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VACUUM PUMPING DOUBLES MAPLE SAP YIELD ON FLAT LAND

Abstract.—Vacuum pumping more than doubled maple sap yield from tubing installations on nearly level land during the 1968 season. Increased yields were greatest when sap had to move slightly uphill.

A Problem on Flat Land

Vacuum pumping of maple sap, first used in 1960, overcomes some of the problems normally associated with plastic tubing networks used to collect sap from sugar maple trees *(Morrow 1963a)*. The presence of vacuum in the tubing helps to overcome friction, to eliminate airlocks, and to reduce losses due to freezing, vent leaks, and reabsorption. It may also increase the amount of sap released from the tree.

Even the natural vacuum that develops in unvented tubing systems can increase sap flow. Blum *(1967)* found an increase of 43 percent in sap yield from unvented suspended tubing over that from vented tubing. He measured vacuums as high as 18 inches of mercury in these installations, which were located on moderately steep slopes.

Blum and Koelling *(1968)* found even greater yields when a vacuum pump was attached to the closed system. The increased yield from pumping, which averaged over 300 percent, was especially notable during weeping flows; but more sap was also obtained during good flow periods. Laing *et al (1962)* have also reported several-fold increases in sap flow as a result of vacuum pumping. Both of the above studies were made under carefully controlled and possibly optimum conditions. Other experiments made under near-commercial conditions have shown somewhat less increase, ranging from about 20 percent in Vermont and New York

(Laing et al 1962; Morrow 1963a) to nearly 100 percent during one poor season in southern Canada *(Macdonald College 1965)*. It is possible that some of the early vacuum systems were not operated efficiently, and better results may be possible. Several commercial producers have also reported substantial gains from vacuum pumping, and interest in this means of increasing sap flow is spreading.

Sap flow through tubing on flat land was recognized early as a special problem *(Morrow 1958)*. Water flow tables show that friction increases rapidly as pipe size decreases and slope decreases. For example, ¼-inch pipe on a 20-percent slope would produce a flow rate of about 1 gallon per minute (to accommodate a flow of 1 quart per tap per hour for a 240-tap area). To obtain that same flow rate on a 2-percent slope, a ¾-inch pipe would be required.

Sap flow on flat land can be aided by careful layout of the tubing to create an artificial slope. However, vacuum pumping would appear to be the best way to overcome tubing problems on such land. Accordingly, an investigation of the influence of vacuum pumping on sap flow on nearly level land was made in 1968 at Cornell's Arnot Forest in southern New York.

The Experiment

The experiment was designed to compare vacuum pumping with no pumping in closed suspended tubing networks on nearly level ground. The area selected was along a stream bottom that fanned out into a small valley terrace. Equipment was located in the center of the area so that sap from both downstream (area I) and upstream (area II) could be measured. Fifty trees in each area were each tapped twice in identical fashion to permit accurate pairing of pumped and unpumped tubing lines.

All tapholes were drilled 2 inches deep, excluding bark, and a paraformaldehyde pellet was placed in each. The two tapholes on each tree were made 6 inches apart, and treatments were alternated between taps of each successive tree to eliminate directional effects. The tubing was suspended and supported with wooden props where necessary, and unvented 18-inch drop lines were used. All tubing was 5/16 inch and a constant slope was maintained on both the main lines and the side lines. The only difference between the two groups of 100 tapholes was in direction of slope (down or up) and, within each slope, the presence or absence of applied vacuum. One small single-piston compressor was used as a vacuum source to activate two dumping units, one for each area (fig. 1).

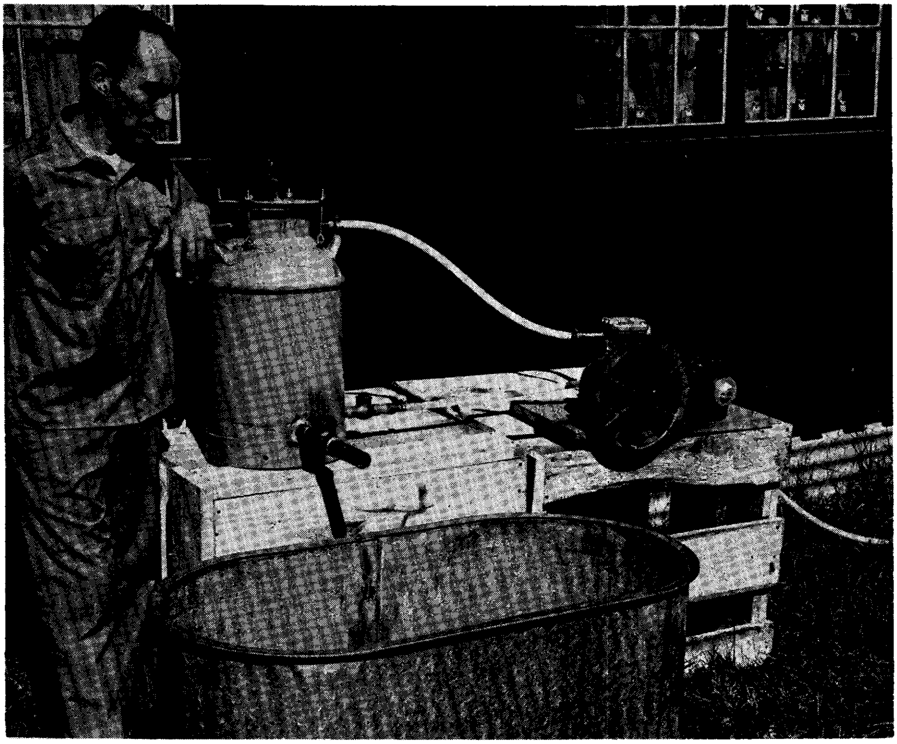

Figure 1.—Vacuum pump and dumping unit of the type used in this study.

The ground slope was 1.7 percent over the entire area. Area I had about 1,000 feet of tubing at an upslope of 1.5 percent, while area II had about 1,500 feet of tubing at a downslope of 1.3 percent. The length of line for the area II unpumped trees was reduced to 900 feet on March 20 because yields were so low.

Trees are about the same size and quality in each area, but sap yield in area II above the pump may be potentially less because of moderate shading by conifers and higher surrounding hills. Except for the possible reduction in early-season flow by this shading, the only important difference between the two areas appears to be the difference in slope percent.

Since the experimental areas consisted of only 50 taps per treatment, considerably less than might be used on a commercial installation, an adjacent area containing a total of 300 taps was also fitted with a suspended tubing installation and subjected to vacuum pumping. Yields from the 300-tap area were then compared with the yields from pumped systems on the experimental areas. The 300-tap area was located on a northwest-facing slope of about 5 percent.

Results

In the area that had a very small downslope, twice as much sap was collected from vacuum-pumped tapholes as from unpumped tapholes (table 1). Vacuum pumping was even more effective in the area where sap moved slightly uphill. Vacuum pumping usually showed the best advantage on days of low tree pressure.

The amount of vacuum was measured on March 22, during a day of negligible sap flow, on March 28 during a weeping flow, and on April 5 when there was no sap flow. At these times it was found that the vacuum measured approximately 20 inches of mercury at the dumping unit, about 12 inches in the middle of the tapping areas, and 4 to 10 inches at the tree farthest from the pump. Even this little vacuum moved sap from the end of the tubing line during the weeping flow while sap in lines not pumped remained motionless.

It seems clear that vacuum pumping increased yield by helping to overcome the friction in the tubing network. How much it may have increased actual production at the tree was not determined. For the unpumped network, it can be speculated that much of the seasonal sap yield came from the nearest trees, and the farthest trees may have contributed little because of network friction.

Table 1.—*Sap yield from pumped and unpumped tubing networks*
(In quarts per taphole)

Date	Area I—up slope		Area II—down slope		300-taphole area
	Pumped	Not pumped	Pumped	Not pumped	Pumped
March					
15-20[1]	8.1	4.3	7.5	1.2	12.0
25-26	7.5	4.0	8.4	4.5	25.5
27-31	12.3	3.6	10.3	7.0	
April					
6-8, 12[2]	15.8	4.5	14.0	5.5	—
Total	43.7	16.4	40.2	18.2	—

[1]Very low yield for the area II unpumped line. The collecting tank was moved so that 600 feet of tubing could be removed from this line on March 20.

[2]This sap was buddy and without commercial value because of the extreme warm spell in late March. In normal years, commercial yields are obtained in early April.

On comparable days, the 300-taphole area produced even more sap per taphole than the experimental area (table 1). Possibly this was because some trees had only one taphole *(Morrow 1963b)*. It is also possible that the steeper slopes of the larger area made a more effective vacuum and helped produce more sap. This suggests that vacuum pumping can increase yields on relatively steep slopes even though the percentage increase in yield is likely to be less than that demonstrated on flat land.

Uphill pulls and air leaks reduce vacuum and limit the number of taps that can be effectively handled by a single vacuum pump. The number that can be operated efficiently with a given pump and tubing size is not known, but the small compressor used in this study made vacuum available to 100 tapholes and substantially increased seasonal yield.

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