PLASTIC TUBING FOR COLLECTING MAPLE SAP:

A Comparison of Suspended Vented and Unvented Installations

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The Author

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THE QUESTION OF VENTING

PLASTIC TUBING for sap collection has been acclaimed as a major factor in modernizing the 300-year-old maple sap industry. Tubing reduces the labor costs involved in sap collection, keeps the sap cleaner, reduces loss due to spillage, and is relatively easy to install. Yet in spite of these advantages, tubing is used by only 9 percent of the maple sap producers.[1]

One of the primary reasons why tubing does not enjoy more widespread use among maple producers today is that the initial installations did not operate efficiently. When tubing first appeared on the scene, maple sap was thought to issue from the tree at considerable pressure, and many of the first installations were patterned after high-pressure water systems.[2] These installations were unvented (closed to air) in the anticipation that tree pressure would be sufficient to force sap through the lines.

It was soon found that the anticipated sap pressure was not adequate, and that in reality sap issues from the maple tree over a range of pressures. Some tubing advocates then designed their installations for gravity flow, and vented the installation at each spout. Since the completely vented installation allowed sap to flow under a variety of adverse field conditions, the vent system was adopted by many producers.

However, a significant number of producers were able to make unvented installations work efficiently and continued to use them. This indicated that some of the trouble with these initial unvented installations must have stemmed from layout and design problems.

[1] Cowen, William. Address given at the Geauga County Institute of Forestry and Maple Syrup Production and Marketing in Burton, Ohio, January 1966.

[2] Willits, C. O. MAPLE SYRUP PRODUCERS MANUAL. U. S. Dep. Agr., Agr. Handbook 134, 112 pp. 1965.

But the two methods of installation were never formally compared on the basis of sap yield until Laing *et. al.*[3] conducted a small-scale comparison of the two, using the sap yield from 40 trees located in northern Vermont. The results of this study indicated that the unvented system outyielded the vented system by about 55 percent.

The subject of venting nevertheless remained somewhat controversial, and most tubing users continued to vent. Therefore, researchers at the U. S. Forest Service's sugar maple project in Burlington, Vt., designed a large-scale comparison of vented and unvented tubing installations for the 1966 sap season. The objective of this study was to compare sap yields from the two methods of tubing installation and to investigate the factors involved in any observed differences in yield.

THE STUDY

To provide a statistically sound comparison, we suspended tubing in paired vented and unvented installations. The installations were identical in the number of tapholes, position of spouts and drops in relation to exposure, degree of slope, total tubing length, the amount of sag between trees, and other factors (fig. 1). All tubing was 5/16-inch inside diameter, and all fittings were identical for each installation in the pair. The only difference between members of a pair was the treatment—one was vented, and the other was unvented (fig. 2).

For further reduction of experimental error, tapholes were paired 6 inches apart and bored to a controlled depth of 2½ inches, excluding bark. Since there is little lateral translocation of sap, paired tapholes yield independently of one another.[4] Tapholes were placed 4½ feet from the ground except where they were adjusted to maintain adequate slope. Paraformalde-

[3] Laing, F. M., J. W. Marvin, and W. J. Chamberlain. RESULTS AND EVALUATION OF NEW MAPLE TECHNIQUES. Univ. Vt. Agr. Exp. Sta. Misc. Pub. 42. (Prog. Rep. 3), 13 pp. 1964.

[4] Jones, C. H., A. W. Edson, and W. J. Morse, THE MAPLE SAP FLOW. Vt. Agr. Exp. Bull. 103, 184 pp. 1903.

Figure 1.—Tubing installations. Members of a paired replicate were kept as alike as possible in line sag, tubing length, and other factors.

hyde pellets were used in each taphole. Vented and unvented installations were assigned to the tapholes at random.

Differences in yield between vented and unvented tapholes were tested for significance with a "t" test for paired replicates.

To provide a comparison large enough to duplicate commercial conditions, we used 15 replicates. Each replicate included 18 to 20 pairs of tapholes, making a total of 580 individual tapholes in the study. The 18 to 20 individual tapholes receiving the same treatment in a replicate were connected into one tubing system.[5]

The length of tubing used for each member in the paired replicates ranged from 237 to 347 feet and averaged 300 feet. The slope of the lines varied from 14 to 21 percent and averaged about 18 percent, although some pairs had nearly level segments. Vertical drop from the first tree tapped to the col-

[5] Tubing manufacturers recommend that about 20 tapholes be connected in each tubing system when small diameter lines like these are used.

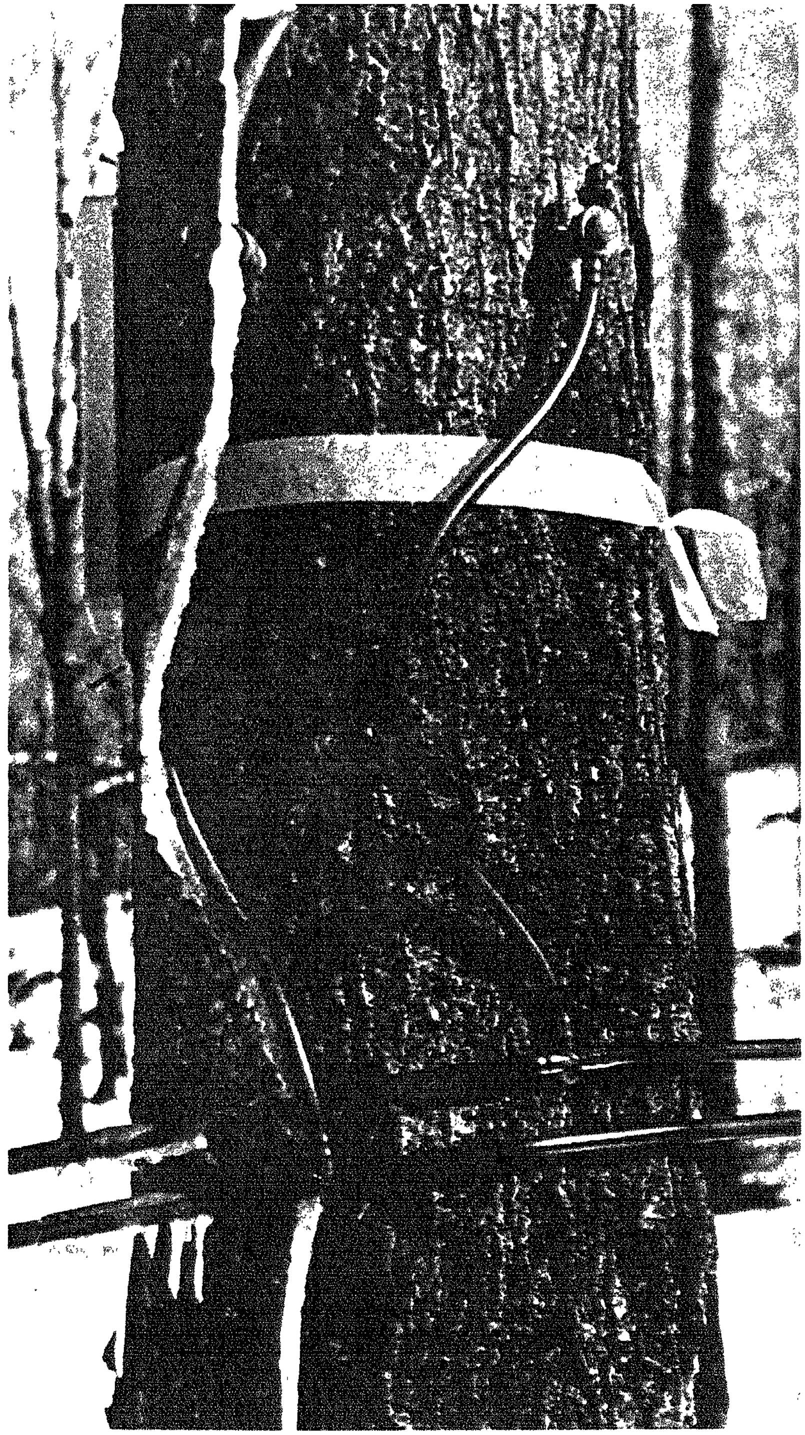

Figure 2.—A taphole pair, typical of those in the paired replicates. Note icicle formed by sap leaking from the vented member of the pair (left).

lection barrel ranged from 17 feet to about 30 feet. No attempt was made to minimize abrupt changes either in the slope or in line direction.

The sugarbush used for the study is densely stocked with about 200 trees per acre; the trees averaged 12 to 14 inches d.b.h. This bush slopes generally northwest and is situated at an altitude of 1,000 feet. It is located in northwestern Vermont in the town of Jericho.

RESULTS AND DISCUSSION

Yield Comparisons

Venting significantly (0.01 level) affected the seasonal yield of sap collected in plastic tubing. From the first week in March to 2 May 1966, the combined yield from the unvented installations on all 15 replicates was 43 percent greater than that from the vented installations (table 1).

Although the unvented system had an average yield for the entire season that was 43 percent greater than that of the vented system, there was considerable variation in the magnitude of this increase from one measurement period to the next. This variation appeared to be related to the volume and rate of flow during the period. In general, fast flows of relatively large volume produced a greater difference in the percent of yield between the two systems. However, yield increases for the unvented installations occurred consistently, even during the extensive period of low-yield, weeping flows between 7 April and 2 May. There was also considerable variation in the size of the yield difference among the 15 paired replicates, a factor that will be discussed in some detail later.

Based on the average yields found in this study, the increase in seasonal yield for an unvented system in a 1,000-taphole operation would be about 2,680 gallons of sap. An increase of this magnitude is economically important, amounting to $134.00 if the sap is sold for $.05 per gallon. This additional yield at

2.5 percent sugar content would make 78 more gallons of syrup—worth $468 at an average of $6 per gallon—for the same outlay of sap collection labor and equipment. And many sugarbushes would have an average sap sugar content of more than 2.5 percent, further increasing the value of the difference in yield. The somewhat cheaper initial equipment costs for an unvented system will also be important in new installations.

We do not know whether this additional yield reflects a reduction of sap from the vented installations or an increase from the unvented installations. However, some information was gathered on this question during the study.

Loss of Sap from Vents

Producers using vented installations often express concern over sap loss from the open vents (fig. 3). This loss usually occurs when sap is forced out of the vents by an obstruction in

Table 1.—Season yields and yield differences for unvented and vented members of the paired replicates, 1966 season

Replicate	Tapholes per member	Yield per taphole		
		Unvented	Vented	Difference
No.	*No.*	*Gallons*	*Gallons*	*Gallons*
1	19	7.60	6.66	0.94
2	20	13.12	5.42	7.70
3	18	9.89	8.57	1.32
4	19	8.68	6.98	1.70
5	19	9.97	7.42	2.55
6	20	10.57	5.59	4.98
7	20	6.53	5.17	1.36
8	19	7.87	5.49	2.38
9	20	8.91	6.67	2.24
10	20	7.74	4.88	2.86
11	19	8.36	6.99	1.37
12	19	7.23	6.03	1.20
13	19	5.64	5.90	—.26
14	20	10.91	6.25	4.66
15	19	10.94	5.80	5.14
Total	290	133.96	93.82	40.14
Average	—	8.93	6.25	2.68

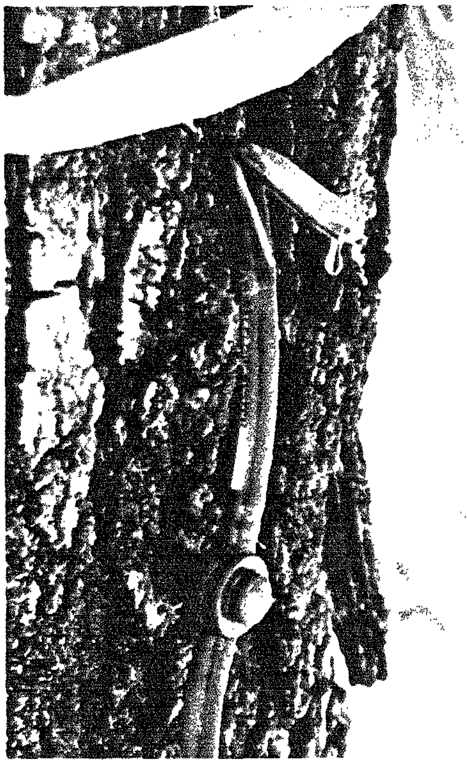

Figure 3.—Sap leaking from a vent. These leaks are caused by obstructions in the line that back up sap. They sometimes form large icicles during cold weather.

the tubing. Obstructions most commonly cited are ice blockages and gas or vapor locks. Vent loss may also occur when too much sap is present in the branch line (this might happen during very heavy flows) or when too many tapholes are put on a line, or when slope is insufficient. Vent loss is particularly noticeable when the weather is very cold, as evidenced by icicles formed where the sap leaves the vent.

Sap loss through the vents was measured for the entire season on the vented members of two paired replicates, numbers 6 and 11 (fig. 4). Both were chosen because they had a number of long spans, shallow slopes in some segments, and a number of sharp changes in direction and slope—all thought to be conducive to vent loss under certain conditions. Actual losses recorded were less than 3 percent of the total seasonal yield of

Figure 4.—Plastic bags were placed over the vents on two replicates to measure sap loss from leaks.

the vented members of the two replicates. Compared with the yield differences between the vented and the unvented members of the replicates, these sap losses were slight (table 2).

In any given year this vent loss could have been either larger or smaller, depending primarily on temperature conditions conducive to ice obstruction during the season. Close observation during the season indicated that vent losses from the other replicates in the study did not differ greatly from those measured on replicates 6 and 11.

Vacuum Relationships

It was apparent that some factor or factors other than vent loss from the vented installations must be involved in the greater yields obtained from the unvented installations. One factor investigated in this study was the presence of vacuum on the unvented lines and its relation to yield increases.

Table 2.—Vent losses from replicates 6 and 11, and the yield increase for the unvented members of these same replicates, 1966 sap season

Replicate	Vent loss per taphole	Yield increase for unvented member per taphole
No.	*Gallons*	*Gallons*
6	0.16	4.98
11	.22	1.37

Table 3.—Vacuum at the uphill end of the closed installations, measured during a moderately heavy flow

Replicate	Vacuum	Replicate	Vacuum
No.	*mm of mercury*	*No.*	*mm of mercury*
1	40	8	20
2	450	9	210
3	20	10	210
4	200	11	250
5	140	12	150
6	470	13	0
7	([1])	14	300
		15	400

[1] Vacuum lost during measurement.

Figure 5.—A drop line distorted by vacuum buildup in the tubing system.

Because of the movement of sap through the tubing, some vacuum was expected to develop in the unvented installations. However, shortly after the first flows occurred it was evident that this vacuum was of considerable magnitude and actually caused tubing distortions on some lines (fig. 5). The possibility of a correlation between vacuum and yield was considered, and steps were taken to measure vacuum at the upper end of each vented installation (table 3). Vacuum readings, taken with a standard vacuum gage, were obtained during a moderately heavy flow for all 15 replicates (fig. 6). The vacuum-forming and -holding capacity of each replicate appeared to be a function of slope, the amount of sap in the tubing at the time of measurement, and the vacuum integrity of the fittings, spouts, and tapholes.

The vacuum readings were plotted against the seasonal yield differences found between the unvented and the vented members of each replicate (fig. 7), and a linear regression line was fitted to these data. The resulting correlation coefficient of 0.86 was significant at the 0.01 level. Since actual vacuums measured on the installations would vary for any given flow, the prediction equation is not of great practical value.

Attempts to get vacuum readings during weeping flows were mainly unsuccessful. However, on one occasion some relatively low vacuum readings were obtained on about half of the replicates, and these were plotted against corresponding yield differences from this same flow. The resulting regression line was also significant at the 0.01 level and indicates that yield increases are also related to the low vacuum levels associated with very light flows.

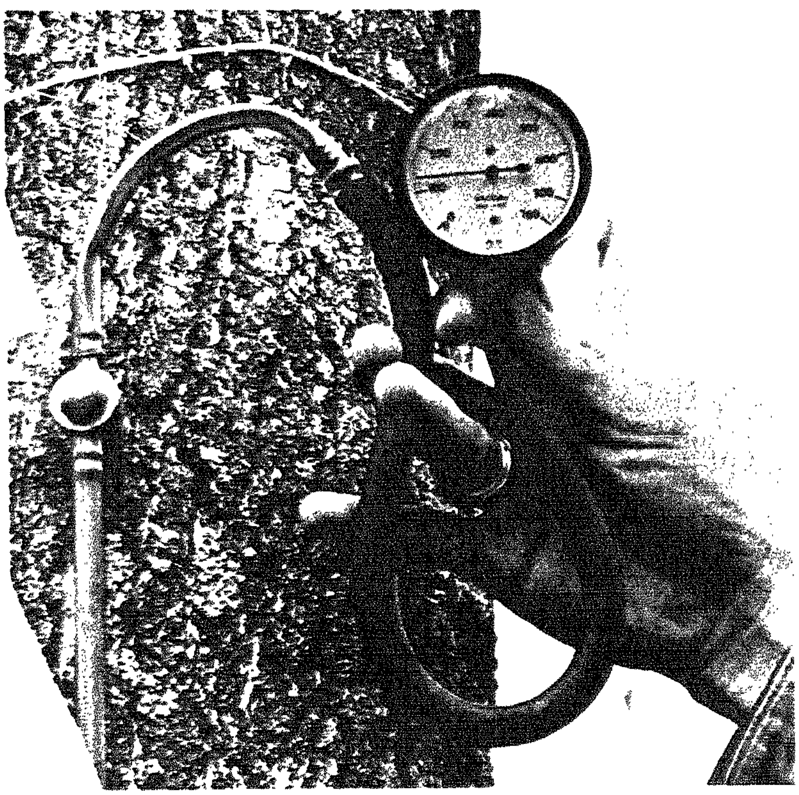

Figure 6.—Measuring vacuum with a standard vacuum gage calibrated in mm of mercury.

In view of the strong relationship between vacuum and increased sap yield, and since direct losses from the vented system were small, it appears that the vacuum present on the unvented system draws additional sap from the tree. The mechanism of

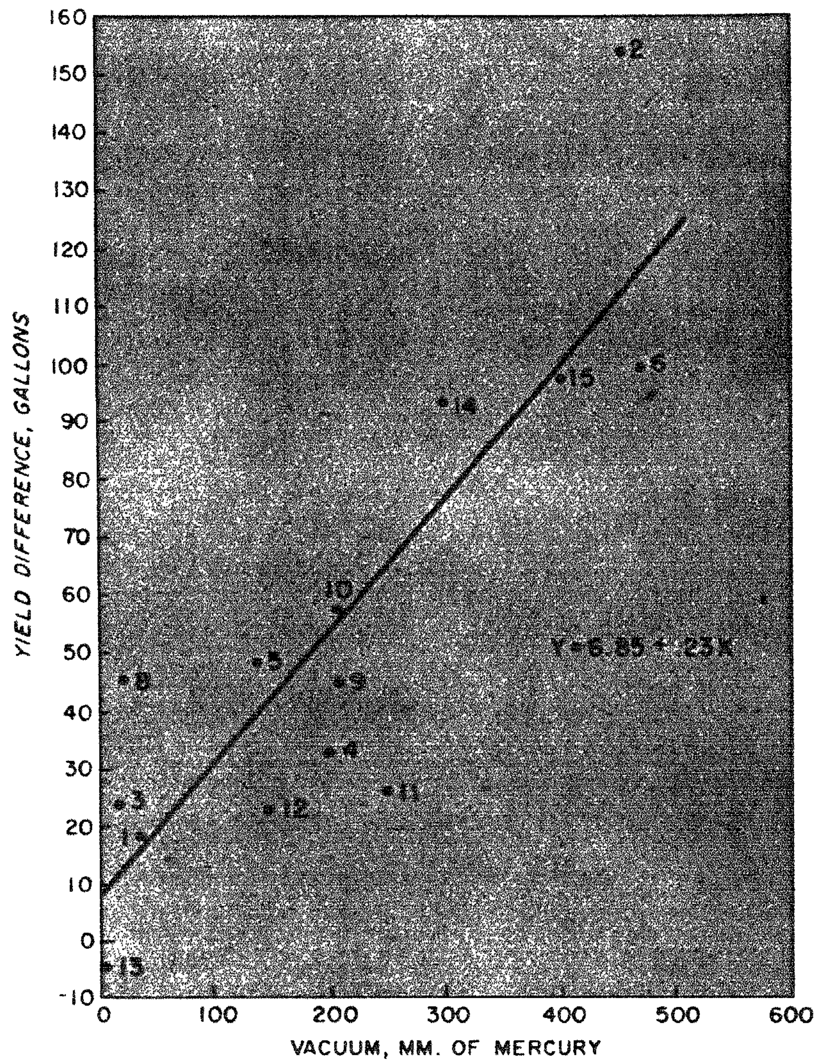

Figure 7.—Relationship between line vacuum and differences in seasonal yield from vented and unvented tubing systems.

this action is unknown. It may be that the vacuum simply prevents a build-up of sap behind the spout, which would restrict flow. Or it may be that the vacuum somehow alters the normal sap translocation processes.

CONCLUSIONS AND RECOMMENDATIONS

This study indicates that higher sap volumes can be obtained from unvented installations. Increases in yield can be expected with certainty only from installations similar to those used in this study and installed where similar conditions of weather and topography prevail. Nevertheless, it is reasonable to assume that yield increases will be obtained from unvented installations over a range of topographic and weather conditions. This likelihood will be studied at a number of locations in the maple region during the spring of 1967.

Coupled with the possibility of greater yields of sap from unvented tubing installations are other advantages: Sap is less likely to be contaminated with micro-organisms in an unvented installation than it is in a vented installation; and in the case of initial installations, costs are somewhat less. Although no particular difficulty was experienced with the suspended installation used in this study, we must caution that a properly working, suspended, unvented system may need tailoring to each different set of field conditions, just as any tubing system does. Since yield increases of the magnitude found in this study are a definite possibility, producers now using vented installations may find it profitable to experiment with sections of unvented tubing under conditions found in their own sugar bushes.

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