATION OF SOIL MOISTURE BY CORN AND SUGARBEETS

J. T. Moraghan and P. Tiedeman

Sugarbeets in the Red River Valley is a deep-rooting crop which in years of limited precipitation may make extensive use of soil moisture to a depth of 6 feet (3). In contrast, numerous trials by the authors have shown that corn utilizes poorly subsoil moisture below a depth of about 3 feet in many North Dakota soils.

During 1971, nitrogen fertilizer trials with sugarbeets and corn were located adjacent to another on a Fargo clay soil at Fargo. The opportunity was taken to monitor soil moisture and soil temperature changes with these crops during the growing season.

Methods

Corn, variety Agsco 3XAA, and sugarbeets, variety American 2 Hybrid B, were planted on May

11 and May 4, 1971, respectively, in separate but adjacent randomized block experiments in which the treatments were nitrogen fertilizer rates ranging up to 200 pounds of N per acre. Population for the corn and sugarbeets were 18,000 and 17,000 plants per acre respectively, and the corresponding row spacings were 30 and 22 inches, respectively.

Six access tubes for determining soil moisture were placed in the sugarbeet and corn plots treated with 200 pounds of fertilizer N per acre. Soil moisture was determined periodically in the 6-12, 12-24, 24-36, 36-48 and 48-60-inch depth increments by use of a neutron probe procedure. Soil moisture in the sugarbeet plots was also determined in the 60-72-inch depth increment. The moisture in the 0-6-inch depth increment was determined gravimetrically. Three sets of thermocouples for measuring

Dr. Moraghan is professor and Tiedeman is technician, Department of Soils.

soil temperatures at depths of 18, 24, 48 and 60 inches were placed in selected nitrogen treated plots of both crops.

Results

No statistical comparison of the effect of sugarbeets and corn on soil moisture use is possible. However, because of the uniformity of the soil in the experimental areas, differences in water use between the two sites were considered to be due primarily to the type of crop. Also, the soil moisture utilization pattern by corn was similar to that normally found for this crop at Fargo.

Little growth of both crops occurred during May. The corn was approximately 12 inches high by June 21, and tasseling and silking occurred on approximately July 19 and July 27, respectively. A relatively complete sugarbeet canopy covered the soil by July 6. No signs of apparent moisture

stress were observed in either crop until around August 10 when the older corn leaves commenced to die, and incipient wilting was observed. The sugarbeet plants appeared to be affected much less by moisture stress at this time.

Soil Temperatures

The soil temperature data for selected depths during the growing season are given in Figure 1. The type of crop had only a small effect on soil temperature, and the differences were generally small and decreased with depth. For instance, on July 6 the soil at depths of 18, 24 and 36 inches was 1.9, 1.0 and 0.3 Fahrenheit degrees warmer with sugarbeets. Differences of this order of magnitude were only subsequently found on September 15 by which time the corn leaf canopy had largely disappeared. Of interest were the findings that the soil temperature at depths of 48 and 60 inches

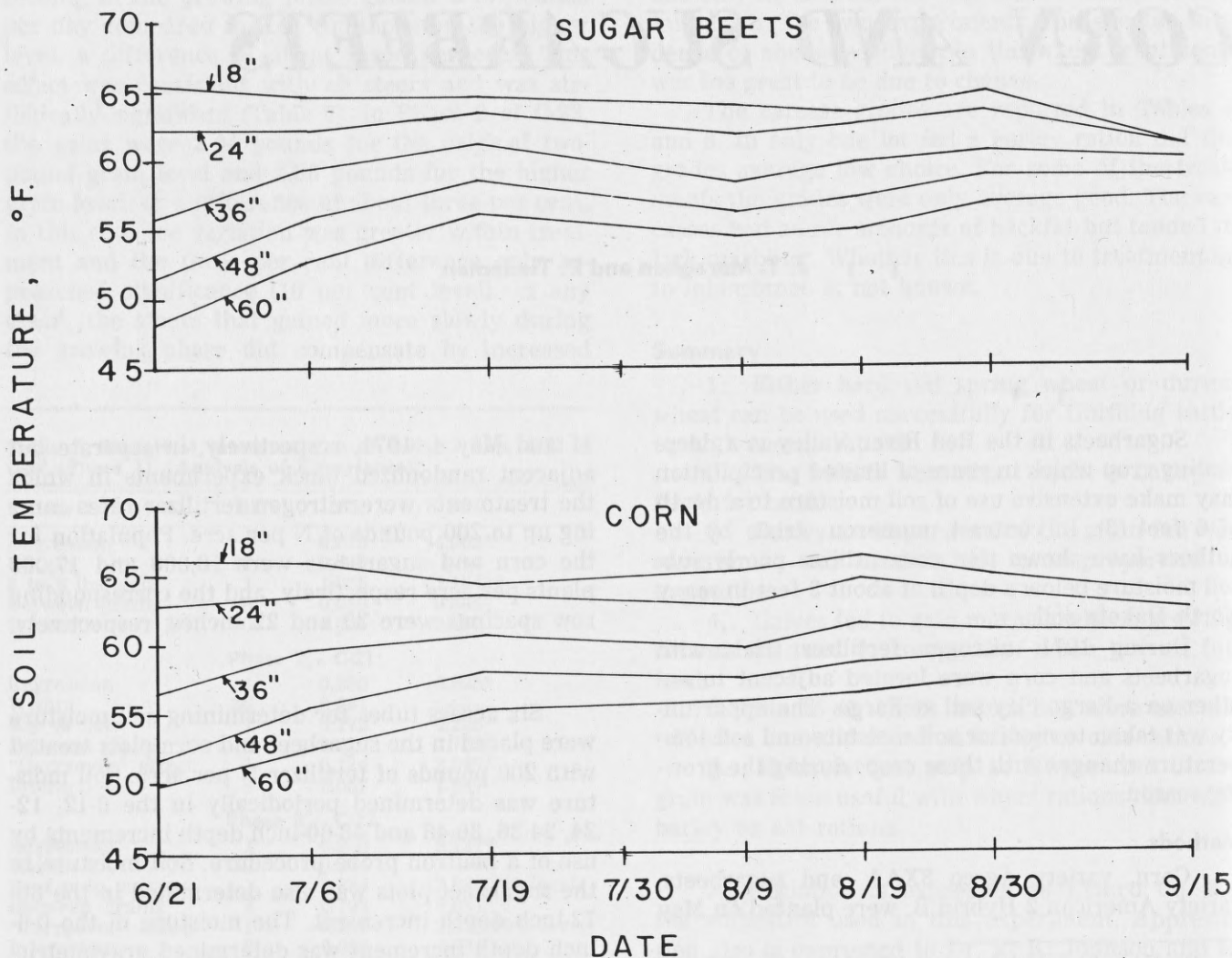


Figure 1. Soil temperatures at selected depths in plots cropped to corn and sugarbeets in 1972.

never exceeded 59°F, while that at 24 inches never exceeded approximately 63°F.

Few, if any, studies have been conducted of the effect on growth of varying the temperature of different parts of the root system. This is the situation which occurs under field conditions. However, based on work in which whole root systems were kept at various temperatures, the growth of sugarbeet and particularly corn roots should be greatly restricted at temperatures occurring in the field at depths greater than 24 inches. The optimum root-zone temperature for sugarbeet root storage growth is in the range 75 to 77°F(4). At a 55°F root temperature the growth was only 30 to 35 percent of that obtained at the optimum temperature. The optimum temperature for corn root growth has been reported to be 78.8°F (5). In this latter study, the root growth at 55.4°F was only approximately 13 per cent of that at 78.8°F.

Precipitation and Soil Moisture

The precipitation received during selected periods of the growing season is given in Table 1. Limited precipitation was received from July 17 until September 4. The precipitation pattern apart from some additional amounts during late June and early

Table 1. Precipitation during selected periods at Fargo during 1971.

Period	Precipitation, Inches
6/21 to 7/19	3.56
7/19 to 7/28	0.35
7/28 to 8/10	0.72
8/10 to 8/20	0.20
8/20 to 8/30	0.35
8/30 to 9/15	3.36

July was similar to that recorded in 1970, a year in which sugarbeets at Fargo extensively used soil moisture to a depth of 6 feet.

The total soil moisture data in one-foot depth increments to a depth of 5 feet are given in Figure 2. Little change in soil moisture under the corn crop occurred below 3 feet. In the sugarbeet plots, however, soil moisture disappeared from the 3-4, 4-5 and to a slight extent from the 5-6 foot depth increments during August. Soil moisture was lost more rapidly from all depth increments in the sugar beet experiment.

Data showing changes in soil moisture for specific depth increments between June 21 and

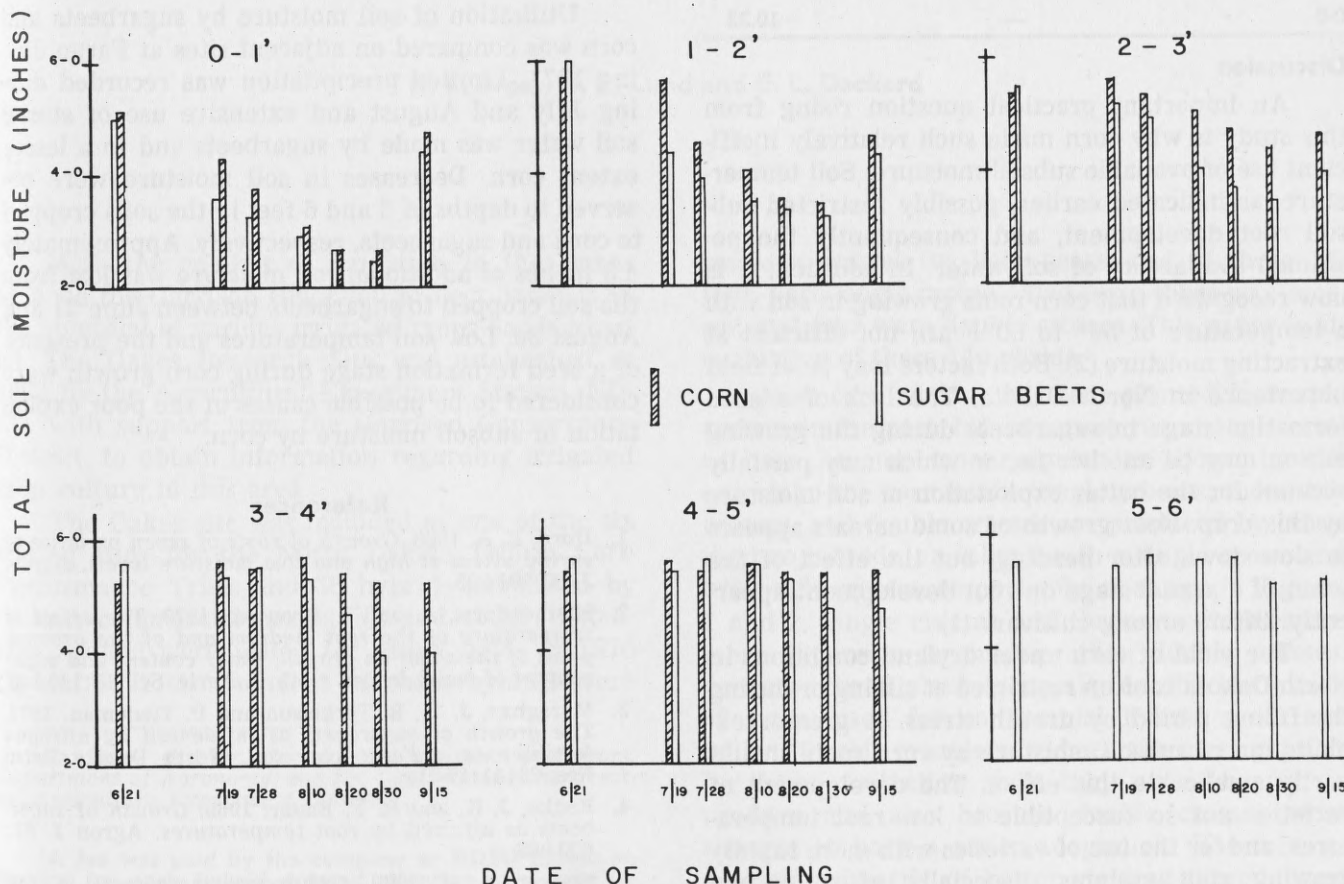


Figure 2. Differences in total soil moisture in selected depth increments of plots cropped to corn and sugarbeets in 1971. September - October, 1972

August 30 are given in Table 2. If it is assumed, as seems likely, that corn used no soil moisture from the 5 to 6-foot depth increment, 4.44 inches of additional moisture were utilized in the sugarbeet experiment. Of this amount, 2.84 inches were derived from the 3 to 6-foot depth increment. The additional 4.44 inches was probably lost mainly by transpiration, rather than by evaporation, since a complete canopy cover was obtained more quickly with sugarbeets.

Table 2. Influence of cropping to sugarbeets and corn on the changes in soil moisture in inches from selected depth increments of a Fargo clay soil between June 21 and August 30, 1971.

Depth increment feet	Corn	Sugar beets
0-1	-2.52	-2.57
1-2	-2.30	-2.79
2-3	-1.06	-2.12
3-4	-0.05	-1.57
4-5	+0.05	-0.87
5-6	—	-0.40
0-2	-4.82	-5.36
0-3	-5.88	-7.48
0-4	-5.93	-9.05
0-5	-5.88	-9.92
0-6	—	-10.32

Discussion

An important practical question rising from this study is why corn made such relatively inefficient use of available subsoil moisture. Soil temperature, as indicated earlier, possibly restricted subsoil root development, and consequently the positional availability of soil water. In addition, it is now recognized that corn roots growing in soil with a temperature of 50° to 60°F are not efficient at extracting moisture (2). Both factors may be of field importance in North Dakota. The lack of a seed formation stage in sugarbeets during the growing season may be another factor which may partially account for the better exploitation of soil moisture by this crop. Root growth of some cereals appears to slow down after heading, but the effect of the onset of a sexual stage on root development apparently differs among cultivars (1).

The yield of corn under dryland conditions in North Dakota is often restricted at silking or during the filling period by drouth stress. A greater exploitation of subsoil moisture by corn roots should partly ameliorate this effect. The development of varieties not so susceptible to low root temperatures, and/or the use of varieties with more rapidly growing root systems, especially after silking, would appear to be desirable aims for researchers.

In addition, better adaption to low soil temperature should quicken early growth and early maturity, both desirable attributes under the short growing season conditions encountered in North Dakota. However, little information is available concerning the genetic diversity in the corn germplasm pool as regards these characteristics. Work has been commenced at Fargo to study the root and top growth at different temperatures of North Dakota and selected exotic corn cultivars. Preliminary work suggests that some exotic varieties grow better at root temperatures below 60°F.

The 1971 sugarbeet moisture data essentially confirm the 1970 findings (3) in showing that sugarbeets may utilize soil water to a depth of 6 feet. Many soils in the Red River Valley are well-supplied with available soil moisture below 3 feet, and, undoubtedly, this reserve of moisture is of extreme importance for dryland production of sugarbeets in many years. Nitrate-N in the 2 to 6-foot increment is probably often available to varying degrees for sugarbeet growth in the latter part of the growing season. This subsoil nitrate availability may in some cases be sufficient to affect quality.

Summary

Utilization of soil moisture by sugarbeets and corn was compared on adjacent sites at Fargo during 1971. Limited precipitation was recorded during July and August and extensive use of stored soil water was made by sugarbeets and to a lesser extent corn. Decreases in soil moisture were observed to depths of 3 and 6 feet in the soils cropped to corn and sugarbeets, respectively. Approximately 4.5 inches of additional soil moisture was lost from the soil cropped to sugarbeets between June 21 and August 30. Low soil temperatures and the presence of a seed formation stage during corn growth were considered to be possible causes of the poor exploitation of subsoil moisture by corn.

References

1. Hurd, E. A. 1968. *Growth of roots of seven varieties of spring wheat at high and low moisture levels.* Agron. J. 60:201-205.
2. Kleinendorst, A. and R. Brouwer. 1970. *The effect of temperature of the root medium and of the growing point of the shoot on growth, water content and sugar content of maize leaves.* Neth. J. Agric. Sci. 18:140-148.
3. Moraghan, J. T., R. Torkelson and P. Tiedeman. 1972. *The growth of sugarbeets as influenced by nitrogen fertilizer on a Fargo clay soil.* North Dakota Farm Res. 29(4):17-21.
4. Radke, J. K. and R. E. Bauer. 1969. *Growth of sugarbeets as affected by root temperatures.* Agron. J. 61: 860-863.
5. Walker, J. M. 1969. *One-degree increments in soil temperatures affect maize seedling behavior.* Soil Sci. Soc. Am. Proc. 33:729-736.