Sugar Losses Caused by Frost Defoliation

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Introduction

A previous study (1)[2] of twenty years' results at the Raymond factory showed that the sugar content on the average rose 0.78 percent in the 10-day period preceding a frost of 26° F. or lower, and fell 0.24 percent within ten days subsequent to frost. A further study (2) involving the freezing of sugar beet tops by covering the beets with an insulated box containing dry ice, showed a reduction *in* sugar content of 1.43 and 2.3 percent two weeks after freezing.

It was well known that defoliation caused by both frost and the knife would stimulate new bud and leaf formations, and that the resulting rapid growth would tend to decrease the sugar stored in the root. However, the possibility existed that the two methods of leaf destruction could differ, in that substances from the frozen leaves could be translocated to the crown and root and induce changes at least differing in degree from those resulting from cutting off the leaves.

The present experiment compares the sugar losses caused by freezing the tops with those caused by cutting off the leaves and petioles with a knife.

Methods

The sugar beets used in these experiments were planted in the field May 20, 1953, and subsequently thinned to eight-inch spacings. Each plot was limited to four beets to facilitate freezing in the field. There were four replicates each of twelve treatments arranged in a randomized block design.

Freezing and knife defoliation were done September 9 with harvesting and sampling for analysis following after the intervals indicated in Table 1.

The method of freezing consisted of covering the plot of four beets *in* the field with an insulated box 40x14x16 inches. Wire mesh trays containing 60 pounds of dry ($C0_2$) ice were placed on a rack *in* the upper portion of the box. A 13-minute treatment period was found to be adequate to freeze the leaves completely, together with varying proportions of the petioles. The exposed crowns showed no sign of having been frozen.

Defoliation consisted of cutting off the leaves and petioles with a knife just above the crown without damage to the crown.

The beets were dug at the times indicated, and the crowns and tops were cut off as in commercial topping. Storage, where necessary, was done by packing the topped beets from each plot in a paper bag and a carton containing these samples was placed in refrigerated storage at approximately 36° F. for the ten-day storage period. The beets were weighed just prior to sampling for sugar and purity.

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[2] Numbers in parentheses refer to literature cited.

Discussion

In Table 1, the data is arranged to compare the general average of the four freeze, defoliate (knife) and check treatments. There was no significant difference beteen treatments in either root weight or purity. Freezing and defoliation with the knife caused significant average reductions of 1.56 and 1.74 percent respectively, in the sugar content, as compared to the check. Detailed examination of this table will show that the freezing and knife defoliation gave very similar sugar contents for comparable pre- and post-harvest treatments. We, therefore, conclude that the loss of the leaves was the primary cause of the sugar loss and it made no difference whether this leaf loss was accomplished by use of frost or the knife.

The data presented in Table 2 compare the sugar losses between two and twelve days' regrowth after treatment. It is interesting to note that the average loss per day was almost identical, being 0.20 percent for two days' regrowth and 0.24 percent for twelve days' regrowth. This indicates the sugar losses were in evidence very shortly after top destruction, and continued at the same rate per day for the period under test.

No. Treatment	Harvested (Days After Treat.)	Storage (Days)	Ave. Root Weight	Percent Sugar	Purity
No. Treatment	Trea				
1. Freeze	2	nil	13.2	14.73	88.0
2. Freeze	2	10	13.0	14.90	88.3
3. Freeze	12	nil	11.6	13.50	87.9
4. Freeze	12	10	11.0	13.65	84.2
		Ave.	12.2	14.19	87.1
5. Defoliate (knife)	2	nil	11.4	14.28	84.8
6. Dfoliate (knife)	2	10	12.2	15.48	89.2
7. Defoliate (knife)	12	nil	12.9	13.15	88.3
8. Defoliate (knife)	12	10	14.6	13.14	85.2
		Ave.	12.8	14.01	86.9
9. Check	2	nil	12.3	14.95	86.1
10. Check	2	10	11.0	15.54	87.9
11. Check	12	nil	13.8	15.85	88.9
12. Check	12	10	9.5	16.68	86.4
		Ave.	11.7	15.75	87.3

Table 2.—Percent Sugar Losses Resulting from Freezing and Cutting-off Foliage ; pared to the Checks.

Treatment Comparisons	Sugar Loss Two Days' Regrowth	Treatment Comparisons	Sugar Loss Twelve Days* Regrowth
	%		%
9-1 (ck-freeze)	0.22	11-3 (ck-freeze)	2.35
9-5 (ck-defoliate)	0.67	11-7 (ck-defoliate)	2.70
10-2 (ck-freeze)	0.64	12-4 (ck-freeze)	3.03
10-6 (ck-defoliate)	0.06	12-8 (ck-defoliate)	3.54
Ave.	0.4	Ave.	2.9
Ave. per day	0.2	Ave. per day	.24

Table 3.

No.	Treatment	Harvested (Days After Treat.)	Storage (Days)	Ave. Root Weight	Percent Sugar	Purity
1.	Freeze	2	nil	13.2	14.73	88.0
5.	Defoliate (knife)	2	nil	11.4	14.28	84.8
9.	Check	2	nil	12.3	14.95	86.1
			Ave.	12.3	14.65	86.3
2.	Freeze	2	10	13.0	14.90	88.3
6.	Defoliate	2	10	12.2	15.48	89.2
10.	Check	2	10	11.0	15.54	87.9
			Ave.	12.1	15.31	88.4
3.	Freeze	12	nil	11.6	13.50	87.9
7.	Defoliate	12	nil	12.9	13.15	88.5
11.	Check	12	nil	13.8	15.85	88.9
			Ave.	12.7	14.17	88.4
4.	Freeze	12	10	11.0	13.65	84.2
8.	Defoliate	12	10	14.6	13.14	85.2
12.	Check	12	10	9.5	16.68	86.4
			Ave.	11.7	14.49	85.3

In Table 3 the data are arranged to illustrate the effect of ten-days' storage at approximately 36° F. Jn spite of the fact that the storage difference was not significant, the beets had a higher sugar content after ten days' storage than at harvest for five out of six comparisons. For beets harvested two days after treatment, this difference was 0.66 percent, and for beets harvested twelve days after treatment, it was 0.32 percent. Preharvest treatments had no effect on the sugar gain in storage. The cause for this increase is unknown, but unexpected dessication of the roots is the most plausible explanation.

The original suggestion that freezing of the leaves might induce physiological changes in the roots as distinct from those resulting from knife defoliation has now been disproved for the conditions of these treatments. It might be assumed, therefore, that sugar losses were caused by the energy consumed by regrowth of new tops. While this undoubtedly does occur where temperatures after freezing are sufficiently high to permit growth, it does not explain sugar losses in a year such as 1951 at Taber, Alberta, where heavy frosts and snow occurred October 5, and the average temperature (mean of daily maximum and minimum) did not again rise above freezing until November 5. No regrowth whatever was possible during this period and yet the sugar content for the five-day factory average,fell steadily from 15.95 and 15.31 percent as illustrated in Figure 1. For the same period during the 1953 harvest, the temperatures remained high with no frost, and the sugar content rose steadily from an average of 16.83 percent for the period October 10-14 to a high of 17.45 for October 25-29. These observations lead us to believe that heavy frosts which penetrate the crown may be capable of reducing the sugar content even though regrowth is impossible because of freezing temperatures.

Wood (3) reported a sharp drop in sugar content following a frost of 15° below zero F. at Longmont, Colorado, in 1951. This drop was not associated with new foliar growth.

Evidence, therefore, is now available from several sources which shows that severe freezing of beets in the field can cause severe sugar losses not associated with regrowth.

The search should be continued to determine the nature of the physiological processes involved in such losses which in certain years are probably quite severe in the more northerly beet growing areas.

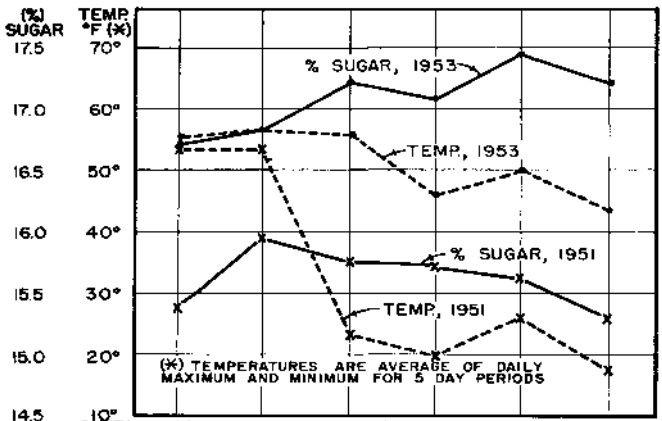

Figure 1.—Relation of temperature to percent sugar.

Conclusions

1. Freezing and cutting off of the leaves and petioles resulted in similar and significant reductions in sugar content averaging 1.56 and 1.74 percent respectively, less sugar than the checks.

2. The average loss of sugar from the combined results of cutting off and freezing of the foliage was 0.4 or 0.2 percent per day for two days' regrowth as compared to 2.9 or 0.24 percent per day fo twelve days' regrowth. This indicates that sugar losses were in evidence very shortly after top destructions and continued at about the same rate per day for period under test.

3. Neither freezing nor cutting off of the foliage caused any observable reduction in root weight or purity.

4. Cold storage of all treatments for ten days after commercial toppings (crown removal) resulted in increases in the sugar content of 0.66 percent in treatments harvested two days after treatment and 0.32 percent in beets harvested twelve days after treatment.

Literature Cited

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