Sugarbeet Yields Unaffected by Afternoon Wilting[1]

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Sugarbeet irrigation has been studied extensively in the western United States. The present "state of the art" has been reviewed by Loomis and Haddock (2)[3]. Most field experiments have been run at three or more levels of soil moisture—wet, medium and dry. Differences in root and sugar yields under these moisture regimes have not been strikingly different so long as the "dry" treatment did not cause prolonged wilting, and so long as the "wet" treatment did not cause leaching of nutrients.

One of the more interesting aspects associated with sugarbeet water relations is the tendency of the leaves to lose turgor on a hot afternoon, even though the soil moisture content is high. Plant moisture stress which causes this afternoon loss of turgor may interfere with growth. If the stomata close, photosynthesis may be reduced by a lack of CO_2. There is also evidence that moisture stress affects growth in other ways. Cell elongation may decrease at low turgor pressures. Moisture stress appears to decrease DNA and RNA contents in new leaves. These and other effects of water relations on the biochemistry of plant cells have been reviewed by Slatyer (5). Shah and Loomis (4), working specifically with sugarbeets, found that there was a direct effect of stress on the biochemistry associated with RNA and protein metabolism. This occurred even before wilting was visibly evident. While these observations were made under greenhouse conditions, they do raise questions about the detrimental effects of afternoon wilting on sugar production and the growth of beets in the field.

This question largely has been one of academic interest. If the plants lose turgor on a hot afternoon even when the soil surface appears moist in the shade of the leaves, what more could one do for them? However, with the development of solid-set sprinkler systems and automatic sequencing valves, some control of the microclimate may be conveniently incorporated

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[3] Numbers in parentheses refer to literature cited.

with the process of restoring transpired soil moisture. For example, would it be better to sprinkle a crop continuously for one 12-hour period each week, or for three 30-minute periods during the heat of each afternoon?

As part of an experiment concerning the water relations of sugarbeets, Owen (3) found that sprinkling plants in pots twice a day did not totally control their wilting. Preliminary greenhouse experiments at this Center indicated, however, that loss of turgor could be controlled by frequent light sprinklings. Under high light intensity, a 10- or 15-minute sprinkling caused a drop in leaf water stress of 2 to 3 bars within 20 minutes or less, even when all the soil in the pot was moist. These results, coupled with the report of Shah and Loomis (4), provided the impetus to conduct a field trial using an automated sprinkler system.

Methods

The experiment was conducted as a randomized complete block design with three replications. The three irrigation treatments were: (1) Surface irrigation to fill the root zone when soil moisture stress at the 18-inch depth reached 0.65 bar; (2) intermittent sprinkling during the time of high evaporative demand to replace water use for the day to maintain soil moisture stress at the 18-inch depth between 0.5 and 0.65 bar; and (3) identical intermittent sprinkling at night to serve as a check on treatment No. 2. All treatments were to receive approximately the same amount of water. Treatment No. 2 received an additional inch of water in early September to equalize soil moisture stress.

The plot area of Portneuf silt loam was Fall fertilized with 66 lb of P and 50 lb of N per acre. Pelleted monogerm sugarbeet seed was planted on April 8. The area was irrigated and thinned, and on June 13 the field was sidedressed with 100 lb of N per acre and cultivated.

An automatic solid-set sprinkler irrigation system was installed on the plots to be sprinkled. Due to cool weather, cloudiness and precipitation, another irrigation was not needed until June 29, on which date the surface-irrigated plots were irrigated and the sprinkler irrigation system was turned on. Surface-irrigated plots were again irrigated on July 8, 14, 22, August 5, 17 and September 2 and 19. Sprinkled plots received between 7½ and 10 minutes of irrigation during each 40-minute period from 10:30 A.M. to 5:10 P.M., depending on evaporative demand. Average application rate was about 0.16 inch per hour.

Climatic conditions at Kimberly, Idaho produced higher evaporative demand conditions during 1967 than normal. August was the third hottest August, and September the second hottest September on record. There were 33 days during which evapotranspiration exceeded 0.25 inch.

During July the 18-inch tensiometer readings on the sprinkled plots averaged slightly below 0.5 bar. The soil moisture stress was allowed to increase to an average of 0.56 bar during August. By early September, the soil moisture stress was allowed to increase to an average of 0.68 bar, with the day-sprinkled plots averaging 0.06 bar higher than the night-sprinkled plots. At this time, the day-sprinkled plots received approximately 1 inch of additional water to reduce the soil moisture stress to that of the night-sprinkled plots.

During the growing season, stomatal resistance, plant moisture potential, soil moisture potential, leaf area index, and leaf temperature were measured. Beet root and sugar yields were determined at harvest on October 16. Stomatal resistance was measured with the unit developed by van Bavel (6). Plant moisture potential was determined in a vapor pressure psychrometer similar to the Peltier unit described by Zollinger et al. (7). Leaf temperature was measured with a Barnes Model IT-3[4].

Results and Discussion

The day-sprinkling treatment was very successful in controlling afternoon wilt. The leaves remained extremely turgid throughout the season. In contrast, the plants in the check plots showed typical afternoon drooping, particularly toward the end of each watering cycle.

The relative stomatal opening of the beet leaves was measured on several occasions in July and August. The meter was unable to detect a difference between any of the leaves on any treatment. All leaves supplied water vapor at the same rate as a wet piece of filter paper, indicating the stomata were well open. This included leaves on plants in the check plot on July 7 which obviously had low turgor and were beginning to droop.

The plant moisture stress measurements are summarized in Figure 1. Each point is a mean of two or three measurements taken about midday on the date indicated. Individual measurements occasionally varied as much as 3 bars from the mean.

[4] Trade names and company names are included for the benefit of the reader and do not infer any endorsement or preferential treatment of the product listed by the U. S. Department of Agriculture.

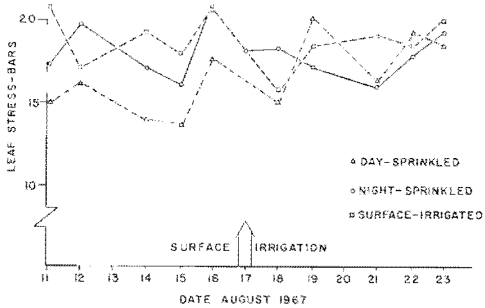

Figure 1.—Sugarbeet moisture stress measurements.

This resulted from random sampling of plants in the plots and reflects moisture stress variations from leaf to leaf. However, these data indicated that the day-sprinkled plants were maintained at a generally lower plant water stress. Between August 11 and 23, the mean midday stresses were 15.8, 17.2, and 18.2 bars for the day-sprinkled, night-sprinkled, and surface-irrigated plots respectively. The lowest field stress of 15.8 bars was about 5 bars higher than the stresses that can be maintained in potted plants growing in the greenhouse. This was evidently due to the difference in environment and may be significant when extrapolating greenhouse studies to field conditions.[5]

Leaf temperatures were measured by placing the sensing head of the infrared thermometer on a tripod 5 feet above soil level and aiming it downward at 40° below the horizontal. A majority of the leaves in view of the instrument were upper leaves, though several were shaded. The instrument recorded a mean integrated temperature for the leaves in its field of view.

When leaves in the sprinkled plots were dry, there was no measureable difference in leaf temperature between the irrigation treatments. Leaf temperatures apparently varied with air temperature, wet bulb temperature, and cloud cover. The temperature of the leaves in view of the thermometer tended to be midway between wet and dry bulb temperatures. On a partially cloudy day, leaf temperatures dropped from 2.5° to 4.5° C when a cloud passed in front of the sun.

Sprinkling reduced leaf temperatures from 2 to 3° C, depending on the initial leaf temperature and the wet bulb temperature; the higher the initial temperature or the lower the wet bulb temperature, the greater the cooling. Soon after sprinkling ceased,

[5] The authors are indebted to H. D. Fisher for making the plant moisture measurements.

the leaves began warming and usually returned to the initial temperature in about 10 minutes. Due to the reduction in leaf temperature during sprinkling the average seasonal temperature of the day-sprinkled leaves would be slightly lower than that of the other treatments. However, on any one day the differences in temperature were small compared to naturally occurring fluctuations.

Table 1.—Mean leaf area indices, beet root yields, and sugar yields for surface— and sprinkler-irrigated plots.

	Leaf area index	Beet root yield	Sugar yield
		tons/acre	tons/acre
Surface-irrigated	7.98	23.0	3.13
Sprinkled daily	9.07	24.5	3.29
Sprinkled nightly	7.75	25.2	3.45

Table 1 shows the mean leaf area indices and yields of beet roots and sugar for the plots. There was no statistically significant difference at the 5% confidence level between any of the results. The day-sprinkled plots did tend to have the largest average leaf area index, although all plots had higher leaf area indices than is considered optimum for efficient sugar production. If there was any trend created by the lowering of the average leaf moisture stress, it was apparently reflected only in greater leaf growth. Since the leaves have priority on the use of nutrients and photosynthetic products, excessive top growth is not necessarily desirable for root crop production. Campbell and Viets (1), working in Montana, obtained their largest sugar production when the leaf area index did not exceed 3 during the growing season.

As there was no significant difference in the yield of either roots or sugar between the treatments, it appears that the afternoon loss of turgor observed in sugarbeets is not an important economic factor in southern Idaho.

Summary

A study was conducted to determine if daily intermittent sprinkling of sugarbeets would control afternoon wilt and if this, in turn, would affect the yield of beet roots and sugar. Daily and nightly intermittent sprinkling was compared with recommended practices of surface irrigation. Plant moisture stress, leaf area index, leaf temperature and yield were measured. Complete control of afternoon wilt was achieved on the sprinkled plots, but yield was not significantly increased.

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