Sugarbeet As Influenced by Row Width, Nitrogen Fertilization, and Planting Date[1]

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In temperate climates the leaf canopy of a sugarbeet crop may not cover the soil surface for more than one-half the time between planting and harvest. The slow development of leaf area during the spring is a critical limitation in sugarbeet production, since the total production of dry matter depends on the size of the photosynthetic system (leaf area), the duration of the leaf area, and its relation to the seasonal income of solar radiation (8). Where nutrients and moisture are optimum, more emphasis should be placed on management practices that will increase the leaf canopy early in the growing season. Early season growth of sugarbeets can be increased by several practices. Dillon et al (5) report that transplanting and the use of polyethylene cover over field-planted sugarbeets increased sucrose yields from 25 to 40%. The objective of our research was to study the influence of nitrogen fertilizer, plant population, and planting date on early growth and the relationship to final yields.

Methods and Materials

Sugarbeets were grown under irrigation in two field experiments at the Colorado State University Research Center near Fort Collins on a calcareous, non-saline Nunn clay loam with row spacing and planting date as variables. Nitrogen fertilizer was broadcast as ammonium nitrate and harrowed into the soil prior to planting. Phosphorus fertilizer was applied uniformly to provide an adequate level of this nutrient. Spring wheat preceded the 1968 experiment and dry beans the 1969 experiment.

The 1968 experiment compared three row widths at two nitrogen levels and two planting dates in a split-block design with 3 replications. The planting dates were April 9 and May 2. Nitrogen fertilizer levels were 40 and 150 lbs. N per acre. Row widths and accompanying plant populations to the nearest 100 were: 1) 22-in rows with 28,500 plants per acre, 2) alternating

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11-in and 22-in rows with 38,000 plants per acre, and 3) alternating 11-in and 33-in rows with 28,500 plants per acre. The plant spacing in the row remained constant at 10 inches.

In the 1969 experiment, there were three row widths at three nitrogen levels and two planting dates in a split-split plot design. Planting dates were April 4 and May 14. Nitrogen fertilizer levels were 0, 60, and 120 lbs. N per acre. Row widths and accompanying plant populations were: 1) 22-in rows with 28,500 plants per acre, 2) alternating 18-in and 22-in rows with 31,400 plants per acre, and 3) alternating 13-in and 22-in rows with 35,800 plants per acre. Nitrogen fertilizer level, the main plot, was split for row width, and planting date was the sub-sub-plot. There were four replications to give a total of 72 plots.

In 1968, the beets in 15 ft. of row were harvested approximately every two weeks beginning June 18. In 1969, the beets in 20 ft. of row were harvested approximately every four weeks beginning June 30. The final harvest in 1969 was 30 feet of row. There were a total of nine harvests in 1968 and four harvests in 1969. Alternate rows were harvested to maintain uniform competition throughout the season. Leaf area index (LAI) was determined by the punch method described by Campbell and Viets (2).

Sucrose content was determined on the brei by a modification of the method outlined in A.O.A.C. (1). Purity of the thin juices was determined by the method of Carruthers and Oldfield (3). Recoverable sucrose percentage was calculated from the sucrose content and thin juice purity by assuming a standard factory loss of 0.3% and a molasses purity of 62.5% (4).

Results and Discussion

Final Harvest Results

The October 14 and October 28 harvests were combined for statistical analysis in the 1968 experiment. There were no main-effect differences between harvests significant at the 10% level, nor were there any interactions between harvests or within the combined harvests. Results of the combined analysis are given in Table 1 for yield and quality, for row width and planting-date effects. Nitrogen fertilizer level had no significant effect on any of the yield or quality characteristics shown in Table 1. The field design gave greatest precision to the row spacing and small differences in yield and quality due to nitrogen treatments were not significant at the 10% level. Petiole nitrate analyses indicated that all treatments had adequate supplies of available nitrogen through September.

Row width had a significant effect on both root yield and recoverable sucrose (Table 1). The significance resulted from lower yields of roots and recoverable sucrose from the 11 × 33-in rows than for the 22-in rows, even though both treatments had the same number of plants per acre. Sucrose content and purity also tended to be depressed by this spacing, although these differences were not significant. The 11 × 22-in row spacing, with one-third more plants, produced about the same yield as the 22-in spacing.

Table 1. Effect of row width and planting date on yield and quality of sugarbeets, October 14 and 28 harvests combined, 1968.

Treatment	Root Yield T/A	Sucrose %	Purity %	Recoverable Sucrose T/A
Row width[1]				
22-in.	19.7	17.9	93.3	3.08
11 × 22-in	19.2	17.5	91.4	2.85
11 × 33-in	16.7*	16.9	91.2	2.31*
Planting date				
April 9	19.2	17.7	93.1#	2.93*
May 2	17.9	17.2	90.9	2.54

[1] Plants per acre: 22-in rows - 28,500; 11 × 22-in rows - 38,000; 11 × 33-in rows - 28,500.

#, * - Differs from 22-in row spacing or from late planting at 10% (#) or 5% (*) levels of significance, respectively.

The early planting increased purity from 90.9% to 93.1% and had the same trend for root yield and sucrose. The combined planting-date effects of root yield, sucrose content, and purity resulted in a significantly greater yield of recoverable sucrose for the early planting. The average yield was 2.93 tons of recoverable sucrose per acre for the April 9 planting compared to 2.54 tons per acre for the May 2 planting. Increased sugarbeet yield and quality from early planting have been reported by Schmehl, et al. (9) in Colorado and by Hull and Webb (7) in England.

The effects of row width and planting date on the yield of the final harvest in 1969 are presented in Table 2. Again, as in 1968, the application of nitrogen fertilizer had little effect on root yield or production of recoverable sucrose. Percentage sucrose, however, was about 3% lower at harvest for all treatments in 1969 than in 1968. Since chemical analysis showed that the nitrogen content of the petioles was about the same in September each year, the low sucrose in 1969 was attributed to cool, wet weather during October. There were 4 inches of precipitation during the first two weeks of October beginning with rain and snow on October 3. The plants were covered with snow much of this two-week period. The mean air temperature for October was 39.5°F and the roots were frozen at harvest.

Table 2. Effect of row width and planting date on root yield and quality of sugarbeets, November 10, 1969.

Treatment	Root Yield T/A	Sucrose %	Purity %	Recoverable Sucrose T/A
Row width[1]				
22-in	21.3	14.6	92.0	2.54
18 × 22-in	21.7	14.6	91.2	2.66
13 × 22-in	20.6	14.9#	92.6	2.59
Planting date				
April 4	24.3*	14.9#	91.8	3.02*
May 14	18.1	14.5	92.0	2.18

[1] Plants per acre: 22-in rows 28,500; 18 × 22-in rows - 31,400; 13 × 22-in rows - 35,800.

#, * - Differs from 22-in row width or from late planting at 10% (#) or 5% (*) levels of significance, respectively.

Increasing the number of plants per acre with closer rows did not affect root yield or recoverable sucrose. The closest row spacing (13 × 22-in rows) did increase the sucrose content slightly (10% level), but the effect was not large enough to increase recoverable sucrose. Although other row widths might have been more advantageous, results of Hills, et al.[3] indicate that stands of 28,500 plants per acre are close to optimum for several different row widths. Goodman (6) considers that under the conditions of southern England, 30,000 plants per acre are sufficient to fill the available space and, given abundant water and nutrients, will produce maximum yields. Thus, it appears that generally there is no advantage to rows closer than 22 inches when the in-row spacing is about 10 inches.

Early planting significantly increased final root yield again in 1969. Beets planted April 4 averaged 24.3 tons per acre compared to 18.1 for beets planted May 14. Early planting also increased the sucrose content from 14.5 to 14.9%. Thus, a delay in planting from April 4 to May 14 reduced the yield of recoverable sucrose from 3.02 to 2.18 tons per acre. The advantage for early planting was much greater in 1969 than in the previous year, but it should be noted that there was a 40-day difference between planting dates in 1969 compared to 23 days in 1968.

Early Growth

Leaf areas and root yields in June and early July are presented in Tables 3 and 4 for 1968 and 1969, respectively. There was no early growth response to nitrogen fertilization, nor were there any significant interactions with nitrogen either year. Therefore, the results are averaged over nitrogen levels for the main effects of planting date and row width.

[3] Hills, F. J., T. M. Little, and G. M. Worker. Sugarbeet spacing and in-row competition. Presented at the 16th General Meeting of the Am. Soc. Sugar Beet Technol., Denver, Feb. 22-26, 1970.

For the June 18 sampling in 1968, planting in 11 × 22-in rows significantly increased early LAI approximately in proportion to the increase in plant population. The 11 × 33-in and the 22-in row widths both with the same plant population had about the same LAI in mid-June. By July 2, the effect of row width on LAI was no longer significant (Table 3).

Table 3. The effect of row width and planting date on leaf area index (LAI) and root yield in June and early July, 1968.

Treatment	June 18		July 2	
	LAI	Root yield, T/A	LAI	Root yield, T/A
Row width[1]				
22-in	0.46	0.24	2.04	3.19
11 × 22-in	0.61#	0.28	2.19	3.22
11 × 33-in	0.48	0.20	1.76	2.66#
Planting date				
April 9	0.76*	0.37*	2.38*	3.75*
May 2	0.27	0.11	1.49	2.09

[1] Plants per acre: 22-in rows - 28,500; 11 × 22-in rows - 38,000; 11 × 33-in rows - 28,500.

#, * - Differs from 22-in row width or from late planting at 10% (#) or 5% (*) levels of significance, respectively.

The first sample date in 1969 was June 30. By this date, row width had no significant effect on either leaf area or root yield (Table 4).

Table 4. The effect of row width and planting date on leaf area index (LAI) and root yield, June 30, 1969.

Treatment	LAI	Root yield, T/A
Row width[1]		
22-in	0.50	0.37
18 × 22-in	0.56	0.39
13 × 22-in	0.56	0.38
Planting date		
April 4	0.95*	0.73*
May 14	0.12	0.03

[1] Plants per acre: 22-in rows - 28,500; 18 × 22-in rows - 31,400; 13 × 22-in rows - 35,800.

* Differs from late planting at 5% level of significance.

Planting date had a significant effect on early growth in both years of the experiment. Delay in planting from April 9 to May 2 in 1968 reduced the mean LAI in June from 0.67 to 0.27 and also reduced root yield in June from 0.37 to 0.11 tons per acre (Table 3). In 1969, delayed planting reduced the LAI on June 30 from 0.96 to 0.12 and reduced root yield from 0.73 to 0.03 tons per acre (Table 4). Thus, the April plantings produced larger leaf canopies earlier in the season which would increase light interception and efficiency in the use of solar radiation.

Seasonal Leaf Area and Root Yield

The effects of planting date on leaf area during 1968 and 1969 are presented in Figure 1. Total solar radiation averaged for two-week intervals is given in the same figure.

For both 1968 and 1969, the beets planted in April produced a larger leaf area early in the season and throughout the year, although relative differences were small later in the season. Although early leaf areas were less for the May planting, maximum LAI for both April and May plantings were attained about the same date each year. The maxima in 1968 were reached about a month sooner than in 1969, caused possibly by greater solar radiation during this early period in 1969 (Fig. 1) or by higher petiole nitrate (4100 vs 5600 ppm NO_3-N) in 1969.

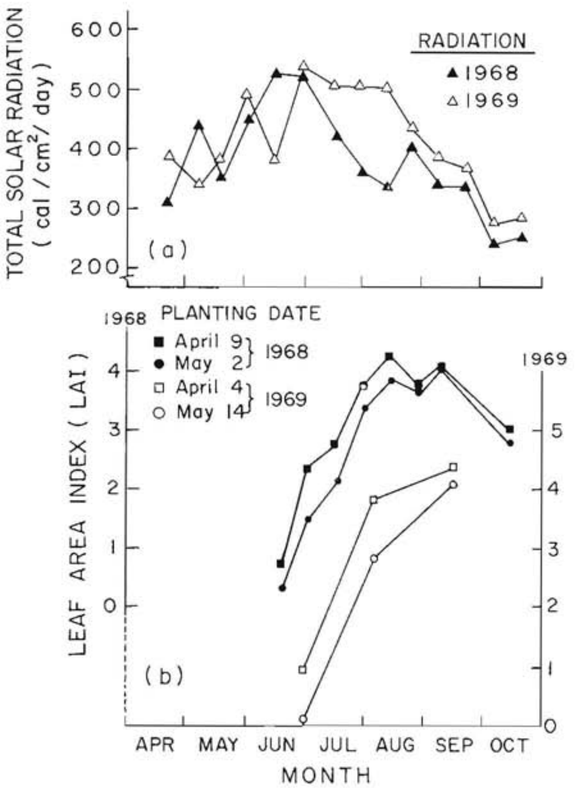

Figure 1a. Total daily solar radiation averaged for two-week intervals for 1968 and 1969 growing seasons.

Figure 1b. Effect of planting date on seasonal leaf area index, 1968 and 1969.

The influence of row width on LAI is shown in Figure 2. As noted previously, differences among row spacings were not significant at the 5% level for either year in late June or early July (Tables 3 and 4). By early August, however, the 11 × 22-in row spacing in 1968 had a significantly greater leaf area than the other treatments (Fig. 2). In 1969 differences among row-width treatments were small throughout the season.

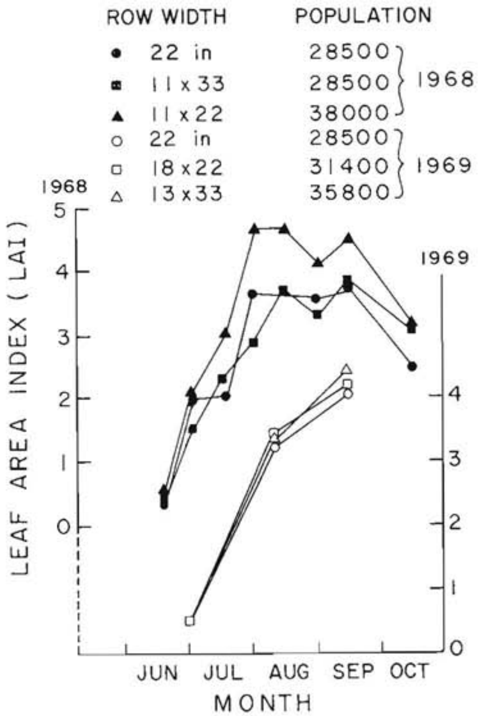

Figure 2. Effect of row spacing on seasonal leaf area index, 1968 and 1969.

The effects of nitrogen fertilization on LAI during the season are summarized in Figure 3. Rates of nitrogen had little effect on LAI until August and September in 1968. Nitrogen effects were not significant in 1969, but the trends were similar.

When LAI for each harvest were correlated with final root yield, correlations were highest for the July 2 sampling in 1968 (r = 0.55, df = 10) and for June 30 in 1969 (r = 0.92, df = 16). Thereafter, correlation of LAI from later harvests with final root yield decreased as the season advanced. Thus, variations in leaf area early in the season had a greater effect on final root yield than did a comparable difference in leaf area at a later date.

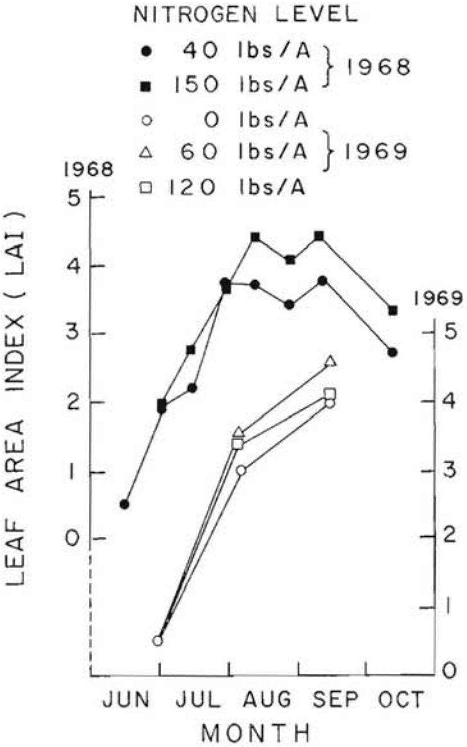

Figure 3. Effect of nitrogen fertilization on leaf area index, 1968 and 1969.

The time of leaf area presentation is as important as the total leaf area, especially when root yield is considered. The only treatment increasing final yields in these experiments was planting date which increased leaf area in June and early July. Although the nitrogen and row spacing treatments increased leaf area in August and September, these treatments did not increase final root yields or recoverable sucrose (Tables 1 and 2) and the 11 × 33-in rows decreased root and sucrose yields in 1968.

Planting date was the only treatment, other than the 11 × 33-in row spacing, that significantly affected the seasonal root growth pattern and final yield. The effect of planting date on root growth shown in Figure 4 is similar for the two years. The advantage of the early planting was greater in 1969, probably because of a greater interval between the two planting dates. The early planting gained an advantage in root yield by early July which was maintained to the end of the season. More than 80% of the difference in final root yield resulting from planting date was attained prior to August 1st of each year.

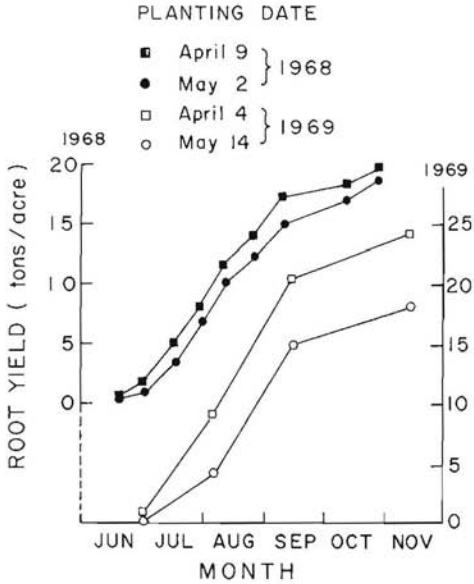

Figure 4. Effect of planting date on seasonal root yields, 1968 and 1969.

The results indicate that cultural practices that do not increase LAI before early July probably will not increase sucrose production in temperate climates. This follows from results of these and other experiments (5, 10) which show that leaf area is the limiting factor early in the season, but that solar radiation generally is the factor limiting growth after about mid-July when the full leaf canopy is developed.

Summary

Field experiments were conducted to determine the influence of row spacing, nitrogen fertilization and planting date on growth and yield of sugarbeets.

The plants were thinned to a uniform 10-in spacing in the row for between-row distances of 11 × 22 (alternate 11 and 22 in between rows), 13 × 22, 18 × 22, 11 × 33, and 22 in. The closer row spacings had only a small effect on early season growth, but did increase the leaf area in August or September. Final yields of roots and sucrose, however, were not increased by rows closer than 22-in, and 11 × 33-in spacing reduced yields of roots and sucrose.

Nitrogen fertilizer had no effect on the early growth of sugarbeets in these experiments, but it did increase the LAI in August and September and reduce final root quality. There was little effect of nitrogen on final yield of recoverable sucrose.

Planting date was the only treatment which had a substantial effect on early-season leaf area and final recoverable sucrose. The earlier planting dates resulted in a closed leaf canopy sooner in the season, and the increase in early top growth was accompanied by an increase in yield of roots. About 80% of the advantage in final root yield from early planting was accrued by the end of July. Light interception and quite probably the efficiency in use of sunlight were enhanced by the early planting because leaf area was increased at a time when LAI was relatively low and solar radiation was high.

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