Soil Water Use by Transplanted and Field-Sown Sugarbeets[1]

J. T. MORAGHAN and R. TORKELSON[2]

Received for publication November 8, 1971

The value of obtaining a well-developed sugarbeet leaf canopy as early as possible in the growing season is widely recognized. In an English study Goodman (3)[3] found a significant correlation between yield of storage roots and leaf area duration.

Considerable interest has arisen concerning the transplantation of sugarbeet seedlings as a means of increasing the leaf area duration and root yields of sugarbeets under field conditions (2). Irrigated sugarbeet root yields in Alberta were increased by 4.24 to 9.2 tons per acre through transplantation (1). The increased yield was attributed to an extension of the growing season under conditions favorable to rapid plant growth. In addition to increasing the leaf area duration transplantation may also increase the net assimilation rate (the rate of increase of total dry matter per unit leaf area) early in the season; Humphries and French (4) found that net assimilation rate of sugarbeet leaves was increased by transplantation, and this was attributed to a larger root sink increasing photosynthesis.

Transplantation of sugarbeets often results in a storage root which differs markedly in shape and appearance from that of a field-sown beet. The transplant storage root is more globular in shape, more sprangled and shallower than its field-sown counterpart (6). Conceivably, the fibrous root systems arising from the two types of storage roots could also differ. However, no information appears to be available concerning the moisture withdrawal and fibrous rooting patterns of transplanted sugarbeets. The utilization of stored soil moisture by sugarbeets is an important consideration in a region such as the Red River Valley of Minnesota, North Dakota and Manitoba in which prolonged periods without precipitation often are encountered. The purpose of the reported research was to compare the moisture withdrawal patterns by transplanted and field-sown sugarbeets.

Methods and Procedures

The experiment was conducted on a Fargo silty clay soil at Fargo in 1970 using American Crystal Hybrid B seed. The soil was somewhat poorly drained and was developed from fine-textured lake sediments. Early in the growing season the soil con-

---

[1] Contribution from the Department of Soils, North Dakota State University, Fargo. Published with the approval of the Director as Journal Article No. 316.

[2] Professor and Instructor of Soils respectively.

[3] Numbers in parentheses refer to literature cited.

tained approximately 14 inches of moisture in excess of the 15-bar moisture content in the upper 6 feet. The cumulative 15-bar moisture content of successive 1-foot depth increments to a depth of 6 feet was approximately 20 inches.

The experimental design was a randomized block with a split-plot arrangement of treatments. Nitrogen fertilizer (0, 50, 100 and 200 pounds N per acre) and planting method and population (10,700, 16,000, 22,600 and 28,600 field-sown plants per acre; 22,600 transplants per acre) were the whole and split-plot treatments respectively. The field-sown beets were sown on May 13, 1970 and thinned to the desired stands during June. The transplants were placed in the intended plots on May 18, at the desired population. Each plot consisted of nine 40-feet rows with the rows spaced 22-inches apart. Each treatment was replicated three times.

Access tubes to allow the determination of soil moisture by a neutron thermalization procedure were installed in the 10,700 and 28,600 field-sown plants per acre plots and the transplant plots. Soil moisture was determined periodically during the growing season by the neutron probe in the 6-12, 12-18, 18-24, 24-30, 30-36, 36-48, 48-60 and 60-72 inch depth increments. Soil moisture in the 0-6 inch depth increment was determined gravimetrically.

The transplanted seedlings were raised for approximately 6 weeks in blocks of paper pots containing a greenhouse soil mixture. Small amounts of nitrogen fertilizer were added to insure satisfactorily greenhouse growth. Transplants having approximately 6 to 9 leaves per plant were placed individually in the field soil using hand techniques.

Results and Discussion

The 1970 growing season was characterized by prolonged periods with limited precipitation. The precipitation recorded between the dates of soil moisture determinations is given in Figure 1. During the important months of July, August and early September the sugarbeets were almost completely dependent on the utilization of stored subsoil moisture for growth. Between June 20 and August 28 only approximately 1 inch of rain was recorded, and this amount was of little significance because of its occurrence in widely separated light showers.

As reported by others (6) the storage roots of the transplanted beets differed markedly from those of the field-sown beets. This is well illustrated by the photograph shown in Figure 2. The stor-

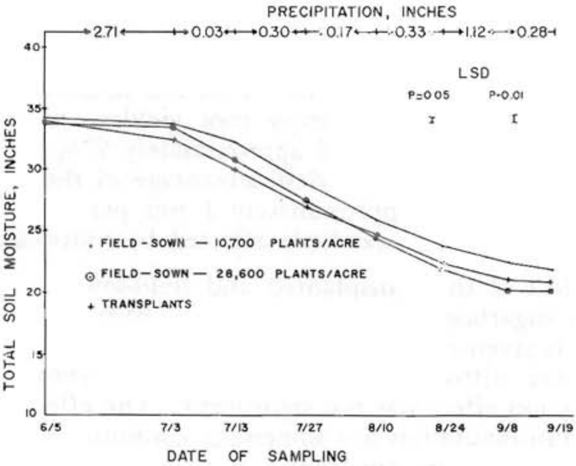

Figure 1.—Effect of transplantation and of two populations (10,700 and 28,600 plants per acre) of field-sown sugarbeets averaged over nitrogen fertilizer treatments on the total water in the 0 to 6 foot depth increment of a Fargo clay soil.

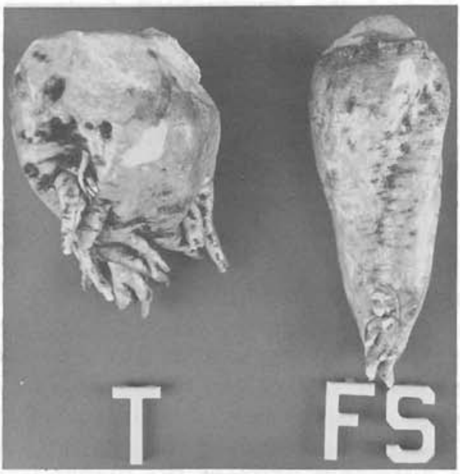

Figure 2.—The shallower, globular, sprangled storage root of a transplanted sugarbeet (T) as compared to the tapered, less sprangled storage root of a field-sown sugarbeet (FS).

age root of the transplanted beets was relatively shallow, globular and displayed numerous fangs. The storage root of the field-sown beets in contrast had the normal taper usually preferred by growers and processors.

Early canopy development of the transplants was superior during May, June and early July. This was reflected in an average increase in transplant storage root yields over that of corresponding field-sown beets of approximately 27% (1.5 tons per acre) on July 28. The final yield advantage of the transplanted beets in October was approximately 1 ton per acre. The percentage sucrose content was little affected by transplantation.

The effect of the transplanted and field-sown low and high population sugarbeets on the total soil moisture in the upper 6 feet of soil is given in Figure 1. The total soil moisture data were averaged over nitrogen treatments since the whole plot—split plot interaction effect was not significant. The effects of population and transplantation are somewhat confounded but the following conclusions are apparent:

(a) During June the transplants used approximately 0.98 and 1.28 inches more soil water than did the higher and lower field-sown populations.

(b) The effect of population and transplantation on water use was relatively small; between June 2 and September 19 the increased water use by the high population field-sown and the transplanted beets was 8.2 and 4.1% respectively greater than that by the low-population beets.

(c) Under the given experimental conditions there was little tendency for transplantation to increase water use over the growing season.

The differences in total soil moisture in selected depth increments during the growing season are given in Figure 3. These data show that the greater use of water by the transplants during June occurred from the 0-12 and to a lesser extent the 12-24 inch depth increments. There was no tendency for the transplants to extract water from deeper soil depths than the field-sown beets later in the season. In fact, the higher population field-sown plants utilized more moisture from the deeper depth increments than did either the transplanted or the lower population field-sown beets. The difference between the higher field-sown population and the transplants could have been due at least partially to a difference in population. Sugarbeets subjected to each of the split-plot treatments made good use of "available" soil mois-

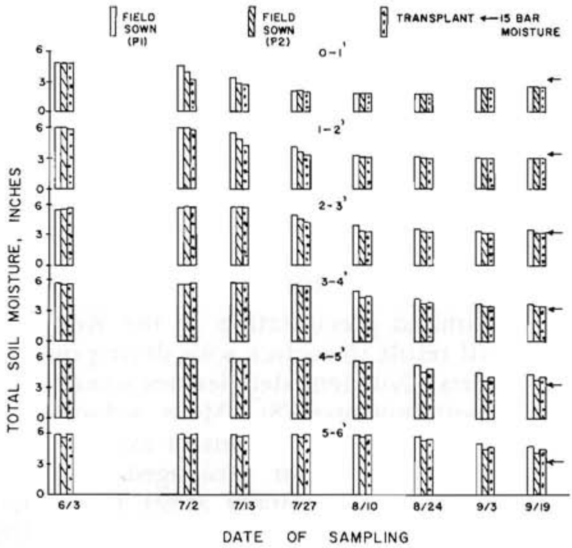

Figure 3.—Effect of field-sown sugarbeet populations of 10,700 (P1) and 28,000 (P2) plants per acre and of transplantation averaged over nitrogen fertilizer treatments on the total soil moisture content of successive 1-foot increments to a depth of 6 feet.

ture (total soil moisture minus 15-bar moisture content) to a depth of 6 feet. The markedly shallower storage root of the transplanted sugarbeets was not associated with drastically reduced water use from the subsoil.

The percentage water lost due to transpiration from the transplanted beets was probably greater than that from the field sown beets during June and early July. The more complete cover early in the season resulting from transplantation probably reduced evaporation from the soil surface. The water use data represent losses due to both evaporation and transpiration.

The commercial success of transplantation under dryland conditions in the Red River Valley of Minnesota and North Dakota would be dependent in many years on the efficient use of subsoil moisture. Soil temperature and fertility may, however, affect the full exploitation of the advantage of a more extensive leaf canopy early in the growing season. A temperature of 12.8 C affecting the whole root system in a greenhouse study drastically reduced sugarbeet root storage growth even though the air temperature 22-24 C (5). Under field conditions the growth of sugarbeet roots into soil at cold temperatures of 12-14 C is probably greatly limited. Such temperatures are found at progressively deeper depth increments in Fargo clay soils during the course of a growing season (9). The tendency for the soil to warm up as the season progresses should decrease the initial advantage that roots of transplants have in exploiting subsoil moisture. Sugarbeet cultivars capable of growing better at low soil temperatures would appear to be most suited for transplantation in the Red River Valley. However, we have been unable to find any references concerning the genetic variability within the sugarbeet germplasm pool for this characteristic.

In seasons of limited precipitation in the Red River Valley transplantation will result in surface soils drying out earlier than with field-sown beets. Nutrient deficiencies sometimes limit the utilization of subsoil moisture (8). Many subsoils in the Red River Valley have extremely low levels of available phosphorus. The absence of precipitation for prolonged periods may slow down root growth and detrimentally affect the exploitation of subsoil moisture as a result of a deficiency of an element such as phosphorus. This effect would also tend to decrease the intial advantage of transplanted over field-sown sugarbeets. Some data obtained during 1970 supported the hypothesis that under dryland conditions in the Red River Valley soil fertility during certain periods may sometimes be more limiting for transplanted than field-sown beets. The acid soluble phosphate content (7) of young but fully mature petioles of transplanted beets during July, August and September was less than that in similar petioles from the field-sown sugarbeets. Also, during August and prior to the late-season precipitation the acid soluble phosphate content of the transplanted sugarbeet petioles was less than the reported critical content (7). The plow layer of the Fargo soil tested "very high" with respect to sodium bicarbonate extractable phosphorus but the subsoil material was "very low" in this fraction.

Summary

The utilization of soil moisture by transplanted and field-sown sugarbeets was studied on a Fargo silty clay soil in the Red River Valley during 1970 under dryland conditions. The growing season was characterized by prolonged periods with limited precipitation. The storage root of the transplanted sugarbeets was shallower, more globular and more sprangled than its field-sown counterpart. However, both transplanted and field-sown sugarbeets utilized moisture to a depth of 6 feet. Transplantation had only a small effect on water use over the growing season. During the early part of the season approximately 1 inch more

of soil moisture was utilized by the transplanted beets. The possible effects of soil temperature and soil fertility in limiting the advantage of transplanted over field-sown sugarbeets in seasons with limited precipitation in the Red River Valley are briefly discussed.

Literature Cited

(1) ANDERSON, D. T., S. DUBETZ and G. C. RUSSELL. 1958. Studies on transplanting sugarbeets in southern Alberta. J. Am. Soc. Sugar Beet Technol. 10: (2) : 150-155.

(2) ANONYMOUS. 1970. Planting idea for a late season. British Sugar Beet Rev. 38:37-38, 50.

(3) GOODMAN, P. J. 1968. Physiological analysis of the effects of different soils on sugarbeet crops in different years. J. Appl. Ecol. 5:339-357.

(4) HUMPHRIES, E. C. and S. A. W. FRENCH. 1969. Photosynthesis in sugarbeet depends on root growth. Planta 88:87-90.

(5) RADKE, J. K. and R. E. BAUER. 1969. Growth of sugarbeets as effected by root temperatures. Part 1: Greenhouse studies. Agron. J. 61:860-863.

(6) SCOTT, R. K. and P. M. BREMNER. 1966. The effects on growth, development and yield of sugarbeet of extension of the growth period by transplantation. J. Agric. Sci. 66:379-388.

(7) ULRICH, A., D. RIRIE, F. J. HILLS, A. G. GEORGE and M. D. MORSE. 1959. Plant Analysis. A guide for sugarbeet fertilization. California Agr. Exp. Sta. Bull. 766. 78p.

(8) VIETS, F. G. 1962 Fertilizers and the efficient use of water. Advances Agron. 14:223-264.

(9) WILKINSON, G. E. 1967. How soil temperature affects plant growth. North Dakota Farm Res. 21:12-14.