Effect of Frost on Sugar Content in Beets

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The very severe frost conditions encountered during the autumn of 1951 in the sugar beet growing areas of southern Alberta encouraged the re-examination of the sugar content of beets as related to frost injury during the first 30 days of the factory operations. The sugar content after 30 days of operation was not taken into account in order not to complicate the situation by introducing unknown storage losses. It was considered that 6° F. would cause killing of most of the tops and do some crown injury. A study was made of the sugar contents of the Raymond factory slice for 5- and 10-day periods before and after the campaign day on which the temperature fell to at least 26° F.

Table 1.—The Effect of a Killing Frost of 26° F. or Lower on Sugar Content in Beets, Data from Raymond Factory.

Year	Campaign Day of First 26° Frost	Change in Percent Sugar Immediately Before Frost		Change in Percent Sugar Immediately After Frost		Remarks
		5 day Period	10 day Period	5 day Period	10 day Period	
1932	16	+0.8	+1.6	—0.1	—1.1	
1933	24	+0.2	+0.7	—0.2	—	
1934	1	—	—	—0.1	—0.2	
1935	15	+0.4	+1.2	—0.2	—0.2	
1936	23	0	+1.4	—0.7	—	
1937	8	—0.2	—	0	0	Rain and Cloudy weather before fr.
1938	24	—0.1	0	+0.2	—	
1939	10	+0.1	—	—0.1	—0.5	
1940	0	—	—	—	—	
1941	30	+0.5	+0.4	—	—	
1942	30	+0.1	+0.2	—	—	
1943	29	—0.7	0	—	—	
1944	5	—	—	—0.4	—0.2	
1945	19	0	+0.9	—0.3	—0.1	
1946	9	—0.7	—	—0.3	—0.2	Rain preceded fr.
1947	23	+1.0	+1.7	—0.7	—	
1948	7	—0.2	—	+0.2	+0.5	Only 1 night of killing frost.
1949	(Pre-crop Sep. 12)	—	—	—	—	
1950	1	—	—	—1.0	—1.1	
1951	11	—0.1	+0.5	+0.5	+0.5	Below freezing for 12 days after first frost.
Ave.		+0.09	+0.78	—0.21	—0.24	

Table 1 shows that the sugar content of the beets sliced tends to rise until the campaign day with a 26° frost or lower. Subsequent to the first frost, regardless of its intensity below 26° F., the sugar content was usually decreased as a result of frost. This decrease showed up quickly within five days and is therefore not associated with obvious regrowth in such a short period. It appears that frost initiates certain biochemical changes in the root which result in loss of sugar. There was evidence from the 1951 data that the sucrose content did not decrease as long as the beets remained

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frozen or close to freezing as they did for 12 consecutive days in 1951. By contrast in 1950, a frost occurred on the first crop-day and the weather warmed up right afterward. This condition caused a serious reduction in sugar content as shown in Table 1.

Further evidence on the effect of frost on the sugar content of beets is illustrated in Figure 2. The average of 20 years' results for the sugar content of the Raymond Factory slice shows that there is a rapid rise in sugar of .78 percent in the 10-day period preceding the frost and a fall of 0.24 percent within 10 days subsequent to frost.

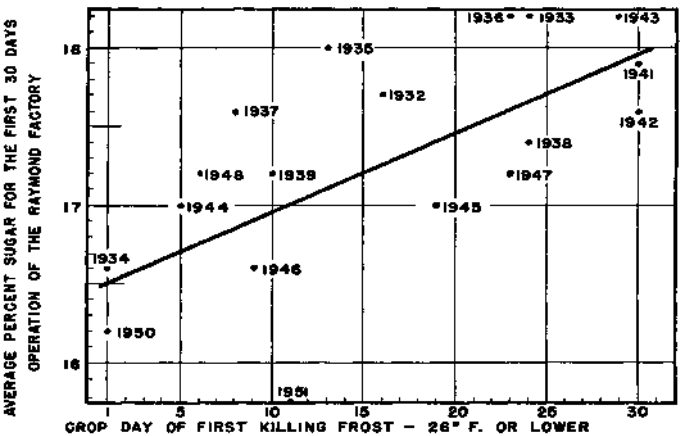

Figure 1.—Relation of Sugar Content to First Killing Frost.

A study of Raymond operations indicated that the date of occurrence of the first killing frost might have a causal relationship with the average sugar content of the crops. Again the 30th crop-day was selected as indicating the true sugar content of the crop without complications of storage losses. Figure 1 shows a relationship between the average percent sugar for the first 30 days plotted against the crop-day when the first killing frost of 26° F. or lower occurred.

It was necessary to eliminate 1940 and 1949 from this data. Nineteen hundred forty was eliminated because no frost occurred during the period and 1949 was eliminated because the first killing frost occurred on September 12. We are convinced that this very early frost was responsible for the abnormally low average sugar content of only 14.5 percent at the 30-day point. However, its effects could not be conveniently correlated with frosts occurring after the commencement of harvest.

The slope of the regression was calculated and is shown in Figure 1. A positive significant correlation of +0.64 was calculated from these data.

Discussion

It has long been recognized that a number of factors influenced sugar content in beets at harvest, e.g.

1. Variety (sugar, normal or tonnage types) .
2. Length of growing season.
3. Soil and fertility factors.
4. Climate—Rainfall.
   Temperature (frost)
   Sunlight

Regrowth after a killing frost has been well known to reduce sugar content. This effect was particularly noticeable when a killing frost occurred in 1949 on September 12. However, it has not been widely recognized

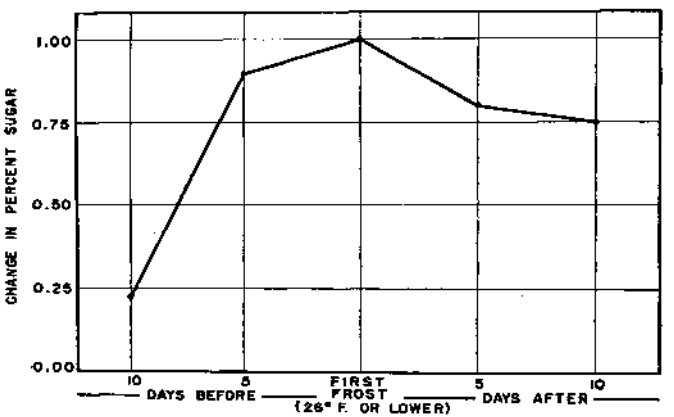

Figure 2.—Effect of Frost on Sugar Content. Average of 20 Years' Results at Raymond.

that practically all killing frosts are followed rapidly by a reduction in sucrose content in the root. One might assume that any inversion of sucrose would be accompanied by a noticeable rise in invert sugars. It may be that inverts are formed but are intermediate and transitory in katabolism. It might also be assumed that any rapid loss of sugar might be accompanied by an increased respiration rate. The plain truth is that there is a serious

deficiency of knowledge on the biochemical reactions associated with the thawing of sugar beets.

The positive correlation which exists between the sugar content of the crop as measured by sugar to date at the 30-day point in the campaign and the date of the first killing frost suggests that frost immediately preceding or during harvest dominates all the other factors which could be involved. Thus, this indicates the importance of frost resistance in sugar production in Alberta.

Marked varietal differences in frost resistance were noted last autumn in Alberta. For example, a high-sugar Polish Variety, Udycz A, appeared to have a much higher degree of resistance than most other varieties. However, in our own stock there is considerable variation in frost resistance so that it ought to be possible to breed specifically for this character.

If sugar losses are associated with freezing of beets in the field, then the likelihood exists that serious losses of sugar in pile storage could result from recurrent freezing and thawing, even though there was no obvious rotting of the root tissue.

Since it is apparent that frost damage is a dominant factor in limiting the sugar producing capacity in many northerly beet producing areas, research programs in these regions should include investigations along the following lines.

1. Biochemical studies to determine what happens to the sugars in beets on freezing and thawing.

2. Respiration studies on beets recovering from frost as compared to unfrozen beets.

3. Further studies on maleic hydrazide and related hormones to determine their efficiency in reducing sugar losses following freezing or in storage without frost.

4. Breeding and selection for frost resistance.