Effects of Early Terminal Irrigation and Late Nitrogen Application on Yield and Incidence of Root Rot in Sugarbeets in the Imperial Valley[1]

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Introduction

Sugarbeets (*Beta vulgaris* L.) are planted in the Imperial Valley, California, in August, September, and October for harvest in April through July. Roots are harvested daily for immediate processing because roots stored at high temperatures break down internally and decay rapidly. In scattered fields root rot incidence has been great before late harvest in some years but not in others. This has often been associated with (a) high nitrate (NO_3^-) concentrations in unrotted roots in the same fields, (b) relatively wet fields, and (c) relatively cool temperatures in winter and early spring. The absorption near harvest of nitrogen (N) applied to the sugarbeets in fall and winter has been blamed for the high nitrate concentrations in the late-harvested roots.

Growers often terminate irrigations 4 to 8 weeks before harvest to dehydrate the roots. Low N content and water stress are needed to retard root growth before harvest for spring-harvested sugarbeets, whereas low N content and cool temperatures are needed to retard root growth for fall-harvested sugarbeets. Retarding root growth before harvest is necessary to allow the sucrose to accumulate in the roots thereby raising the sucrose concentration (5)[3]. Terminating irrigations early also reduces the probability of root rot in fields with root rot histories. Negligible effects on total sucrose have been reported from afternoon wilting (4) and by terminating irrigations for 3 or 4 weeks before harvest at Phoenix, Arizona (2) or for 30 days in Kern County, California (3). The effects on sucrose yield and root rot of long periods of water stress in the Imperial Valley were questioned because of the high temperatures and the extreme leaf deterioration possible before harvest of early-irrigation-terminated sugarbeets.

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[3]Numbers in parentheses refer to literature cited.

We conducted experiments at the Imperial Valley Conservation Research Center to determine the effects of late applied N and early irrigation termination on yield, sucrose concentration, total sucrose, nitrate concentration, and the incidence of root rot in late-harvested sugarbeet roots.

Methods and Materials

Sugarbeets (cv. USH 10) were seeded in a dry silty clay loam soil (typic torriorthent of the mixed, calcareous, hyperthermic family) on one row beds with 76 cm between row centers. After a previous wheat crop, the 1.5-ha field was plowed to a 0.5 m depth and irrigated. Nitrogen and phosphorus were broadcast at 84 and 46 kg/ha, respectively, and disced into the top 15 cm of soil before bed formation. The field was sprinkler-irrigated on October 1 to 3, 1973, to initiate seed germination. A herbicide, Roneet[4] was applied at 3½ kg/ha with the irrigation water during the later part of the irrigation. The field was resprinkled on October 7. Seedlings were thinned to a 20- to 25-cm spacing on October 23 to 26. An additional 184 kg N/ha (as urea) was sidedressed on November 5. The field was furrow irrigated on eight dates between November 12 and May 17, inclusively. Irrigation water was applied for about 24 hours whenever cumulative evapotranspiration from sugarbeets in an adjacent weighing lysimeter reached 10.2 cm water, following a method that has been described previously (1, 8). Pesticides were applied as required for controlling insects, spider mites, and powdery mildew.

An additional N application and an additional irrigation were compared individually and in combination with no additional N application or irrigation. The additional N was applied at 160 kg/ha (as urea) immediately before an April 3 irrigation. The additional irrigation was applied on June 3. Four replications of a split-split-plot design were used. Within each replication, the N split was within the same plant rows and the irrigation split was between different plant rows which permitted applying the same irrigation treatment over the entire length of a plant row. Individual plots for the N application were 15 m long × three rows wide. A similar-size plot, without the N application, was also marked. The irrigation treatment was applied to an additional three or four rows to each side of the N plots.

Petioles were sampled on April 17 and June 13 and dried at 70°C. Petiole NO_3^--N concentrations were determined colorimetrically utilizing the diazotization method (Technicon industrial method IND-33-69W)[4]. The sugarbeets were observed weekly from April until harvest for root rot. Roots were harvested from a 2 m × 2 row section of each plot on June 25. The harvested roots were topped, washed, weighed, and sampled for determinations of sucrose and nitrate con-

[4]Mention of a trademark or proprietary product does not constitute a guarantee or warranty of the product by the U.S. Department of Agriculture and does not imply its approval to the exclusion of other products that may also be suitable.

centrations. Percent sucrose was determined with a polarimeter. Brei nitrates were determined by the diphenylamine method with a rating of 1 (no color, low nitrate) to 5 (maximum color, high nitrate). Incidence of root and crown rot were also noted.

Experimental Results

Favorably warm temperatures (Table 1) contributed to rapid seed germination, emergence, and growth. Plant leaves completely covered the soil by mid-December. Visible symptoms of foliar N-deficiency appeared in March. Warm April and May temperatures promoted rapid plant uptake and utilization of the late-applied N. Leaves of the plants that received the late N application regreened rapidly after April 3. These plants produced large green leaves in April and May and successively smaller and lighter green leaves in June. Plants that did not receive the late N-application produced successively smaller and lighter green leaves in April and May, followed by small and erect leaves in June.

Table 1. — Summary of air temperatures recorded at the Imperial Valley Conservation Research Center, Brawley, California during the growing season for sugarbeets from October 1973 to June 1974, inclusively.

	Temperature					
Month	Mean Max	Mean Min	Mean† Daily	Max	Min	Normal‡ Mean
	°F					
October	92.0	54.8	73.4	101	45	73.7
November	77.2	45.7	61.4	93	34	62.1
December	72.1	37.7	54.9	79	32	53.8
January	66.8	41.2	54.0	78	27	52.9
February	72.9	39.0	55.9	80	31	57.9
March	78.5	47.4	63.0	90	34	62.1
April	85.3	52.2	70.4	93	43	67.9
May	93.8	57.6	75.7	109	49	75.7
June	106.4	67.3	86.9	117	56	83.4

†arithmetic mean
‡Based on temperature averages for 15 years in 1973 and 16 years in 1974.

Average-leaf-petiole NO_3^--N concentrations were below 800 ppm in unfertilized plots and above 7000 ppm in the fertilized plots on April 17, 2 weeks after the late N application (Table 2). Average leaf petiole NO_3^--N concentrations were equally low in all plots on June 13.

Terminal irrigations on May 17 and June 3 were applied 38 and 21 days, respectively, before harvest on June 25. The older plant leaves wilted slightly during afternoons about 2 weeks after the last irrigation. Older leaves wilted successively more severely with time after the last irrigation until they started dying. The oldest leaves then died progressively as the roots became increasingly less able to absorb water from an increasingly drier soil to meet transpirational losses.

Table 2. — Petiole nitrate on May 17 and June 13 and number, weight, sucrose content, and nitrate level of sugarbeet roots harvested on June 25, 1974. A late nitrogen application of 160 kg/ha was applied on April 3.

Terminal Irrigation Date	Late Application	Roots/ Plot	Root Weight	Brei Sucrose	Total Sucrose	Brei† NO_3^-	Petiole NO_3^--N 4/17	Petiole NO_3^--N 6/13
			kg/plot	%	kg/plot		ppm	
May 17	Yes	15.8	32.8	14.7	4.8	2.8	7029 a	185
	No	15.8	30.8	15.6	4.8	1.8	766 b	160
June 3	Yes	15.2	32.5	14.1	4.6	2.5	7115 a	180
	No	15.5	33.0	14.4	4.8	1.8	756 b	128
Significance*			NS	NS	NS	NS	$P = 0.01$	NS

*Significance at $P = 0.05$, unless oerwise noted.
†Brei nitrate was rated on a scale of 1 (very low) to 5 (high).

At harvest, leaves covered about ⅔rds of the soil surface for the late terminal irrigation and about ½ for the early terminal irrigation, regardless of whether they had received the late N fertilization. Only small leaves were alive which showed little or no visible symptoms of wilting. Roots remained turgid at all times. The soil cracked extensively upon drying.

Average weight, sucrose content, and nitrate content of the harvested roots were equal for all treatments (Table 2). An average plot root weight of 32 kg at 14.7% sucrose yielded 106 MT/ha roots and 15.6 MT/ha total sucrose. Root nitrate concentrations were relatively low. Incidence of rotten roots was negligible, although there was an early stage of crown rot in about 20% of the harvested roots, regardless of treatment. The crown rot appeared as darkened areas or small volumes of soft tissue adjacent to crown cavities. The causal organism(s) was not identified although we suspected *Rhizoctonia*. Root yield was unaffected by the slight crown rot, because the crowns were removed in the harvest procedure.

Discussion and Conclusions

Climatic factors favored rapid growth throughout the growing season. Favorably warm temperatures promoted excellent and rapid seedling emergence and growth, rapid uptake and utilization of the late applied N, and high root and total sucrose yields. The high root yield (106 MT/ha) precluded a high sucrose concentration. By present concepts that the leaf petiole NO_3^--N concentration should have been below 1000 ppm for 60 to 90 days before harvest (5), on April 17 the leaf petiole NO_3^--N concentration was unsatisfactorily high for the late-fertilized plots and sufficiently low for the unfertilized plots for harvest on June 25.

Results from this experiment suggested that residual concentrations within the root zone of N applied judiciously to sugarbeets during fall and winter should not cause high NO_3^--N concentrations in late harvested roots. We cannot recommend an application of 160 kg N/ha in April according to our data; but it did not cause a high NO_3^--N concentration in the roots on June 25. The additional N was used in leaf production during April and May. The equally high total sucrose in both the fertilized and unfertilized plots suggest that the large green leaves photosynthesized sufficiently more sucrose than the light green leaves to compensate for the extra photosynthate required to produce the additional leaves. Data of Krantz and MacKenzie (7) support this conclusion, although there was additional root growth in their experiments with late N applications to sugarbeets planted in late October and early November. In their experiment, leaf petiole NO_3^--N concentrations were below 500 ppm by May 31, with N applications as high as 90 kg/ha in March plus 90 kg/ha in late April. Their root yields were only about ½ of our root yields. These experimental data suggest that we reevaluate the source or cause for the high NO_3^--N of unrotted roots from fields with high incidence of root rot.

Terminating irrigations early as in this experiment did not dehydrate the roots and raise the sucrose percent as much as we had anticipated. Unpublished data from a preliminary experiment in spring of 1972 had indicated that roots dehydrated when water was withheld for 22 days, as compared with 13 days before harvest. Roots were harvested at 2 week intervals from March 28 to June 21. During the 2-week period ending on April 26, 22 days after last irrigation, root weight increased from 63 to 67 MT/ha or 5% and sucrose concentration increased from 12.4 to 14.8%. This compared with a root weight increase from 54 to 63 MT/ha or 18% and a sucrose concentration increase from 11.8 to 12.4% during the previous 2-week period when sugarbeet roots were harvested 13 days after last irrigation. When the harvest date was returned to 13 days after irrigation in the succeeding 2-week period, root weight increased from 67 to 84 MT/ha or 26% and sucrose concentration decreased from 14.8 to 13.9%. During each of the 2-week periods, average total sucrose production was relatively constant at 113 to 131 kg/ha/day. These small differences in average total sucrose production were explained by an increase in photoperiod.

In our experiment, root dehydration was equal for both terminal irrigation dates. The roots remained turgid and dehydrated only slightly before the older leaves died to balance plant water losses with a decrease in plant water absorption, as the soil dried. Further dedydration may not be desirable since rot may occur more frequently in farmers' fields to flaccid roots than to turgid roots. Terminal irrigation date in this experiment did not affect total sucrose.

We did not establish a causal relationship between high root NO_3^--N concentrations and incidence of root rot. If the crown rot had continued to develop and enlarge for an additional 2 to 4 weeks, root yield and sucrose concentration might have decreased markedly in spite of low root NO_3^--N concentrations. Root rot was not significant in farmers' fields until the last 2 weeks in July. Future experiments should be continued until the end of July and should include a season with colder fall and winter temperatures than those in our experiment. These should provide greater contrasts than were obtained in this experiment.

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