Effect of Harvest Injury on Respiration and Sucrose Loss In Sugarbeet Roots During Storage*

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Introduction

The severity of injury inflicted on sugarbeet roots during harvesting and handling has a profound effect on their storage life. Respiration rates are increased in direct relationship to severity of injury (2, 3, 14). Infection by Botrytis and Pencillium, two dominate storage fungi, is dependent on surface injury (9). Once the surface of the root is broken, infection by these fungi can occur and the subsequent degree of rot is related to storage temperature and length of the storage period. Invert sugar accumulation during storage is normally very slight except when mold growth occurs (6, 11). Invert sugars are, in fact, a good index of mold growth (9).

Therefore an important aspect of any improved storage management system is to identify sources of significant injury and to develop improved handling procedures in order to minimize the extent of these injuries.

The objective of this study was to determine the effect of harvest injury on the respiration rate of sugarbeet roots immediately after harvest and on sucrose losses during long term storage.

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Materials and Methoas

Sugarbeet roots (Cultivar, UI 8) were subjected to the following harvest procedures:

(1) Hand harvested, untopped (All green material was removed by hand with a knife)
(2) Hand harvested, topped
(3) Hand harvested, flailed
(4) Machine harvested, flailed
(5) Machine harvested, topped

In the hand harvested and topped treatment, the crown was removed at about its midpoint using a topping knife. This simulated very closely the degree of topping by the mechanical harvester. In the flail treatments the tops were removed with a roto beater containing a single set of rubber flails that rotated counter to the direction of travel. Two passes were required for complete petiole removal.

Immediately after harvest, each treatment was divided into 30 samples of 10 roots each. The samples were not washed. Fifteen samples were selected at random for immediate analysis and 15 were prepared for storage. Ten of the storage samples were placed in a respirometer for respiration analysis. The remaining five replications were stored in polyethylene bags. All samples were held at 10° C for the first 50 days of storage and then at 5° C until they were removed after 105 days in 1976 and 130 days in 1977.

Respiration rates in 1976 were determined at 10° C after 14 days of storage and at 5° C after 105 days of storage. In 1977 respiration rates were monitored continuously at 10° C for the initial 12 days after harvest. They were measured again after 50 days of storage at 10° C and after 130 days of storage at 5° C.

Chemical analyses for percent sucrose (1) and reducing sugars (8) were made at harvest and after storage. Sodium and potassium were determined by flame photometry and amino nitrogen by the method of Stout (10). Respiration rates were monitored as described previously (14). All measurements expressed on a weight basis were corrected for any weight loss.

Results

Respiration rates during the first 12 days of storage in 1977 are given in Figure 1. Respiration rates of the most severely injured machine-harvested roots were higher than those of the hand-harvested controls. Removal of the crown reduced respiration rates slightly in comparison with non-topped beets. Flailing had no effect on respiration rates.

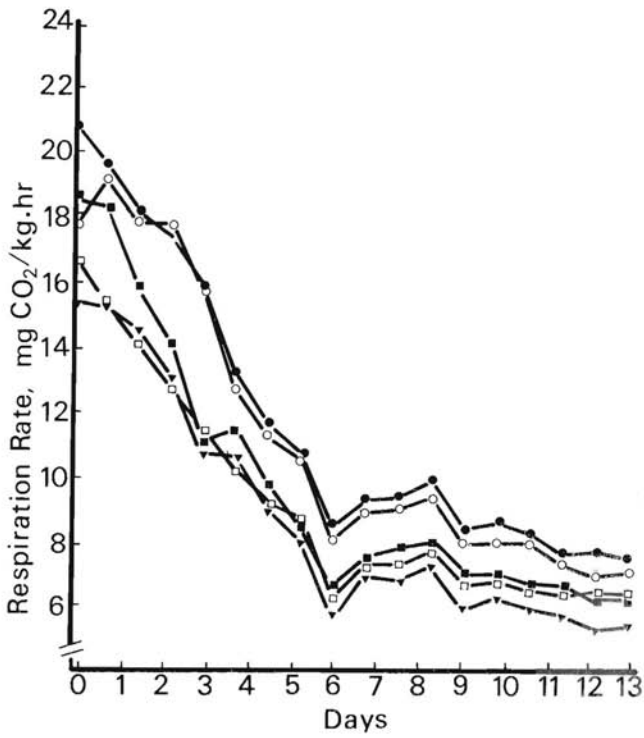

Figure 1. Effect of various harvest treatments on the respiration rate of sugarbeet root during the initial 12 days after harvest. Hand-harvested - untopped, □ ; hand-harvested - topped, ▼ ; hand-harvested - flailed, ■ ; machine-harvested - topped, ○ ; machine-harvested - untopped, ● .

In 1976 there were no differences in the respiration rates after 14 days of storage among any of the hand-harvested treatments (Table 1). However, in 1977 the precision of the experiment was better and differences were detected among the hand-harvested treatments. Removing the crown lowered the respiration rates slightly in contrast with either flailing or merely trimming the petioles with a knife. This reduced respiration rate undoubtedly resulted from removal of the high-respiring crown tissue (14). Apparently the effect of the injury inflicted during crown removal was less than the effect of the presence of the crown tissue with its high respiration rate. However, the most significant effect on respiration in both years was due to the injury inflicted by machine harvesting. In 1976 machine harvesting and topping increased the respiration rate slightly over that of the machine-harvested flail treatment. However, in 1977, there was no difference between topping and flailing.

Table 1. Effect of harvest procedures on the respiration rates of sugarbeet roots during storage. Storage temperatures were 10° C for the first 50 days and 5° C for the remainder of the storage period.

Storage Period	1976-77 14[a]	105[b]	1977-78 12[a]	50[a]	130[b]
			mg/kg.hr		
Hand-harvested-flailed	9.6	11.9	6.2	8.3	3.09
Hand-harvested-topped	11.6	16.9	5.4	7.2	4.22
Hand-harvested-untopped	11.1	12.1	6.4	7.6	2.53
Machine-harvested-topped	17.3	28.0	7.0	10.5	8.42
Machine-harvested-flailed	13.1	19.3	7.5	10.5	6.05
LSD (.05)	2.02	4.2	.64	1.0	1.2

a/ Respiration measured at 10° C
b/ Respiration measured at 5° C

After 50 days of storage at 10° C in 1977, the respiration rates of the hand-harvested treatments increased but their relative rankings remained the same as at harvest. In the machine-harvested samples, the slight advantage of topping early in the storage period had disappeared. In long term storage (105 and 130 days) the respiration rate of the topped beets increased significantly over that of untopped beets in both years. The increased respiration rate was apparently the result of extensive mold growth in the exposed hollow areas of the crowns. The mechanically harvested roots also showed extensive mold growth in areas where the surface of the root had been severely injured at harvest (Figure 2).

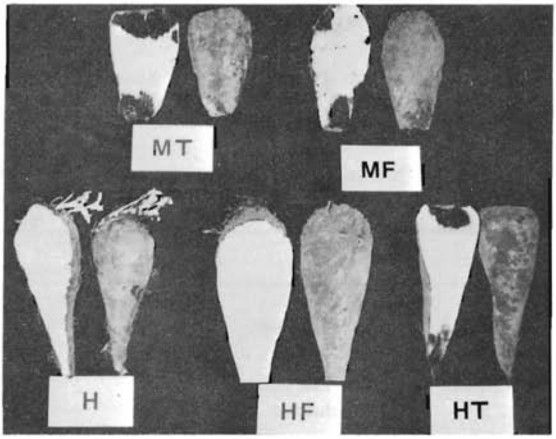

Figure 2. Appearance of roots after 120 days of storage in 1977-78. Dark areas indicate rotted tissue. H - hand harvested, M - machine harvested, F - flailed, T - topped.

Machine topping significantly reduced impurity levels at harvest in 1976 in contrast with the other treatments (Table 2). The harvester removed a greater amount of the crown tissue than did the hand-topped treatment, which would explain the lower impurity levels. In 1977 both hand topping and machine topping significantly reduced impurity levels at harvest.

The magnitude of sucrose loss and reducing sugar accumulation in 1977 were slightly less than in 1976 considering

Table 2. Effect of harvest procedure on impurity levels at harvest.

	Impurity Content[a/]	
	1976-77	1977-78
	mg/kg	
Hand-harvested-untopped	4641	4392
Hand-harvested-topped	4408	3497
Hand-harvested-flailed	4443	4037
Machine-harvested-flailed	4472	3843
Machine-harvested-topped	4009	3349
LSD (.05)	383	319

[a/] Impurity content is the sum of Sodium + Potassium + Reducing Sugars + Amino Acids

the longer storage period (Table 3). However, the treatment effects were essentially the same in both years.

Table 3. Effect of harvest method on sucrose loss during 105 days of storage (1976-77) and 120 days of storage (1977-78).

		1976-77 Sucrose	1977-78 Sucrose
		kg/ton	kg/ton
Hand-harvested-untopped	At harvest	180	144
	change	- 8	- 6
Hand-harvested-topped	At harvest	184	152
	change	-17	-11
Hand-harvested-flailed	At harvest	176	150
	change	-10	-10
Machine-harvested-flailed	At harvest	176	146
	change	-27	-20
Machine-harvested-topped	At harvest	170	155
	change	-37	-30
LSD (0.5)	(for change)	8	9

Machine harvesting increased sucrose losses by 135% in both the flailed and topped treatments as compared to their hand-harvested controls. Crown removal increased losses in the hand-harvested treatment in 1976-77 but had little effect in 1977-78. In the machine-harvested treatments, crown removal increased losses by 57% over flailing alone. Petiole and leaf removal by flailing had very little effect on sucrose loss.

The effects of the injury treatments on reducing sugar accumulation closely paralleled the treatment effects on respiration rates and sucrose losses (Table 4). The reducing sugar content was a good indicator of the relative amount of mold growth (Figure 2). Crown removal facilitated mold growth in both the hand-harvested and machine-harvested roots and resulted in a significantly higher reducing sugar content. If the increases in reducing sugars during storage, which result from topping, are compared to the impurity levels at harvest (Table 2), it is apparent that the slight advantage of topped roots at harvest was readily lost during storage.

Table 4. Effect of harvest method on reducing sugar accumulation during 105 days of storage (1976-77) and 120 days of storage (1977-78).

		1976-77 Reducing Sugars	1977-78 Reducing Sugars
		mg/kg	mg/kg
Hand-harvested untopped	At harvest	1019	1404
	change	+1311	+1334
Hand-harvested-topped	At harvest	691	894
	change	+5906	+2737
Hand-harvested-flailed	At harvest	865	1243
	change	+1628	+1523
Machine-harvested-flailed	At harvest	887	1043
	change	+4913	+3031
Machine-harvested topped	At harvest	784	871
	change	12,252	+5826
LSD (.05)	(for change)	1275	1188

Discussion

The importance of injury in determining the storage life of potatoes is well known. It is becoming apparent that injury may be equally important in determining the economic storage life of sugarbeet roots. Previous reports have shown that the respiration rate of the sugarbeet root responds to injury immediately after harvest and that the response may continue throughout the storage period (2, 3, 5, 12, 13). Although respiration rates immediately after harvest are important in pile cooling and sucrose loss, the major effect of injury apparently is to facilitate mold growth. Many of the effects of injury, such as mold growth, can be minimized by maintaining cool pile temperatures and using fungicides (7, 9). These measures, however, are only part of the solution.

Sugarbeet harvesting and handling equipment has been designed for maximum harvesting capacity and cleaning ability with no regard for injury to the root. It seems logical, therefore, that sources of injury should be determined and equipment redesigned to minimize injury. A major source of harvest injury is crown removal. The data in this and other studies (2, 3, 4) have indicated the importance of crown removal to prolong storage life. However, it is important that, if the crown is not removed, all petiole material be carefully removed. Failure to do so will result in a trash-filled pile and in development of "hot spots."

The practice of crown removal has been perpetuated on the premise that the crown contains high levels of impurities. Although quality at harvest may be improved by crown removal, the evidence is now quite clear that any advantages to crown removal at harvest are readily negated by losses in storage (2, 3, 4). Since a majority of the sugarbeets grown in the United States are stored for at least 30 days before they are processed, it may be time to re-evaluate the practice of crown removal.

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