THE TIMING OF TAPPING FOR MAPLE SAP COLLECTION

Timothy R. Wilmot
University of Vermont Extension Maple Specialist
Proctor Maple Research Center

Why do sugarmakers tap their trees on a certain date (around March 1st in Vermont)? For many producers, the date is selected to encompass what is typically the best 4-6 weeks of sugaring weather. Tap too early, so the theory goes, and the holes may run poorly later in the season when the weather is favorable for good sap runs; tap too late and miss some of the best early season weather.

Unfortunately, the weather is often unpredictable and uncooperative. At the University of Vermont Proctor Maple Research Center, for example, the winter and spring of 2006 was characterized by several episodes of ideal sugaring weather in January and February, followed by March temperatures that were initially too low, and then soon were too high for sustained sap flow. The following year featured a few days of favorable sugaring weather in early January, followed by cold temperatures until mid-March. In neither winter, at many locations, did the "best" 4-6 week period begin on March 1st.

There are a variety of reasons why sugarmakers might want to tap earlier than the traditional date: thousands of taps that take several weeks to install, lower snow cover and easier walking before mid to late winter, climate change generally moving the season forward and providing more sap flow weather in January and February. For most sugarmakers, the bottom line is simply this: what tapping time frame results in the highest sap yield? The experiments described below, which were performed between 2000 and 2007, were designed to answer this question.

Methods: Gravity Collection

All trees in these and subsequent experiments were located at the University of Vermont Proctor Maple Research Center in northern Vermont at an elevation of 1300-1500 feet. During the years 2000-2002, sap yields from trees tapped on different dates were studied using gravity collection. Sixty trees were divided into 3 groups of 20, with each group tapped 3-4 weeks apart. All trees had a single taphole and to reduce variability, all tapholes were on the same aspect (SW to SE, depending on the year). Trees were mostly in forest stands, with some open grown, and had an average diameter of 16". Sap and sugar content were measured whenever the sap ran, from the time of tapping until all taps had ceased running. For the sap collection, plastic spouts were connected to a short length of tubing which ran into individual covered plastic buckets. Spouts were new in 2000, they were washed and reused in 2001 and 2002. Half the spouts were 7/16" and half were 5/16". In 2001 and 2002, groups of trees were alternated so that the trees tapped first in 2000, were tapped second in 2001, then last in 2002.

Results and Discussion: Gravity Collection

Sap volumes are presented in Table 1. Although sap sugar content was also measured, sap volume was of primary importance in this study because it was directly affected by taphole "drying". Sap sugar content is unlikely to be affected by tapping date, with the exception that sap collected in January or early February may be less sweet.

The dates chosen for tapping were selected to be about a month early (first tapping date), near the "traditional" date (second tapping date) and about 2 weeks late (third tapping date). In 2001, very deep snow in March both shortened the season and pushed it back, as can be seen by the collection dates.

A. Gravity	Tapping date 2000		
	2/1	**2/28**	**3/17**
Sap run date	Gallons of sap collected		
2/20 - 2/28	1.1		
3/2 - 3/9	7.9	7.6	
3/11 - 3/16	2.7	2.5	
3/20 - 3/24	4.8	4.8	5.5
3/29 - 4/7	1.3	2.5	3.8
4/11 - 4/20	1.2	1.8	4.1
Total	**19**	**19.2**	**13.4**

B. Gravity	Tapping date 2001		
	2/1	**3/5**	**4/4**
Sap run date	Gallons of sap collected		
3/18 - 3/20	1.4	1.3	
3/29 - 4/2	4.1	4.2	
4/5 - 4/10	3.4	3.4	4.0
4/16 - 4/30	1.8	2.8	4.9
Total	**10.7**	**11.7**	**8.9**

C. Gravity	Tapping date 2002		
	1/31	**2/28**	**3/21**
Sap run date	Gallons of sap collected		
2/21 - 2/26	2.6		
3/7 - 3/9	2.8	3.3	
3/13 - 3/16	3.7	4.5	
3/29 - 4/2	3.2	3.9	4.8
4/9 - 4/16	3.2	3.3	6.0
Total	**15.5**	**15.0**	**10.8**

Table 1: A,B,C. Sap yield for the different sap flow periods of each year, collected by gravity. Yields, shown in gallons, are the average of 20 trees for each tapping date.

Three trends were evident in the results. First, the overall yields for the first two tapping dates were very similar, even though the tapholes in the first group were a month older than those in the second group. Second, the sap did flow less as the holes became older, as can be seen by comparing the yields in different columns in April, but for the most part this did not occur until the last week or two of the season. Third, tapping well beyond the start of the season resulted in tapholes that out-produced all others; however, production from these tapholes could not make up for the earlier lost sap runs. During these three years there was very little sap flow weather in February, so the advantage of tapping on February 1 was negligible in terms of yield . . . only in 2002 was a significant amount of sap collected before the "traditional" date. Thus, these experiments showed that while tapping early did not appear to hurt overall sap yields, neither did it supplement them.

Methods: Vacuum Collection

During the years 2006 and 2007, sap yields from different tapping dates were studied using collection by high vacuum. The study trees, which were growing in a forest stand and ranged from 10-16" DBH, were divided into 3 groups of 10 trees and each group was tapped on a different date. All trees had one taphole located on the south side of the trunk (to reduce variability-in our main bush we tap all sides of the tree). As was done with the gravity collection, the groups were alternated so that the trees tapped latest in 2006 were tapped first in 2007. Sap was collected in 3.2 gallon vacuum chambers (see June 2007 Maple Syrup Digest page 22 for a picture of a vacuum chamber). These chambers allowed collection of sap from individual tapholes under vacuum; the sap remained in the chamber for volume measurement and sampling for sugar content until it was manually emptied. New spouts and droplines were used each year. Vacuum was supplied by an oil-cooled liquid ring pump and was approximately 24" Hg at the taphole.

Results and Discussion: Vacuum Collection

The three groups of trees were tapped at widely spaced intervals, beginning in January (Figure 1); thus the difference in age from the newest to the oldest tapholes was considerable-61 days in 2006 and 76 days in 2007.

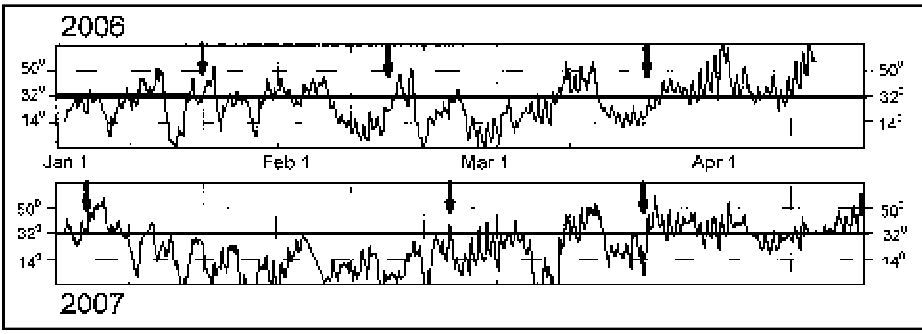

Figure 1. Air temperatures (degrees F) from January 1 through April 20 at the Proctor Maple Research Center. Arrows indicate the tapping dates for 3 groups of trees in 2006 and 2007. Note the number of days in January and February 2006 where the temperature exceeded 32 degrees.

Overall yields for trees of this size, or any size, were very large, as can be seen in Table 2, which illustrated the superior performance of both high vacuum, and the collection method which essentially eliminates any lateral line restriction by using only a 5/16"dropline connected directly to the chamber. These experiments tested the efficacy of tapping very early and in both years a fairly large amount of sap was collected in January and February. It is instructive to note the yields during the sap run of 3/24 in 2006 and 3/28 in 2007; in both cases, the earliest tapholes, which were 9 and 11 weeks old, respectively, equaled or nearly equaled the performance of tapholes that were much newer.

As was true with gravity collection, during the last week or two of the season the average sap flow declined in the older holes relative to the newest holes. During this time, some tapholes stopped flowing altogether, while others continued at a rate nearly comparable to earlier weeks. Warmer weather, particularly after the end of March 2006, was strongly correlated with the decline in flow from both the January and February tapholes. In another study in 2006, we recorded

A. Vacuum	Tapping date 2006		
	1/20	2/24	3/22
Sap run date	Gallons of sap collected		
1/20 - 1/28	2.1		
1/30 - 2/4	6.2		
2/15 - 2/23	2.4		
3/9 - 3/14	4.8	6.1	
3/24 - 3/ 27	5.6	5.7	5.9
3/28 - 4/2	4.8	5.6	5.9
4/3 - 4/6	2.1	2.8	3.8
4/7 - 4/12	2.2	3.5	5.7
Total	**30.2**	**23.7**	**21.3**

B. Vacuum	Tapping date 2007		
	1/4	2/22	3/21
Sap run date	Gallons of sap collected		
1/5 - 1/8	5.0		
3/11 - 3/15	4.0	4.0	
3/22 - 3/27	7.8	6.5	7.5
3/28 - 4/3	8.6	7.7	7.8
4/10 - 4/13	5.4	5.5	6.7
4/14 - 4/23	3.8	4.1	5.8
Total	**34.6**	**27.8**	**27.8**

Table 2: A,B. Sap yield for the different sap flow periods of each year, collected by vacuum. Yields, shown in gallons, are the average of 10 trees for each tapping date.

greatly reduced flow starting in late March from south-facing tapholes compared to north-facing tapholes, again related to heating of the trunk.

Sap sugar content in January, particularly in 2006, was low compared to sugar content in March. During the first runs in 2006, the sap averaged 1.3% brix, compared to 2.1% by mid-March. In 2007, the January sap run averaged 1.8% compared to 2% in March. Low sweetness translates to greater fuel consumption in order to make syrup, although for producers using reverse osmosis the difference in fuel consumption should not be large. Despite the differences in sap sugar between the earliest tapped trees and those tapped in March, syrup yield (sweetness x volume) was still much higher for the January tapped trees; in fact syrup yield for these trees in 2007 was over 0.7 gal/tap.

Why Do Tapholes "Dry Up"

If tapholes can run well for as long as 14 weeks, as many did in 2007 under vacuum, then the traditional wisdom that they will run for only 4-6 weeks needs to be re-examined. Actually, the term "dry up" is not an accurate description. Some people believe that air getting into the hole dries the wood tissue, much like a damp sponge dries when left in the sun. To further test this theory, gravity collections were made in 2007 using 7/16" Vermont type (rolled metal) spouts, open to the air and not connected to any tubing. Trees were the same size as those used for vacuum collection and located across the road from the vacuum stand. Two groups of 10 trees were used, and all sap was collected in buckets.

Gravity-7/16" tin spouts	Tapping date 2007	
	1/26	**3/16**
Sap run date	Gallons of sap collected	
3/11 - 3/15	1.3	0.7
3/22 - 3/27	2.9	2.7
3/28 - 4/3	2.8	2.5
4/10 - 4/14	4.1	4.1
4/18 - 4/23	1.2	1.1
Total	**12.3**	**11.1**

Table 3. Sap yield for the different sap flow periods of 2007, collected by buckets using rolled metal spouts. Yields, shown in gallons, are the average of 10 trees for each tapping date.

The similarity of these results with those from experiments using tubing suggests that an open spout does not dry up sooner than a spout in a closed system. In this experiment, the two tapping dates were separated by 7 weeks, and no sap was collected from the January tapped trees for the first 6 weeks. Despite the difference in age, there was no indication that the yield from the older tapholes declined relative to the newer tapholes, despite being open to the air for a total of 12 weeks.

If air drying is not responsible for the cessation of flow, then what is the mechanism that causes the decline in yield near the end of the season, especially as the weather warms? Several microbiological studies of tapholes made in the mid-twentieth century are instructive. Sheneman et al. (1959) compared sap yields from tapholes inoculated with populations of microorganisms with tapholes that were relatively uninfected, and found that high populations of bacteria, fungi and yeasts, observed in the warmer portions of the sap flow season, were strongly correlated with cessation of flow. Ching and Mericle (1960), in similar experiments, identified common Pseudomonas bacteria, found in large numbers on the bark of un-tapped trees, to be the microorganism most likely responsible. The apparent mechanism involves an interaction between the bacteria and normal sap constituents, which resulted in the formation of a gummy substance which caused the physical blockage of sap conducting vessels within the taphole.

As a result of these and similar findings, the paraformaldehyde tablet, a registered pesticide, came into common usage as a way to prolong sap flow by killing or delaying the growth of microorganisms in the taphole. Unfortunately, paraformaldehyde, now illegal in maple production, also increased the size and severity of the taphole wounds. In addition the pesticide had the potential to introduce a toxic substance into a natural food product.

Morselli and Whalen (1991) attempted to keep tapholes from being infected without paraformaldehyde by using "aseptic" tapping practices, including chiseling the bark away from the hole, using sterile spouts and tubing, and flooding the wood and drill bit with alcohol. Despite these sanitary practices, which would be time-consuming and impractical for most sugarmakers, many of the aseptic tapholes still became contaminated by the second half of the season.

One of the underlying conclusions from these and similar studies is that infection of the taphole is inevitable, as bacteria, yeasts and fungi are present on the bark and throughout the forest, and that the populations of infecting microorganisms will increase as the temperature increases. As population growth of bacteria is exponential, one could expect their numbers to skyrocket as the temperature of the wood surrounding the taphole rises from 350- 400 degrees F, which is common in the early part of the sap flow season, to 450 - 500 degrees F later in the season. Sun exposed wood can actually warm far above air temperature, with taphole temperatures reaching 600 - 700 degrees F. January and February thaws may allow sap flow but rarely involve the prolonged warmth seen in April, thus populations of microorganisms may remain low for many weeks in tapholes drilled in early winter.

Our data do show that sap flow from the earliest tapholes does eventually slow down compared to tapholes drilled in March, so time is also a factor in the development of a significant microbial population. Thus, tapping in January or

February may have provided a head start for bacterial growth. This did not have a notable effect on sap yield during periods of low temperature, but reduction in sap yield near the end of the season was observed. Related to this, but not thoroughly tested in these experiments, is the effect of any residual microorganisms on used spouts. While one and two year old spouts were used in the gravity experiments, new spouts and droplines only were used with vacuum. It is possible that a used spout could infect a taphole and cause reduced yields, further compounding the reduction seen in older holes at the end of the season. However, it is likely that this effect would be pronounced only at warmer temperatures that favor bacterial growth. Experiments at the Proctor Maple Research Center in the spring of 2008 comparing yields using new and used spouts placed in tapholes of the same age seem to support this interpretation.

Finally, it should be taken as a cautionary note that while this research showed that tapping as early as January may lead to increased sap yields in some years, this article did not address the possible problems entailed in processing sap to syrup throughout the winter. January and February thaws are often followed by sub-zero weather, which could lead to unforeseen difficulties in the pumphouse and sugarhouse.

Conclusions

Under both gravity and vacuum, sap flow from tapholes drilled in January and February was comparable to sap flow from much fresher holes during the cooler part of the sap flow season.

Toward the end of the season, when temperatures had exceeded 500 degrees F on several days, January and February tapholes yielded less sap than newer tapholes. In years when many of the sap flow periods involve relatively low temperatures, perhaps 400 degrees or less, the additional yield from early tapping may provide a significant advantage compared to tapping on March 1st.

The results from these experiments are consistent with the interpretation that microorganism growth during warm weather is responsible for the cessation of sap flow from tapholes.

Acknowledgements

This research was partially funded by grants from the North American Maple Syrup Council Research Fund.

References

Ching, T.M. and Mericle, L.W. 1960. Some evidences of premature stoppage of sugar maple sap production. For. Sci. 6:270-275.

Morselli, M. F. and M. L. Whalen 1991. Aseptic tapping of sugar maple. Can J. For. Res 21: 999-1005.

Sheneman, J.M., R. N. Costilow, P.W. Robbins and J. E. Douglass 1959. Correlation between microbial populations and sap yields from maple trees. Food Res. 24:152-159.