Maple Syrup Digest

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20 year Record of Maple Syrup Production at UVM PMRC

3/16-inch Tubing Systems Biofilm Dev. and Sanitation

History of the George D. Aiken Sugar Maple Lab

The Newsletter of the North American Maple Syrup Council

MAPLE SYRUP DIGEST

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NAMSC's Vision is for all sugarmakers to consistently and sustainably produce high quality maple products.

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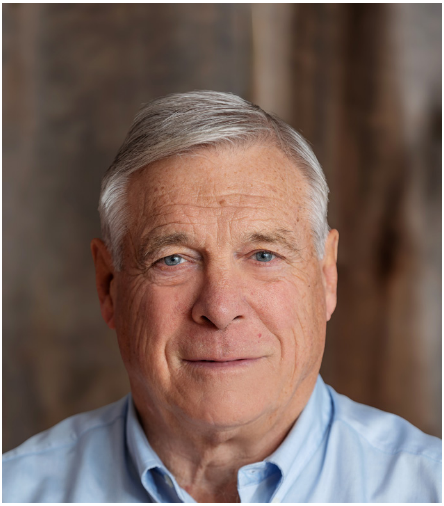

President's message

As I write my first President's message from the largest freshwater island in the world (Manitoulin Island), we have had our first snow in the bush, with work still to be completed. I am sure most of it will be done before the snowshoes are needed here. Yet I have learned after 60 years around Maple there are always tasks that need doing in the bush. That is one of the reasons I love working in Maple.

I feel humbled by the honour of this position as I reflect. Long before all of us — more than sixty years ago — the groundwork for this organization was laid by those who saw the need for an International Maple organization. NAMSC provides the forum for all the Maple organizations to pool their knowledge, and share amongst all producers. That might involve best practices, funding, research and education, with the goal of making a high quality and safe food product for others to enjoy.

I become only the second person from Ontario, Canada to hold this position. My predecessor was Ron Shaw, a supporter of the NAMSC in the early stages. We have some challenges to face with changing weather, increased consumer demand, and labour supply. Yet all the while, we strive to maintain a unique food product, distinct from other sugar substitutes. The opportunity to share our knowledge and look forward together is what NAMSC provides us. Welcoming engaged and involved delegates to sit at the table benefits the whole industry. Please reach out to your local delegate or any member of the executive director to offer input or express concerns.

In the wider group, our in-person International Maple Convention is one of the best forums for sharing knowledge. Congratulations to Massachusetts for hosting a successful International Maple Conference in historic Sturbridge, where attendees enjoyed balmy summer weather. The conference was very well attended. With a slight change in format, NAMSC conducted its business meetings at the beginning of the conference before the tours and presentations. The tours were held the first day followed that evening with the excellent Taste of Massachusetts gathering in that evening . Days two and three provided a variety of technical speakers (day 2) and practical workshops (day 3). The banquet was held in the evening of day 2, and included awards and presentations.

Hall of Fame inductees announced at that time were Stu Peterson (Minnesota) and Yves Bois (Quebec), both well deserving recipients of this honour. The actual Hall of Fame induction will occur in Croghan, NY May 11. NAMSC will hold a delegate meeting there the day before. If you haven't then welcome. Please come.

Debbie Thomas justly received NAMSC's Special Recognition Award for her years of service to the maple community. Bill Robinson was given lifetime membership into NAMSC for all he has done with NAMSC. Mark your calendars as Maine will host the International Conference October 21-24, 2024 in Portland, MA.

Congrats to the winners of the syrup contest! It was gratifying to help judge and see the numerous quality entries in all categories. It's a positive sign to see only a handful of disqualifications due to off- flavours and only one related to density. We must keep improving the overall quality of the product we produce. With that in mind the International Grading School continues to be held on the two days after the conference, with the next one in Maine in 2024. If you haven't taken the school please consider it; I guarantee you will benefit from it.

This year NAMSC funded a research project at Carleton University for work in developing a test strip to determine when sap has gone buddy. A huge thank you to all of NAMSC's Alliance Partners in helping fund Maple Research.

NAMSC has decided to become a member of Centre Acer, becoming the first organization outside of Quebec to be granted membership. This will be a positive relationship for both parties going forward, in sharing research, education and training.

All the best for the upcoming Holiday Season.

Brian

In this issue...

Cover: Alejandro Condega Bisbee, Priceton, Massaachusets

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A 20-Year Record of Syrup Production at UVM Proctor Maple Research Center from 2004-2023

Timothy D. Perkins, A.K. van den Berg, Mark L. Isselhardt, and Wade T. Bosley
University of Vermont Proctor Maple Research Center, Underhill, Vermont

The University of Vermont (UVM) Proctor Maple Research Center (PMRC) in Underhill, Vermont, has along history of research on sap production. Maple syrup has been made at PMRC since shortly after its founding in 1946, in part for research and in part for demonstration. Syrup production has always been an important component of the work of PMRC as it keeps the faculty and staff aware of the issues involved in sap collection and syrup production, it provides more of a "buy in" from producers when they understand that we face the same hurdles as they do each season, and the revenue gained from the sale of maple syrup helps to fund the operation.

The tubing system after the turn of the century had been constructed piecemeal over several previous decades since tubing systems had been introduced as funding allowed and as a result of different research projects. Vacuum was provided by a modified dairy pump and a custom-built releaser generating (at best) 15" Hg of vacuum. Clearly, PMRC was not operating a "state-of-the art" tubing production system at that time. Syrup production averaged 0.34 gallons per tap, about 42% above the Vermont industry average at that time (including all types of production).

In 2003, the decision was made to totally replace the legacy system in the main portion of the PMRC sugarbush with a modern high-yield sap collection system and to more fully incorporate sap collection into the research program and to progressively work on tubing or retubing other sections of the PMRC lands. A generous grant from the Chittenden County (VT) Maple Sugarmakers Association and financialassistance from several other Vermont maple groups funded the project in large-part. The goals of the project were:

1. To design and install a state-of-the-art (for 2004) maple sap collection system in the main bush.

2. To progressively replace other sections of the PMRC sugarbush and to expand into non-tapped areas of the woods.

3. To compare equipment, installation techniques, and economics among several mapleequipment manufacturers.

4. To incorporate more of the production woods into the research program.

5. To allow quantification of sap yields from different portions of the

sugarbush.

Methods

To accomplish these goals, the main sugarbush at PMRC was divided into four roughly equal-sized areas based upon tap count. Several maple equipment companies were invited to participate in this project. Guidelines for the companies included a restriction on tree diameters and general system considerations for installation (# taps per lateral – "strive for five", short laterals running downhill) were discussed. This was followed by a walk-through of the woods in the fall of 2003 with representatives from the various companies selected. Afterwards, sections were randomly assigned to each company and their costs estimates developed and provided. UVM PMRC paid the full installation costs, including materials and labor, for each of the installed systems. Companies were allowed to design, choose the materials and methods used, and install the sap collection system in their portion of the woods, keeping in mind that the costs could be included in the presentation of results, the costs weighed against the sap yields achieved, and that maintenance efforts, costs, and problems might also be reported. A fourth system was installed by a professional tubing installation company which was allowed to select the equipment (tubing materials) they thought was economically advantageous and worked best irrespective of the maple supply company. All the tubing systems terminated at the Sumner Hill Williams Sugarhouse at PMRC with individual Lapierre mechanical releasers equipped with counters connected to a common vacuum pump (initially a Leader Oil-Flood pump, but upgraded to a Busch Rotary-Claw pump several years later). In this way, sap volumes for each section could be monitored.

In the fall of 2005, the remaining portion of the current sugarbush at PMRC was also retubed. This area, called "Red Series" was set up primarily as a research platform, with 16 separate ¾" mainlines, with each mainline connected to its own custom Lapierre mini-releaser. A professional tubing installer set up the woods at the direction and guidance of PMRC staff. The entire system was serviced by a Busch Rotary-Claw vacuum pump.

Land adjacent to the Red Series section was acquired in 2009 and was tubed in time for the 2010 season. This "Martin Block" section was set up in a similar fashion to the "Red Series" section, with 12 individual ¾" mainlines each connected to their own custom Lapierre mini-releaser, again professionally installed. This system also had its own Busch Rotary-Claw vacuum pump.

In 2021, a 1,000 tap expansion was conducted in a new section of the woods. This consisted of two duplicate single-pipe systems: one servicing approximately 500 red maple trees and the other servicing approximately 500 sugar maple trees. Sap flowed through one of two identical Lapierre electric releasers (one for red maple sap, the other for sugar maple sap) equipped with meters and connected to a common Busch Rotary-Claw vacuum pump. The mainline was installed by a professional tubing installer, but the lateral line system was installed by PMRC staff.

Changes to all parts of the sugarbush after retubing were primarily aimed at maintenance and sanitation related efforts, but also included some occasional modest expansion into peripheral areas as well as the addition of trees due to ingrowth. Over the 20 yr span of this work, the type, number, and capability of vacuum pumps used at the sites varied. For the majority of the time, Busch rotary-claw vacuum pumps were used and a vacuum level of around 24-25+ "Hg was the target (our woods average above 1,500 ft elevation). In some years the vacuum level achieved was better than others for various reasons (powerfailure, pump/moisture trap/releaser failure, major tubing failure, etc.).

During each spring season, after sap volume and sap sugar content were measured, the sap was concentrated then boiled to syrup.

Results

Our goal in this paper is not to examine each of the individual factors contributing to total syrup yield during this 20 yr time period at UVM PMRC in detail, but rather to provide a high-level overview ofproduction and make generalized conclusions about the performance of the tubing systems used.

The main bush area initially totaled approximately 1,175 taps averaging 18.6 inches diameter (dbh). Themajority of tapped trees were over 12 inches dbh in 2003. Only 5.2% of trees that ended up being connected to the new tubing systems had diameters less than 12 inches – most of these were over 11 inches dbh. The minimum tapped tree dbh was 9.8 inches – the maximum was 47.3 inches. This area of the sugarbush was the original PMRC sugarbush and had been heavily managed for maple production according to existing standards from the early-1900s to early-2000s. Thus, this area was dominated almost exclusively by large sugar maples that had been tapped for decades. By 2023 tap count in the main bush had expanded to 2,689 trees, more than doubling the original tap count. This occurred primarily though the addition of trees between 9 and 12 inches dbh (as tapping guidelines relaxed due to the introduction of the "small" spout), growth of trees, extension of mainlines into upper areas of that were less accessible by tractor, and the addition of red maple taps that had been passed over in the legacy tubing system.

Three of the four subsections in the main bush were tubed with dual-pipe systems. The fourth was a single-pipe system. Three systems used blue-translucent HDPE maple mainline – the other used thinner-walled, black, poly waterpipe. All of the dual-pipe systems used PVC-pipe manifolds (common in 2004). Failure of these due to breakage by sap freezing in them was common in the first several years, sometimes resulting in considerable sap loss before the breakage was located and repaired. Initially the PVC manifolds were repaired or replaced with like items, then later were replaced by stainless steel-manifolds, and eventually all of the "pipe" manifolds were replaced with "whip" style manifolds. These proved to be very robust and reliable.

All lateral line installed in the woods was either semi-stiff tubing or rigid tubing. Although the companies used were instructed to "strive for five, no more than ten" taps on a lateral line, the lateral tubing installation actually averaged under three taps per lateral. Only rarely were more than five taps installed on a single lateral. Lateral lines tended to be short as a consequence of this.

All spouts used for the duration of this study were 5/16". For all but two years, all trees received only 1 tap – regardless of diameter. Tapholes generally averaged 2" deep (including bark), but varied somewhat by year, ranging from 1 1/2" to 2 1/2 deep. Sanitation was initially accomplished by air-water pressure cleaning, but later (after about 2010) was done by the use of new spouts each year, the use of Check-valve spouts, and/or periodic dropline replacement.

The one single-pipe system failed after five yrs use, probably due to low or insufficient UV inhibitors in the plastic used for extrusion. Both the lateral line tubing and mainline became brittle and shattered under light impact. Repair was impractical, so the system was entirely replaced with a dual-pipe system at that time.

In the "Red Series" sections, tap count for the newly tubed area for the first sap collection season in 2006 was around 630 trees. By 2023 tap count in Red Series had doubled to 1,285 due to the same factors described for the Main Bush area above. Average tree size in 2005 was 14.8 inches dbh. About 62% of trees were sugar maple – the remaining 38% were red maple. The number of taps per lateral averaged three. Research in this section of the woods originally focused on spout and tubing sanitation approaches before transitioning to a platform to study various the effects of various tapping factors (tapping depth etc.) on sap yield.

The "Martin Bush" section, added for the 2010 season, originally added 885 taps, all lines with exactly three taps per lateral. Mainlines averaged 74 taps. By the 2023 season it reached 1,411 taps, a growth of 59%. Research in this area has focused on exploring tubing system design factors to improve yields.

The "Red/Sugar" section, added in 2021, consisted of 534 red maple taps averaging 11.4 inches dbh and 499 sugar maple taps averaging 12.7 inches dbh.

Overall, the tap count at UVM PMRC grew from 1,549 taps in 2004 to 6,248 taps in 2023 (Figure 1) values shown across top of graph), a four-fold increase, or about 20% per year when averaged over the 20 yrs. This largely mirrors the growth in taps of the Vermont maple industry over the same time period. As described above, growth in the number of taps was not uniform over time, but was usually associated with the extending tubing into new sections of woods, the lowering of minimum diameter for tapping, and the addition of ingrowth as trees reached minimum tapping diameter. new sections of woods, the lowering of minimum diameter for tapping, and the addition of ingrowth as trees reached minimum tapping diameter.

The reported syrup values in Figure 1 represents mostly Grade A marketable syrup. Production at PMRC is generally halted when syrup turns sour or buddy or if the syrup becomes difficult/impossible to process (filter). In many years all syrup was Grade A. In a few seasons a small amount of syrup produced (usually only a barrel or two at the end of the year) graded commercial, generally if syrup turned sour or buddy before boiling out the pans could be accomplished.

Over the 20 yr time period from 2004-2023, average yield was 0.58 gal syrup per tap (or 6.4 lbs per tap, Figure 1). The highest yield occurred in the first season after retubing (2004) – a not unusual phenomenon in maple production. Low production years were observed in 2012 and 2021, both primarily due to weather. In 2012, record high temperatures in mid-March resulted in the early appearance of buddy off-flavor. In 2021, prolonged warm-hot weather without intervening freezes caused sap to sour or go ropey within the tubing system, making processing sap into syrup difficult and the resultant product unpalatable. Interestingly, in 2021 sap production totals averaged close to normal, however spoiling in the lines prevented much of that sap from being imum target production (0.5 gal syrup per tap), but fell below average. Only two seasons (10%) fell below the target minimum level. What is quite clear however is that syrup yields throughout this 20-year timespan are considerably higher than the average yield from the legacy sap collection system at PMRC prior to retubing (0.34 gal syrup per tap). Not a mm at PMRC prior to retubing (0.34 gal syrup per tap). Not a single year prior to retubing in 2004 resulted in breaking 0.5 gal syrup per tap at PMRC. Ninety percent of years from 2004 onward exceeded that production level. Overall, the average syrup production at UVM PMRC in this twenty-year period following retubing was 70.6% higher than the average production rate prior to retubing. During this same time period, syrup production of Vermont maple producers increased from an average of 0.24 gal syrup per tap to 0.37 gal syrup per tap, a 54% improvement in yield. This likely represents the addition or expansion of new high-yield systems in the Vermont maple industry and the replacement of older, legacy sap collection systems (older tubing, lower vacuum, 7/16" spouts) with newer high-yield systems.

Average production during the first five years in all three dual-pipe systems was almost identical at 0.60-0.61 gal syrup per tap (Figure 2). Yield was slightly lower in the single-pipe system at 0.54 gal syrup per tap. The small differences among systems from one year to the next mostly seem to stem from the timing of breakage of PVC manifolds rather than actual variation in sap flow.

While there is obvious variation in syrup yield from year-to-year, there doesn't appear to be any strong overall trend in yield over this 20 yrs of observation, either positive or negative. Despite the growth in number of taps and aging of the systems over 20 yrs, given adequate system maintenance and operation, production has remained good to this time (Figure 3). The slight (and non-significant) trend in syrup yield downward over 20 yrs is very low, averaging only 1.7-3.8% per decade. This indicates that maple tubing systems that are well-maintained and operated using good vacuum and adequate sanitation practices can remain productive for at least two decades and probably longer. Moreover, not a single year in this 20 yrs of operation fell as low as the best year of the preceding tubing system.

Although sap quality was not quantified as part of this project, observational data indicate that the sap from the system built with black water pipe may have been slightly more degraded.

The cost of retubing the main bush in 2004, including both materials and labor, ranged from $10.56 to $24.48 per tap, averaging $17.34 per tap. The variation was due in part to the type of system installed (single-pipe mainline system was considerably cheaper than the dual-line systems), the materials used (poly black waterpipe was cheaper than maple HDPE mainline), the number of taps in the section (economy of scale), and the density of trees in that section lower tree density necessitating more materials and labor to reach the same number of taps).

When the cost is expressed as a dollar amount per gallon of sap annually over the first five years of operation (2004-2008), it ranges from $0.09 to $0.20 per gallon (Figure 4), largely following the factors described above. More importantly, at the high sap yields achieved, when looking at ONLY the cost/benefit of the tubing systems themselves (and not including the equipment and labor to process sap into syrup), all of the systems achieved complete payback in the first year. The failure of the single-pipe system due to UV-breakdown after five years represents a major expense, essentially total replacement. All the remaining systems are still in place and operationally functional after 20 yrs. The tubing used in the failed system was warrantied for only five years. It is therefore recommended that producers purchase (if possible) tubing made with a considerably longer warranty period to avoid the trouble and expense of having to remove affected tubing from the woods and replace it.

While tubing system design, installation, operation, and maintenance are key factors in achieving high yield, the vagaries of different seasons imposed an overall limit on syrup production in some years. In particular, the hot years of 2012 and 2021 were quite detrimental to high productivity. Other years in which sap yields were low were associated with equipment failures of different types. Choosing the proper equipment and maintaining it in peak operating spare equipment and parts readily available in case of failures, using good spout and drop sanitation practices, and maintaining good vacuum are all recommended to avoid calamitous seasons.

Conclusions

- High syrup yields (> 0.5 gal per tap) over a long period of time are achievable with modern methods. Averages of double or more that of gravity sap collection can be realized.

- Careful attention to detail at multiple steps in the process is imperative.

- Preparing for things to go wrong, having extra equipment and spare parts readily available and identifying and repairing any failures that occur promptly will help to ensure success.

- Payback periods for the cost of a new tubing install utilizing high yield methods can be as short as one season for producers making syrup, or within two-seasons if selling sap.

- Using quality tubing materials with a long lifespan is important to avoid the need to replace systems more frequently.

- Dual-pipe systems tend to outproduce single-pipe systems on vacuum by at least 10-12%.

- Whip-style manifolds are superior in performance, less costly than PVC or stainless-steel manifolds, and require less maintenance.

- Loss in overall system productivity as measured by syrup yield, was-was very low over 20-yrs, averaging only about 0.17-0.38% per year for systems that are well operated and maintained. Acknowledgements

We are grateful to Chittenden County Maple Sugarmakers Association for their generous support of the initial retubing project. Other support was supplied by Orleans Co. Maple Producers (VT), Orange County Maple Producers (VT), Windham Co. Maple Producers (VT), and Franklin Co. Maple Producers (VT). Conversations with many maple equipment companies and individuals during this project and over the years have been instrumental. These include the folks from Leader Evaporator Company (now Leader/H2O), CDL, Dominion & Grimm, and Lapierre as well as Robert (Bob) White, Gary Corey, JR Sloan, Glenn Goodrich, and Joël Boutin (Quebec) among others. We thank all for the advice, comments, and consultation. A large number of PMRC staff, especially Brian Stowe, were involved in the planning, installation, maintenance, and operation of these tubing systems over the past 20 yrs. Their tireless work of these highly dedicated individuals is recognized and acknowledged with gratitude.

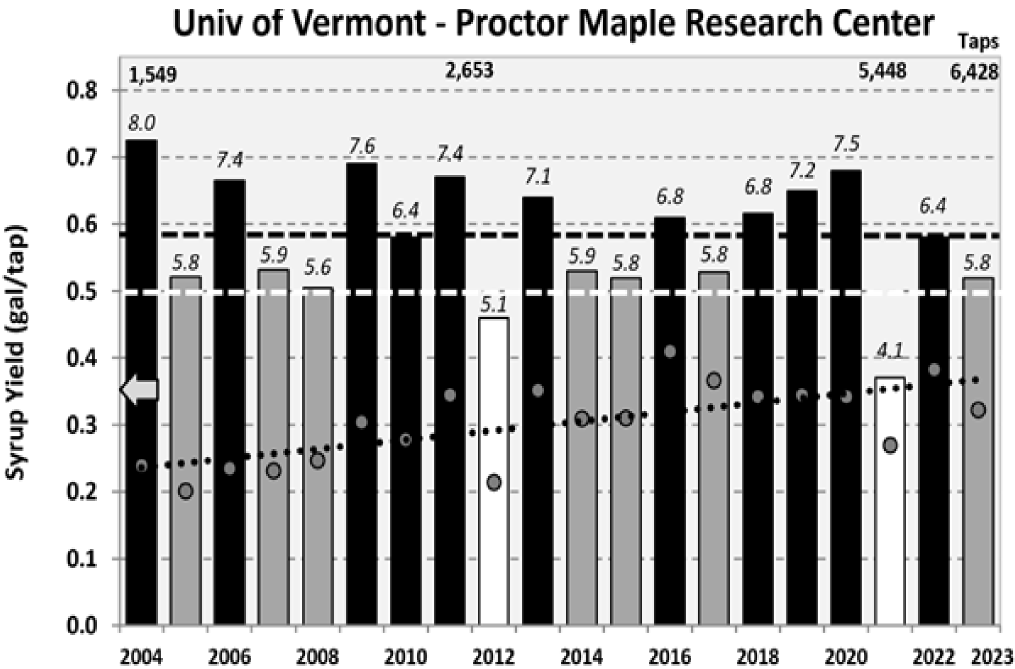

Figure 1 Total annual seasonal maple syrup production from 2004-2023 Research Center in Underhill, Vermont. Bars depict total yield of primarily Grade A syrup produced each season. The black dashed line represents the long-term average production of 0.58 gal syrup per tap. The white dashed line is the minimum annual target production of 0.5 gal syrup per tap. Black bars indicate years with at or above average production. Grey bars are seasons where syrup production was at or higher than the minimum target level, but below the long-term average. White bars indicate years in which syrup production was below the minimum target level. Numbers above each bar are the annual syrup production. in lbs per tap. Grey dots represent the average annual yield per tap for Vermont producers as reported by NASS and black dotted line is the linear trend of those data. The arrow along the left Y-axis inicates the average UVM PMRC production for the 20-yr period prior to 2004. Numbers near the top of the chart indicate the approximate number of taps for that year.

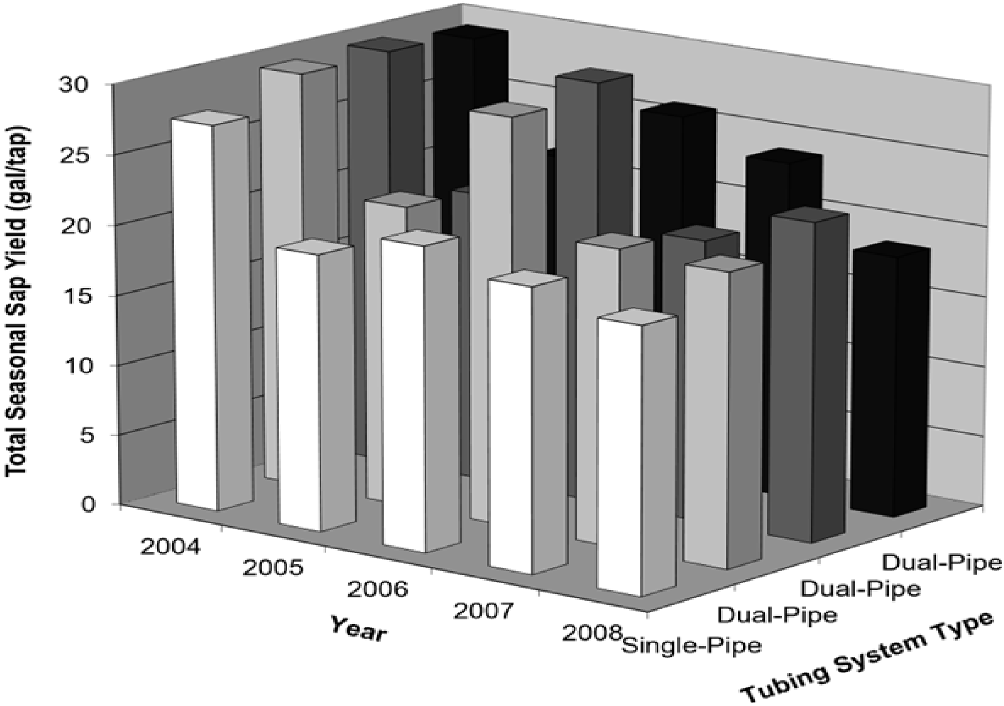

Figure 2. Total seasonal sap yield (gal per tap) for each section in the UVM Proctor Maple Research Center Main Bush for the first five years following installation. The single-pipe system (white bars) tended to produce about 11.4% less each season than the average of the dual-pipe systems. The dual-pipe system with black water pipe mainlines (black bars) typically produced just slightly less than the translucent-blue dual-pipe mainline systems (grey and dark grey bars).

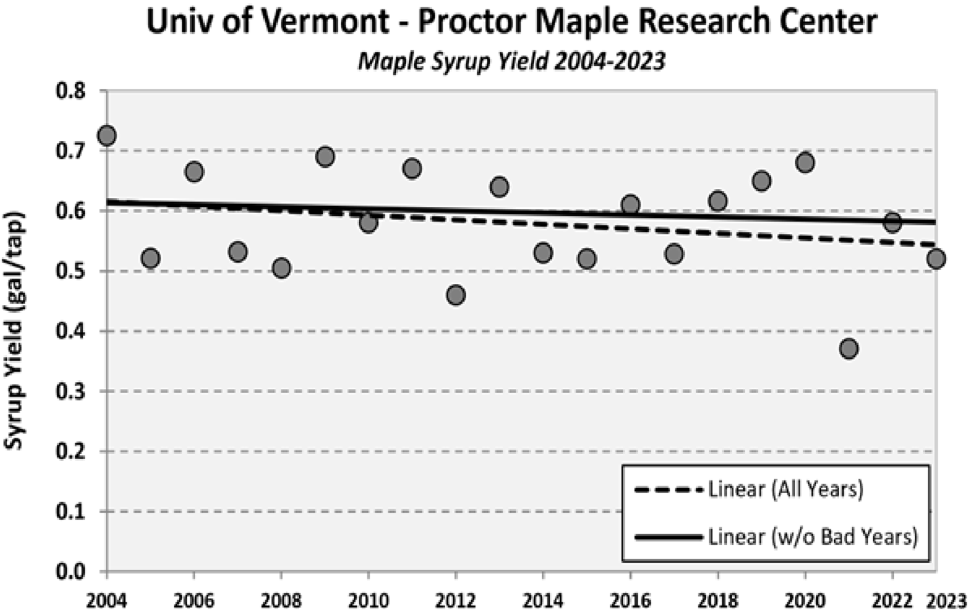

Figure 3. Annual syrup production from 2004-2023 at the University of Vermont Proctor Maple Research Center in Underhill, VT. The linear trend in syrup yield over this time period (dashed black line) shows a (non-significant) loss of approximately 0.38% per year, or 7.6% over the 20-yr time. If poor production years due to obvious weather-related issues (2012, 2021) are removed, the (non-significant) linear trend (solid black line) is reduced by more than half to only 0.17% per year, or 3.4% over 20-yrs. This indicates that tubing system aging of modern tubing systems that are maintained properly does not contribute to long-term loss of sap yield up to at least 20 yrs of age as long as proper sanitation practices are employed.

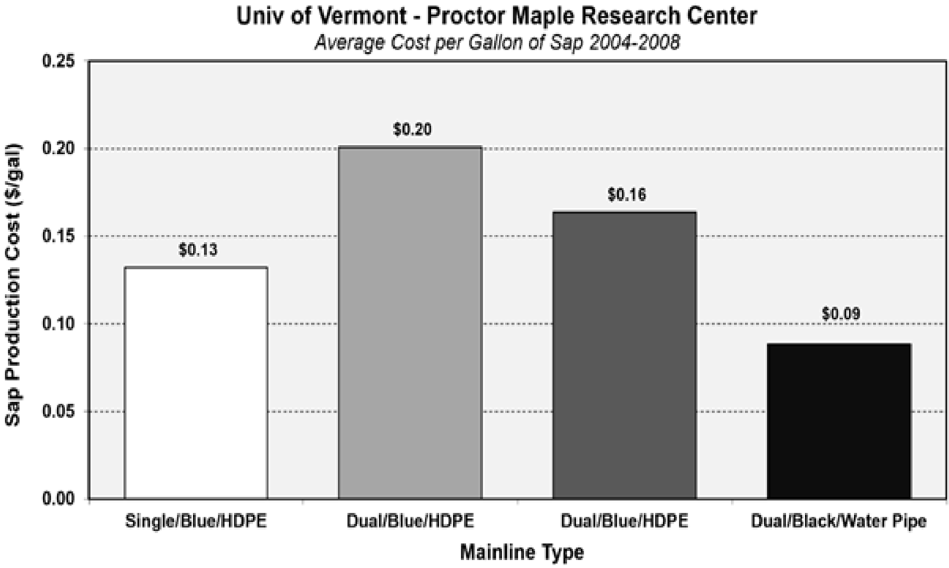

Figure 4. Average cost of a gallon of sap over the first five seasons (2004-2008) after installation by mainline type at UVM Proctor Maple Research in Underhill, Vermont, for the four individual sections of the Main Bush. These are: a single-pipe/blue/HDPE tubing system, a dual-pipe/blue/HDPE tubing system, a dual-pipe/blue/HDPE tubing system, and a dual-pipe/black/water-pipe system. This cost includes only material and labor to install and excludes regular operation and maintenance expenses over that time period. The mainline, lateral line, and drops of the single-pipe system failed due to brittle fracture (due to suspected lack of sufficient UV inhibitors) after the fifth season and had to be completely replaced. The dual/black/water pipe system had over twice as many taps and a higher density of trees compared to the other systems, so the lower cost reflected some economy of scale as well as reduced material cost.

3/16-inch Tubing Systems Biofilm Development and Sanitation

Yangjin Jung, West Virginia State University and Mike Rechlin, Future Generations
University and Thalia Guadalupe Ocho Bernal, West Virginia State University

The buildup of microbial mass (known as biofilm) growing in buckets, tubing lines, and collection tanks signals trouble to any maple sugaring operation. Evidenced by a slippery feel to the contaminated surfaces, this biofill and its accompanying high microbial count in the sap leads to sour sap, fermented syrup, metabolism off-flavor, ropey syrup, and overly dark syrup at the end of the season. Furthermore, microbial contamination of the taphole, caused by the drawback of contaminated sap, initiates a physiological process within the tree that results in taphole drying, ending the sap flow season. The problem is universal, but most pronounced in southern tier sugaring states where warm spells are a common occurrence during an otherwise productive season. It should be of increasing concern in more northern states where climate change is leading to much less predictable weather patterns (Giesting, 2020; Garthwaite, J. and A. Sheshadri, 2021).

To stay ahead of this microbial buildup, syrup makers need to pay attention to cleaning and sanitation. Cleaning involves physically removing dirt from surfaces, while sanitizing focuses on.reducing or eliminating microorganisms. Although cleaning may remove some microbes, it does not necessarily kill them.

Extensive research has been conducted by the Proctor Maple Research Center and Cornell University on 5/16 sap line sanitation. This work is summarized in "A Decade of Spout and Tubing Sanitation Research Summarized" (T. D. Perkins, A. K. van den Berg and S. Childs, 2019). That summary clearly states that," All studies presented in this summary were performed with 5/16 tubing on pumped vacuum tubing systems. These results and recommendations do not apply directly to 3/16-inch tubing systems.

"Three-sixteenth tubing systems rely on gravity-initiated tension in the sap column to develop a pull equated to vacuum. Without the need for a vacuum pump, releaser, or a power source these systems are often referred to as "natural vacuum" tubing systems. They provide substantial increases in sap flow without the added equipment or energy expenses of the 5/16 systems. Over time it was discovered that they also have their own unique challenges. One of which is the accelerated growth of the biofilm in tubes that remain full of sap for extended periods. This can lead to plugging of the tubing,).

especially at points of reduced diameter associated with line fittings (Childs, 2019). Another is the potential for a greater volume of contaminated sap being drawn back into the tree during the freezing period of a sap flow cycle.

With the problems of plugging and contaminated sap drawback more pronounced in 3/16-inch systems than 5/16-inch systems, the need for cleaning and sanitation becomes more imperative. Despite this need, little work has been done on the sanitation of 3/16-inch sap collection systems. To better understand microbial growth in 3/16-inch tubing systems and its impact on sap flow, in 2023 Future Generations University's Appalachian Program in collaboration with West Virginia State University, initiated a study comparing sap flow and microbial buildup in new 3/16-inch tubing, one-year-old un-sanitized tubing and tubing sanitized with a 600-ppm concentration of Calcium Hypochlorite as the sanitizing agent. This paper reports on the findings from the first year of that study

Study site

The study is being conducted on research collaborator Randy Kimble's farm in Upper Tract West Virginia. Six 3/16-inch sap lines were installed with 10 to 11 trees on each line (Figure 1A). Trees on all six lines are on a relatively flat ridgetop with a 200 feet elevation drop between the last tree on each line and the collection barrels (Figure 1B).

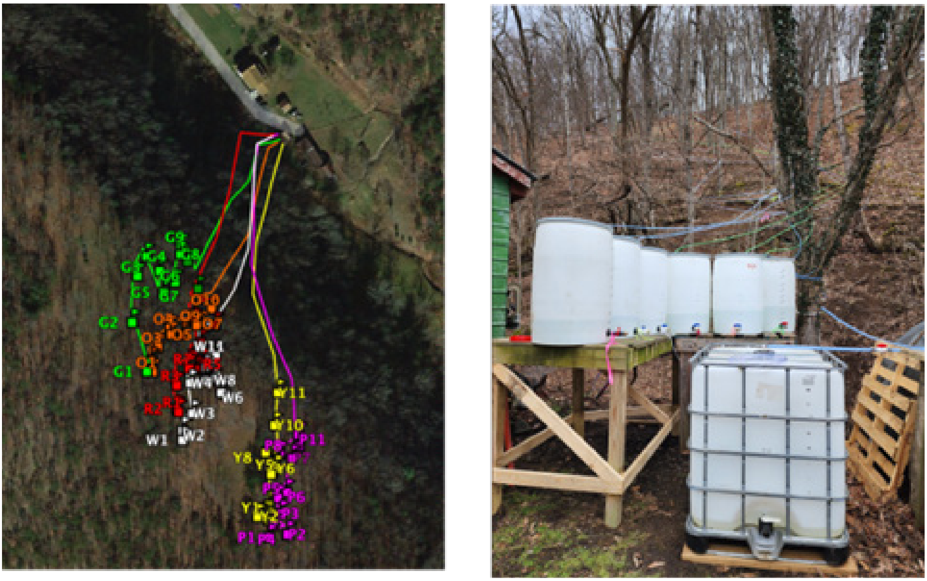

Figure 1. Sap lines color coded left to right: Green, orange, red, white, yellow and pink (A) and sap collection barrels (B)

In the first year of this study, we collected sap from each line to determine their relative productivity. Vacuum levels and end line temperatures were measured with a Farmblox monitoring system. While gathering this baseline data, we were also able to conduct several studies because we had on hand an additional line with one year's microbial growth. Additionally, we addressed specific questions raised by maple syrup producers through a series of lab-based experiments. Firstly, we determined the microbial growth in sap at different temperatures (4, 7, and 10°C). This exploration was prompted by the fact that sap, when collected in barrels, experiences temperature fluctuations during the day, and prolonged storage can lead to microbial overgrowth, potentially affecting syrup quality and flavor. Secondly, a preliminary study was conducted to evaluate the effectiveness of low concentrations of calcium hypochlorite (100 and 200 ppm) with a 10-minute contact time in reducing microbial load.

Field procedures

All trees were tapped on January 30, 2023. On each Monday, from February 6 to March 6, 30 inches of tubing were cut and 300ml of sap gathered from each study line. The sap samples were drawn from the sap collection barrels (Figure 1B). The samples were packed in ice and sent overnight delivery to the West Virginia State University lab for microbial analysis. West Virginia had a very short 2023 sap flow season. By February 26, the commercial sugaring season was over. We collected minimal amounts of sap from the two study lines to continue the microbial study through the first week of March.

Laboratory procedures

Sap and tubing samples were processed within 24 hours of their arrival at the WV State laboratory. The sap sample underwent serial dilution with 0.1 percent peptone water and were plated on Trypic Soy Agar, Pseudomonas agar with CFC (cetrimide, fucidin and cephaloridine) supplement, and Dichloran Rose Bengal Chloramphenicol agar for the enumeration of psychrotrophic bacteria, Pseudomonas spp., and mold and yeast, respectively.

For the tubing samples, the exterior was treated with 10 percent bleach and subsequently rubbed with 70 percent alcohol. The tubing was then cut into 10 cm-long pieces. Each 10 cm-long piece was further divided into 2 cm-long segments, and five of these 2 cm-long pieces were cut in half to expose the interior surface. These tubing pieces were transferred to 20 mL of phosphate buffer with 2 g of 3 mm glass beads and vortexed for one minute. The tubing pieces were then swabbed thoroughly with a cotton swab. The swab, tubing pieces, and the glass beads were then vortexed for an additional minute and plated on agar plates. The tubing pieces were subsequently transferred to a tube containing 20 mL of phosphate buffer for washing. This washing process was repeated three times. The washing solutions were pooled and plated on agar plates. The duplicate counts were presented as logarithms of the number of


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colony-forming units per cm2 of tubing(log CFU/cm2).

For the lab-based experiments, fresh sap collected at the beginning of the season was stored at -20°C until needed. To assess microbial growth at different temperatures, the frozen sap was thawed and kept at 4, 7, and 10°C for 168 hours. At the specified time intervals, the sap samples were taken out and plated on agar plates for the enumeration of psychrotrophic bacteria, Pseudomonas spp., and mold and yeast.

To evaluate the efficacy of 100 and 200 ppm calcium hypochlorite, the frozen sap was thawed and connected to new 3/16-inch tubing with a peristaltic pump for continuous flow at 9°C for four weeks. After the four-week treatment, the 3/16-inch tubing was removed from the pump and connected to 100 and 200 ppm calcium hypochlorite. Following a 10-minute application, the calcium hypochlorite was flushed, and the tubing was subjected to microbial analysis as described above. Additionally, the tubing was treated for Scanning Electron Microscopy (SEM) to visualize its inner surface.

Results

Table 1 shows the 2023 baseline sap flow data. The vacuum on all but the pink line was 21 inches Hg or higher. The pink line had a vacuum sensor malfunction halfway through the season, not allowing us to monitor and perform repairs if needed. This may be why that line had a lower seasonal accumulative sap flow (Table 1). After establishing this 2023 baseline, the study design calls for post treatment monitoring of sap flow and microbial growth during the 2024 season.

Table 1. 2023 Sap line tree data, cumulative sap collected and year 2 treatment Plan

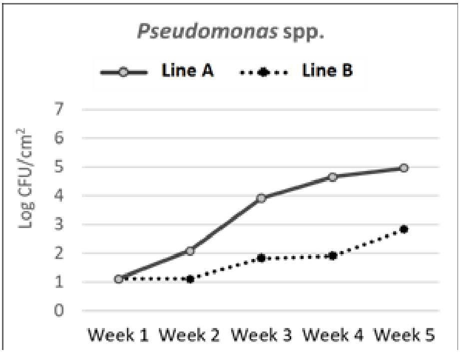
Set	Line	# Trees	Basal Area ft. sq.	Ave DBH inches	Yr. 2 Treatment plan	Yr. 1 gallons Sap Collected
1	White	11	7.3	10.8	sanitize	53
1	Green	10	7.3	11.1	Replace (new in 2023)	50
1	Yellow	10	6.9	11.1	old (unsanitized)	57
2	Red	10	6.9	11.0	sanitize	68
2	Orange	10	7.4	11.1	Replace (new in 2023)	47
2	Pink	11	7.5	11.0	old (unsanitized)	42

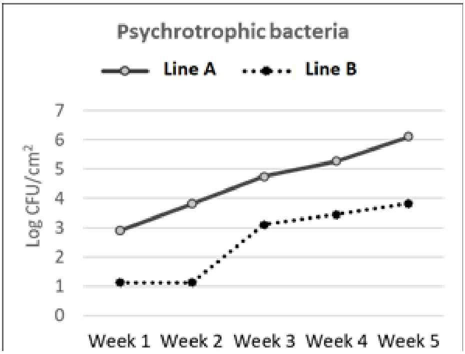
Microbial load inside of the tubing over the season

It is well-established that certain species of bacteria, mold, and yeast can impact sap volume and quality. In this study, Psychrotrophic bacteria, capable of thriving at low temperatures (≤7°C), and Pseudomonas spp., as key contributors to the formation of biofilms, as well as mold and yeast were enumerated. Figure 3 shows the microbial load within the tubing over a span of 5 weeks. In this study, the detection limit for the tubing analysis was established at 1.1 log CFU per cm2, which is 13 bacterial colonies/cells per cm2.

Over the course of the season, accumulation of microbes was observed in both the new (Line B) and one-year- old unsanitized (Line A) tubing. As expected, a higher microbial load was evident in the A tubing. For Line B, Pseudomonas spp. and psychrotrophic counts began to recover after the initialtwo weeks, with mold and yeast recovery initiating after three weeks. By the season's end, the levels of Pseudomonas, psychrotrophic bacteria, and mold and yeast had reached 2.8, 3.8, and 2.83 log CFU/cm2, respectively. In contrast, Line A exhibited initial levels of Pseudomonas, psychrotrophic bacteria, and mold and yeast at 1.2, 2.9, and 2.8 log CFU/cm2, respectively. These numbers escalated to 5.0, 6.2, and 5.0 log CFU/cm2 by the season's end. These findings align with a previous study conducted by Lagacé et al. (2006).

Sap samples were taken from the collection barrel rather than directly from the tubing. The microbial levels fluctuated throughout the season. Initial levels of Pseudomonas, psychrotrophic bacteria, and mold and yeast were all approximately 4 log CFU/mL, increasing to more than 7.5 log CFU/mL of sap by the season's end. There was no significant difference between Line A and Line B. This observed variation is attributed temperature fluctuation within the barrels. This circumstance prompted us to investigate the microbial growth in sap under different temperature conditions.





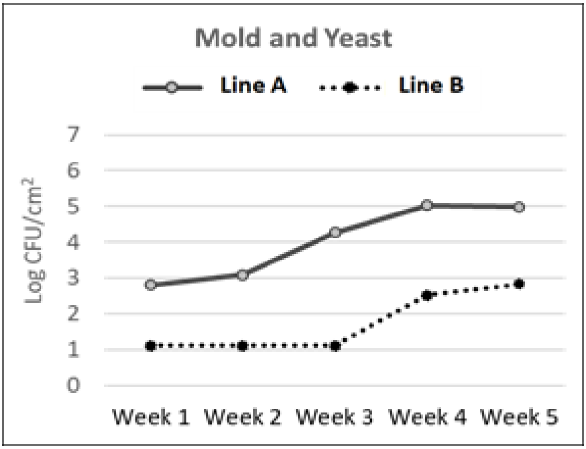
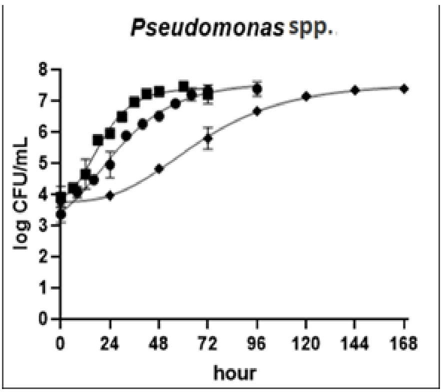


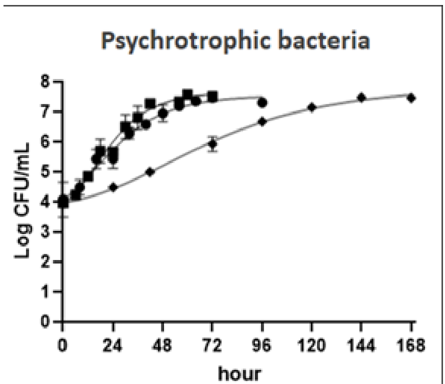
Figure 3. The microbial load inside of the tubing over the season represents microbial growth over the course of one year (Line A, the microbial load for the new line (Line B) over the season.

Microbial growth at different temperatures

Figure 4 illustrates the growth patterns of Pseudomonas spp., psychrotrophic bacteria, and mold and yeast in sap at temperatures of 4, 7, and 10°C. Notably, Pseudomonas spp. reached approximately 7 log CFU/mL (10,000,000 cells per mL of sap) within 36 hours at 10°C, while the same level of growth required 120 hours at 4°C.

Similar trends were observed for psychrotrophic bacteria and mold and yeast, with a consistently faster growth rate at higher temperatures compared to lower temperatures. This data highlights the importance of storing sap at lower temperatures.





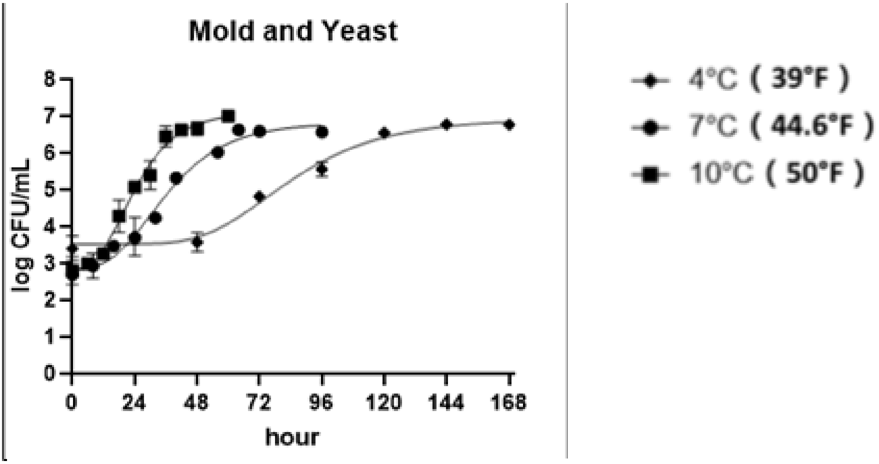


Figure 4. Microbial growth at 4, 7, and 10°C in sap.

Efficacy of calcium hypochlorite: Low concentration (100 and 200 ppm)

The practice of sanitizing 3/16-inch tubing with calcium hypochlorite, as opposed to sodium hypochlorite, household beach, is meant to minimize tubing damage by squirrels attracted to the salt residue. However, there is a lack of scientific data on the efficacy of calcium hypochlorite on 3/16″ tubing sanitizing. According to the EPA registration document for the specific calcium hypochlorite used in this study, a maximum of 600 ppm can be applied o porous food contact surfaces, maintaining contact for at least two minutes.

At the beginning of the study, we assessed the effectiveness of calcium hypochlorite at lower concentrations (100 and 200ppm) with a 10 minute contact time. As depicted in Figure 5A, the initial levels of mold and yeast, Pseudomonas spp., and psychrotrophic bacteria within the tubing were 5.6, 5.5, and 6.4 CFU/cm2, respectively. After 100 ppm treatment for 10 minutes, these levels decreased to 2.9, 3.6, and 3.5 log CFU/cm2 respectively. With 200 ppm treatment, the levels further decreased to 2.4, 3.1, and 3.2 log CFU/cm2. In other words, approximately 1,000,000 cells were reduced to a range of 250 - 4,000 cells. This reduction corresponds to the SEM images of the inner surface shown in Figures 5B, 5C, and 5D. The unsanitized tubing (Figure 5B) exhibited full coverage of microbes, while both 100 ppm (Figure 5C) and 200 ppm (Figure 5D) sanitization showed fewer microbial cells and disrupted cell structures on the surface. However, even with 200 ppm calcium hypochlorite applied for a 10-minute contact time, complete elimination of the microbes was not achieved. Survivors resulting from inadequate sanitizing practices could be expected to recolonize the tubing surface during the off-season. While achieving complete sterilization (killing everything) is hard to achieve, we can minimize the microbial load with higher concentrations and proper contact time.

For the second-year study, we plan to assess the efficacy of higher concentrations of calcium hypochlorite (400 and 600 ppm) with varying contact times (10 minutes, one hour, one day, seven days, and four weeks). Scientifically validated data from these studies will be crucial in establishing effective sanitizing practices.

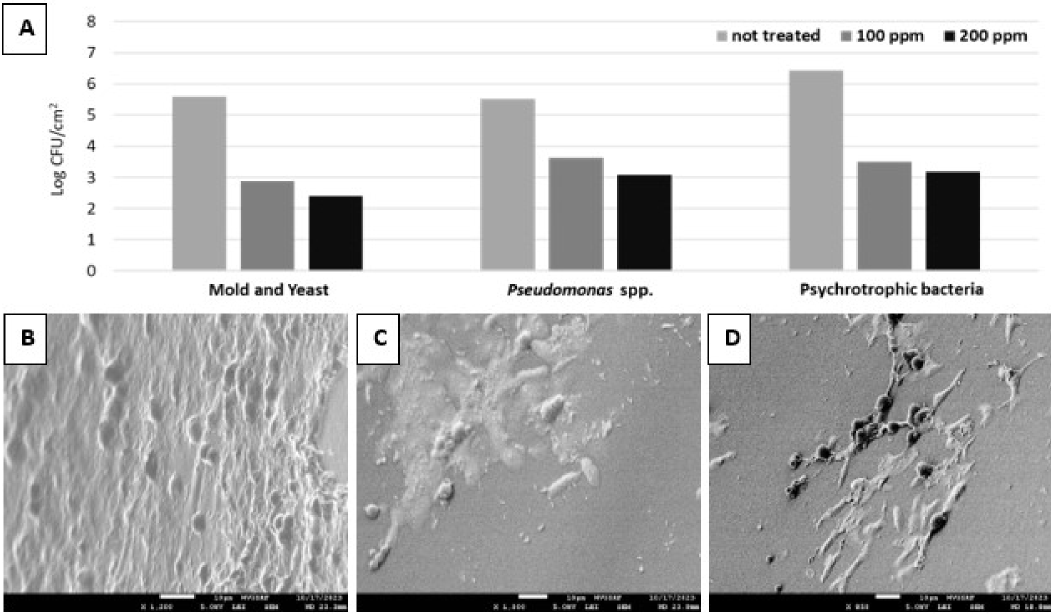


Figure 5. The Effectiveness of Calcium Hypochlorite: A) Comparison of microbial load before and after treatment with 100 and 200 ppm of calcium hypochlorite, B) Inner surface of untreated tubing, C) Inner surface of tubing treated with 100 ppm calcium hypochlorite for 10 minutes, D) Inner surface of tubing treated with 200 ppm calcium hypochlorite for 10 minutes.

The second year of this study will see two replicates of the three treatments, (new, sanitized, and one-year- old unsanitized). Microbial growth will be monitored as well as sap flow. When normalized for tree differences on the lines it should give us the information needed to develop effective strategies for sanitizing 3/16-inch tubing systems. The sap flow component of this study is being replicated at the WVU school forest. So far, we have learned that:

- Sanitation with calcium hypochlorite significantly reduces microbial load throughout the season.

- Keeping collected sap cool increases the time it can be held before excessive levels microbial buildup are reached.

- Sanitation is not sterilization. At the concentrations tested, remaining microbes can be expected to recolonize sap lines reducing sanitation treatment efficacy.

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Ask Proctor: How does Sap Move Near Tap Wounds

Timothy D. Perkins, Abby K. van den Berg, Mark Isselhardt, and Brendan Haynes University of Vermont, Proctor Maple Research Center, Underhill, Vermont

Because of the vertical orientation of the dominant anatomical feature of wood (vessels and fibers), sap within the stem of maple trees moves primarily in a vertical direction, either upward during as the tree is freezing/uptake phase or downward (mostly) during the thawing/exudation phase. When a tree is tapped, a zone of impermeable wood forms around the wood. This wound zone, referred to variously as "stain", "discoloration", "compartment", or "non-conductive wood" (NCW) is slightly darker in color than normal, unaffected wood (Shigo and Marx 1977). Owing to the anatomy of maple sapwood, the NCW that forms after tapping is normally just slightly wider and deeper than the taphole, but extends both upwards and downwards a considerable distance from the wound (Figure 1). Recent research has shown the NCW occupies an average volume about 50 times that of the precipitating taphole (van denBerg et al. 2023).

The physiological reason behind the formation of NCW is to render the affected area inhospitable to disease-causing organisms. By "walling off" or "compartmentalizing" the wound, infection cannot readily gain a foothold and spread throughout the wood tissues. As a consequence, the wood in the zone of NCW is rendered forever impermeable to liquid. Water and sap cannot flow through and carbohydrates (starches and sugars) cannot be stored in the affected zone. In effect, the stained area is no longer functionally a part of the tree except as structure.

Isselhardt (2022) demonstrated the strong negative relationship between sap yield and the proportion to the amount of stained wood hit during tapping. It is clear that avoiding old tapholes is vital in maintaining good sap yields and is why it is important to not overtap and create a high proportion of stained wood within the tapping band.

So how do trees cope with these internal zones of NCW in their stems, particularly in maple trees that are tapped year-after-year? Isn't it important that their conducting tissues be intact?

As it turns out, the vascular system of maple trees is incredibly redundant. There are billions of tiny vessels within the stem. Some of these vessels stop functioning for one reason or another as they age. In some cases, such as when vessels embolize due to drought in the summer or freezing during thewinter, vessels can be repaired and the conduits refilled with liquid. In other cases, such as that accompanying the formation of NCW, functionality cannot be restored. As vessels get buried deeper into the tree by radial growth, the hydraulic conductivity (the ability to move liquid of older tissues diminishes. This is the reason why making tapholes really deep doesn't result in increasing sap flows.

However, movement of sap and water in the stem is renewed by the addition of additional functional wood during each growing season. As long as enough new wood grows each year, the loss of functional wood by wounding or aging can be compensated for and the formation of NCW by maple tapping is sustainable.

What happens to the flow of sap around areas of NCW? Is it slowed down? Generally this is not the case. Because there are so many vessels extending from the roots to the crown, but instead are comprised of a series of short (ranging from a fraction of an inch to over a foot long) conduits that are loosely associated with each other at the top and bottom in groups, liquid can readily flow around blocked areas of modest size. In effect, sap moves around the zone of NCW.An analogy to this is a stream. A stream generally flows fairly well and in a relatively straight line. However, if you drop a big stone in the stream the water above the rock doesn't stop – it goes around. In fact, the water immediately adjacent to the rock the water runs slightly faster than it would if the rock eren't there. The same thing happens in a maple stem in the area around NCW – the sap flows around the wound. Extending this analogy further, if you keep dropping stones in the stream, you still don't really impact the flow much – the water will keep running around the stones. However, if you persist in adding stones you will eventually reach a point where there are too many stones piled up in one area and the water can't move around quickly enough, in effect causing a dam. The corollary to this in a maple stem is overtapping or cluster-tapping. Too much NCW builds up to the point where liquid cannot readily find a path around that area, and sap flows will diminish. This effect is exacerbated if annual radial (stem) growth is slow, either because the trees are small and not fully in the canopy, or if trees are very large and the growth rings are very narrow. Avoiding overtapping, cluster tapping, or repeated heavy tapping on just one side (south side of stem, above a large root, or below a large branch) is the best approach to sidestepping this problem because recovering from this problem may require considerable time, energy, and careful monitoring.

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Maple Digest 63(2): 7-15. Maple Sugar Makers Association (Vermont), whose support is recognized with thanks.

Acknowledgments

University of Vermont Agricultural Experiment Station and by a grant fromthe Chittenden County Maple Sugar Makers Association (Vermont), whose support is recognized with thanks..

Figure 1 . What's under the bark? A photo of a maple steam along side another stem with the bark removed to show NCW from previous taphole wounds. Note that the zoneof NCW is just slightly wider than the tapwhole, but extends vertically upward and downward from the wound for a considerable distance. Avoiding tapping into these areas ofNCW is critical in maintaining good sap yields. Original display created by David Folio, Hillsboro Sugarworks, Bristol, Vermont. Photo Credit:Mark Isselhardt, UVM Extension Maple


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ACER Grant-Funded Maple Research Project Seeks Producers as Collaborators

Life cycle carbon footprint analysis and improvement strategies for US maple syrup production

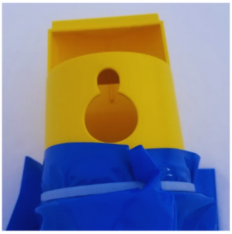
The University of Michigan Center for Sustainable Systems began this USDA ACER research project in the fall of 2022. The goals of this project are to support producers as they seek to improve energy efficiency and reduce emissions associated with producing maple syrup. While most producers strive to be as efficient as possible to keep their costs low, knowledge is limited on which production practices have the greatest impact on greenhouse gas emissions (GHGs). This project will develop a web-based calculator based on real-world process data that producers can use to estimate their own energy and GHG emissions per gallon of syrup produced, as well as providing recommendations on how they can reduce these impacts.

To assist us in building this calculator, we are seeking producers who are interested in joining our current group of research collaborators by providing data on their sugaring operations over the 2023 season as well as the next two seasons (spring 2024 and 2025). The calculator will be directly based on the data shared with us by producers, and while your data won't be provided to us anonymously, we will not be sharing or publishing your operational data with anyone. We are looking for producers of all sizes, locations, and production practices (including sap collection method, whether vacuum and RO are used, evaporator fuel type and efficiency features, etc.). In addition to data on processing sap into syrup, including pre-season prep and post-season clean-up, we are interested in your off-season sugarbush activities (road and sap collection infrastructure maintenance, brush clearing, liming/ fertilizing, etc.).These data will be assembled into a life-cycle inventory of syrup production that will be the heart of the calculator, and will also allow us to provide feedback on other impacts, such as water use and waste generated. We are planning to provide each participating producer with their own life cycle inventory results based on the data they provide on their operations, as well as a printable certificate identifying the producer as a research collaborator and provider of data for each season they share data.

Since the start of the project, we've constructed a life cycle inventory model that contains emissions and energy data on fuel processing and combustion, as well as on vehicle and equipment production and operation. This model will be used to process the data that producers share with us on their maple operations. We enrolled 39 producers and packers as research collaborators who are sharing data on. their operations with us. Of the collaborating producers, 8 were small (less than 1,000 taps), 18 were medium (1,000 – 10,000 taps), 9 were larger (greater than 10,000 taps)

Geographically, 10 are in NY, 10 in VT, 5 in MI, 4 in WV and ON, with one each in WI, MN, NH, IL, OH, and KY. Given the wide variety of practices used by sugarmakers, we'd like significantly more producers (of all sizes and locations) to participate in order to more accurately capture this variability in our analysis. We are also currently characterizing the distribution network for maple syrup and compiling potential strategies for reducing impact from syrup production.

We will set up information sessions on zoom or phone to discuss the data collection process with interested producers and processors and to answer your questions about the project. Producers or processors who attend one of these sessions and then provide data on their operations will be entered into a drawing for a cash prize for each year they provide data. If you'd like to hear more about participating in this project, please send an email to Geoff Lewis (glewis@umich.edu) with the subject-line Maple syrup research. We're looking forward to working with you on this project!



A Short History of the George D. Aiken Sugar Maple Laboratory

Matthew M. Thomas

In today's world of maple industry research most are familiar with the work of the Proctor Maple Research Lab in Vermont, the Cornell Maple Program in New York, and the Centre ACER in Québec. What is easily forgotten is that from 1973 to 1982 the USDA Forest Service operated another dedicated maple research center, the George D. Aiken Sugar Maple Laboratory in Burlington, Vermont.

Maple-related research by the Forest Service began in Burlington in 1956 with the creation of a general research station as a sub-unit of the Forest Service's Northeastern Forest Experiment Station. With offices in the federal building in downtown Burlington, researchers like William J. Gabriel, Albert G. Snow, and Harold W. Yawney, worked in partnership with University of Vermont (UVM) faculty on questions skewed towards maple sap and syrup production, including a well-known sweet tree breeding program. At that same time in the 1950s and 1960s, the USDA's Agricultural Research Service was home to a maple research program in its Eastern Regional Research Center in Philadelphia under the directionof C.O Willits.

Despite there already being a federal laboratory-based research program in Philadelphia, as early as 1962, Vermont Senator George D. Aiken began speaking about the idea of starting a Forest Service maple laboratory in Vermont to study ways to help the maple industry address problems with marketing maple products. Senator Aiken kicked the maple laboratory idea into full gear in 1964 when he began inserting funding requests in the annual appropriations bill. It took eight years of ongoing pressure and funding requests before Senator Aiken's efforts paid off in 1971 when the one million dollars requiredfor construction was finally allocated. At the same time, the maple research program in Philadelphia wasbeing discontinued following the 1969 retirement of C.O. Willits, its founder and longtime director.

A contract was awarded to a local Burlington builder in April 1972 and construction on the Lab began afew months later. Secretary of Agriculture Earl Butz, Senator Aiken, and Forest Service Chief John R. McGuire in attendance at the grand opening ceremony on August 20, 1973, announcing the naming of the Lab in honor of the senator who had championed the Lab's creation.

Located on Spear Street in South Burlington on lands leased from UVM, the Aiken Lab was a beautifuland well-planned facility with 41 rooms of laboratory, office, and work space, complete with attached greenhouses, state of the art computer technology, and the staff to help crunch numbers. What it was lacking however, was its own dedicated sugarbush and sugarhouse. As a result, Aiken Lab research was always dependent on working with private sugarbush owners or the sugarbush at UVM's Proctor Maple Research Center.

The Aiken Lab's first director, Dr. Lawrence David Garrett, was transferred to Burlington from another Forest Service research lab in West Virgina two years before its 1973 opening. With his new position, he was tasked with developing a five-year plan focusing on marketing and continued improvements in sap and syrup processing. Garrett did not have a background in maple sugaring, rather his expertise was in forest and agricultural economics. However, he did not let that slow him down and he dove in to his challenge, soliciting input from industry representatives and quickly learning as much as he could about the maple industry in a very short time. In response, Dr. Garrett and his staff developed several projects and initiatives that caught the industry off guard. In an interview with the author, Dr. Garrett shared that in hindsight their plan was a bit too aggressive for some, with a focus on streamlining the syrup grading system, developing an international marketing organization, and the introduction of new techniques for sap and syrup processing. Organizational change was slow to come to the maple industryand Dr. Garrett often required the help of Bill Clark, then president of the Vermont Maple Sugarmakers Association, to open doors and get industry to

o listen to the ideas and programs that were being proposed.mont Maple Sugarmakers

As a federally funded facility, Dr, Garrett felt that the Lab should have a strong emphasis on outreach to the maple industry, through both direct engagement and meaningful and accessible publications. One of the most important early efforts of the Aiken Lab was to bring together maple industry representatives from the U.S. and Canada to begin discussing their shared interests in marketing maple products. In August of 1974 the first US-Canadian Maple Marketing Conference was held in Burlington at the Aiken Lab, which resulted in the agreement that the maple industry needed an international organization to aid in the promotion of maple products. A few months later in November at a second meeting in Montreal, Aiken Lab staff proposed an organizational model and bylaws for the creation of the International Maple Syrup Institute (IMSI) and the stage was set for its formation.

Earlier maple research begun by Burlington based Forest Service researchers prior to the creation the Lab continued, such as William J. Gabriel's work with tree physiology and genetics and Russell S. Walters work perfecting tubing and vacuum systems to improve sap production. New studies led by Paul Sendak looked at consumer preferences and attitudes on syrup types. Lab staff also worked on improvements in syrup quality, investigating maple flavor and color parameters in efforts to develop a universal grading system. Other new research aimed at more fuel-efficient methods of syrup production investigated sap preheater technology, heat exchangers, and vapor compression distillation.

Building on their successes and accomplishments in the first five years of work, the Lab looked to address other areas of need in the maple industry with a second five-year plan. In the second five years of the Lab, Dr. Garrett began meeting with representatives from various food production sectors to learn more about that area of industry. The Lab was tasked with coming up with new ideas for new maple products, such as dried maple flakes that was developed by Lyman Jenkins. According to Garrett, had he stayed in Burlington and the Lab's purpose not been redirected, he would have added food scientists to the staff and pushed for a significant focus on the development of other maple products. The second five-year plan was also influenced by a desire by the Forest Service and the Department of Energy to study the efficiency of wood energy and other alternatives to petroleum-based fuels, an important consideration during the 1970s energy crisis.

Dr. Garrett's success with directing the Aiken Lab was noticed by Forest Service leaders and in 1980 he was asked to put his skills to work leading a new laboratory in Flagstaff, Arizona with the largest science-based research program in the Forest Service. Without Dr. Garrett at the helm, the Aiken Lab was now in a vulnerable position, and in 1982 the Forest Service announced it was refocusing the Lab's research emphases. Moving away from research important to the maple industry, the Lab was directed to study the effects of acid rain and environmental stress on forest health along with considerations of forest management for recreational use. In justifying their decision, USFS officials claimed that the Aiken Lfab had done as much as it could to improve maple sugaring and that acid rain was a more pressing issue. As something of a culmination of the Lab's work and a definitive closure of the maple research program, that same year, the Forest Service published "Sugar Maple Research: Sap Production, Processing, and Marketing of Maple Syrup" a synopsis of much of the important work accomplished in the Lfab's ten short years.

Despite the change in direction of the Lab, existing Forest Service staff continued working in conjunction with UVM faculty to conduct research of interest and importance to the maple industry. Most notable was research by the Forest Service's Paul Sendak and UVM's Mariafranca Morselli into the economics of the use of reverse osmosis technology and its effects on sap and syrup quality. With the discontinuation of maple industry related research, the Lab was renamed the George D. Aiken Forestry Sciences Laboratory in 1988 and in 2013 the Forest Service transferred ownership of the Lab to the Rubenstein School of Environment and Natural Resources at the University of Vermont. Dr. Matthew M. Thomas is a maple industry historian. You can read more maple history articles like this at his website, www.maplesyruphistory.com.

Figure 1
Senator Aiken speaking to the audience at the grand opening of the Aiken Lab in August 1973. (photo courtesy UVM Special Collections).

Figure 2
Planting a commemorative maple tree at the grand opening of the Lab, left to right - Senator Aiken, Forest Service Director of Northeast Forest Experiment Station Warren Doolittle, Forestry Technician Bob Gaboury (kneeling), Agriculture Secretary Earl Butz, and Aiken Lab Director Lawrence David Garrett (photo courtesy USDA Forest Service).

Innovations in Maple Sap Collection Systems: Reducing Clogging in 3/16" Tubing

Timothy D. Perkins and Wade T. Bosley
University of Vermont, Proctor Maple Research Center, Underhill, VT
http://www.uvm.edu/pmrc

Natural vacuum created in 3/16" tubing has been a boon for many maple producers in stands wheresufficient grade allows it to function properly. The column of sap moving downhill in 3/16" tubing doesn't readily allow air bubbles to pass, but rather pushes them out of the system, creating a vacuum (Wilmot 2014, Perkins and van den Berg 2018). Unfortunately, several years of use have demonstrated that 3/16" tubing systems can be prone to clogging by microbial masses (Wilmot 2018, Perkins and vanden Berg 2019), especially at fittings (Childs 2019) where the internal diameter is greatly reduced (Figure1). This leads to progressively lower yields over a 2-3 year period, eventually reaching the point where sap yields can be lower than 5/16" tubing without vacuum (Perkins and van den Berg 2019). Solutions to this problem devised so far include either cleaning the tubing annually with a chemical sanitizer or replacement of all fittings in the 3/16" lateral line system every three years (Perkins and van den Berg 2019). An alternative approach using ¼" tubing which might be somewhat less prone to clogging (Wild and Otto 2021) but vacuum might not develop as readily as in 3/16" tubing.

Another possible approach might involve reducing or eliminating the reductions in the internal diameter in and around fittings where clogs develop. This would allow the full internal diameter to be maintained throughout the 3/16" tubing system and therefore greatly reduce the propensity for clogs to develop and to be caught up at fittings.

We first sought to test this using an off-the-shelf solution. John Guest™ push-to-connect fittings that would fit around the outside of 3/16" maple tubing were acquired and a small test setup was made in the field. Within a short time, expansion/contraction due to the wide ambient temperature swings combined with the added weight of sap in the lines resulted in the fittings failing to hold and the tubing came apart. In addition, while these fittings could be used for a long time, they are considerably more expensive as compared to maple fittings. Given this, we sought to design a new type of fitting that would meet the following criteria:

◎ connect to 3/16" tubing externally,

◎ not reduce the internal diameter of 3/16" tubing,

◎ be approximately the same dimensions as standard maple fittings,

◎ hold securely across the range of

temperatures encountered in the field,

◎ hold securely when tubing was full of sap,

◎ be comparable in cost to standard maple fittings, and

◎ utilize the same type of tools used with standard maple tubing fittings

Several concepts led to various prototypes being designed and constructed at the University of Vermont Proctor Maple Research Center, then later by machinists at UVM Instrumentation and Modeling Facility.Several designs were tested for holding power across a wide temperature range (ambient temperature, refrigerator temperatures, and freezer temperatures). To understand whether and how these prototypes might be commercially made, the involvement of an Progressive Plastics, Inc., an experienced maple injection-molding company, was solicited, and further designs were developed. Several discussions led to the develoment of the fitting shown in Figure 1. The barrel of device has small projections on the hinged plate to securely hold the tubing in place once inserted it is into thefitting and the plate closed. The central barrel of the fitting is slightly tapered inward from the ends of the fitting to the center stop (smaller towards the center, larger towards the ends) to accommodate slight variations in extruded tubing diameter. In use, tubing would be inserted firmly into the end of the fitting until it reaches the stop (by hand or preferably with a tubing tool), then the hinged door on each end closed and latched to hold the tubing in place securely.

This approach is still under evaluation, but current plans are to build a mold to produce test articles for examination by researchers and selected maple producers during the 2024 season. Modifications will then be made based upon feedback from these producers. If testing goes well, full production will commence in time for fittings to be available for the 2025 sap flow season through Middle Valley Maple (https://middlevalleymaple.com/).

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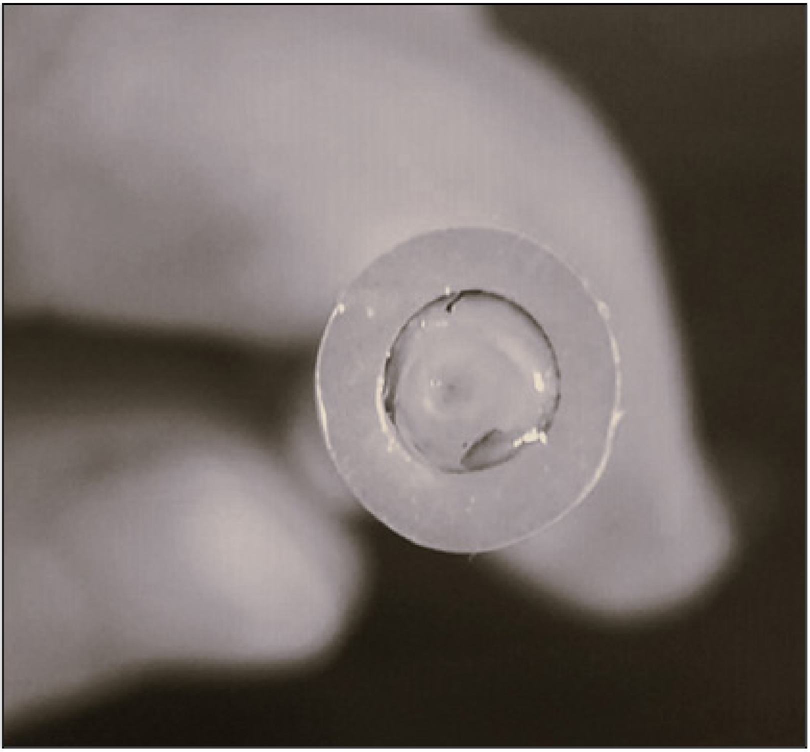

Figure 1 . Microbial clogging in 3/16 maple tubing. Photo credit: Adam Wild, Cornell Maple Program.

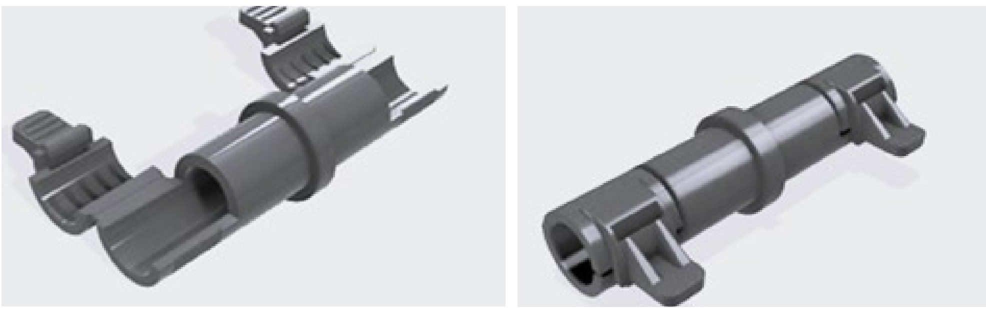

Figure 2. Drawing of an external 3/16" tubing connector designed by UVM and Middle Valley Maple
(Williamstown, VT, http://www.middlevalleymaple.com) shown in the open (left) and closed (right)

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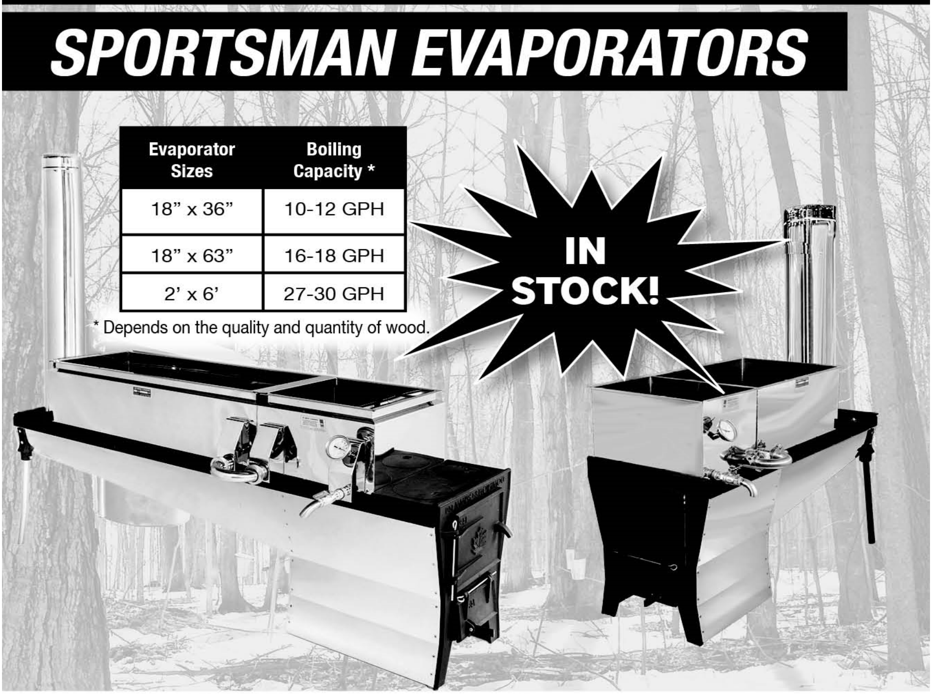

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Ask Proctor: Why do I sometimes make light-colored syrup at the very end of the season?

Timothy D. Perkins, University of Vermont, Proctor Maple Research Center, Underhill, Vermont

The typical trend over a sugaring season is for syrup to start out light in color and get progressively darker, eventually ending up with very dark (and strong or off-tasting) syrup at the end. While there can be some temporary excursions up and down in syrup light transmittance, the natural progression is from light syrup early on to dark syrup near the finish. However, occasionally a syrup producer finds that right as the season is concluding the syrup color goes up dramatically and wonder why this happens.

The explanation has to do with syrup chemistry during boiling. Sap is naturally slightly acidic (pH below 7.0). As it boils, minerals and organic acids in the liquid are concentrated and quickly reach the saturation point. As this happens, the pH of the boiling sap rises rapidly to the point where the liquid becomes fairly alkaline (Figure 1), often well above pH 7.0. The material in solution precipitates out to form niter (scale) and sugar sand in the pans, which gradually reduces the pH of the liquid throughout the remainder of the boil. Several chemical browning reactions occur during the time the pH is above 7.0. These reactions cause the breakdown of invert sugars (glucose and fructose) and the formation of color and flavor compounds. Because microbes are more active and produce more invert sugar with warmer temperatures as the season progresses, syrup tends to get darker later in the season as a result of these alkaline degradation reactions during boiling. This also explains why scale/sugar sand formation can be more problematic later in the season.

Very late in the season, when sap flows are low and temperatures are high, there can be substantial fermentation of sap in the tubing system or during storage. Fermentation causes the acidity of the sap to rise to very high levels (low pH). When this spoiled sap is boiled, the pH rises as it normally does, but because the sap started out so strongly acidic, the pH of the liquid never rises above 7.0 before it achieves syrup density. Since the boiling sap pH never gets above neutral, the alkaline degradation reactions do not take occur, color formation is impeded, and the syrup never darkens.

However, nature is not being gentle to maple producers. Instead, the cosmos is playing a paradoxical joke on us because the syrup made at this time, while appearing very light, has a sour taste due to the excessive amount of fermentation. The overall effect is that you make some of the most beautiful-looking light syrup of the season but it tastes terrible. So even though the syrup may look great…this is one sign that the season is over and it's time to stop.

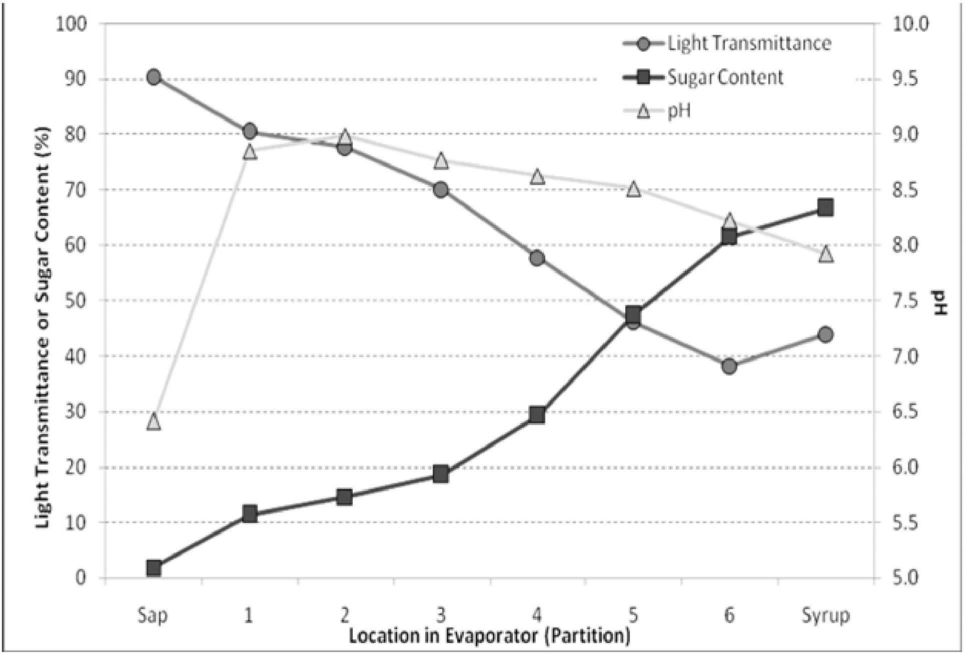

Figure 1. Changes in sugar content(density), light transmittance (color) and pH during boiling from sap to syrup during boiling in an evaporator.


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2023 NAMSC Annual Meeting Update/Quality from Tree to Table conference in Sturbridge, MA-

Missy Leab, Coordinator
MA Maple Producers Association

I would like to thank all those that attended and participated in the conference in any way. A few numbers to share. We had a total of 318 attendees with 169 full registrations and 149 one day registrations, 27 vendors, as well as 98 tour bus attendees plus 25 tag along in their own cars among the three different tours options. There were 181 attendees that enjoyed the Taste of MA Reception featuring maple BBQ pulled pork, maple baked beans, clam chowder soup, oysters, local cheese &baquettes, maple snack mix, pumpkin whoopie pies, and make your own ice cream sundaes! The Banquet and Awards Night hosted 162 representing 24 states/provinces……WI, OH, NY, MA, NH, IA,IN, MI, MN, CT, CA (yes California), KY, OR, VT, ME, RI, WV, PA, NJ, WA, MT, Quebec, Ontario, New Brunswick. The silent auction and raffle raised $3000.00 MMPA matched to give a total of $6000.00 to the NAMSC Research and Education fund used for grant programs.

The Massachusetts Maple Producers Association membership deserves recognition for their dedication and contributions this year as we transitioned from Winton stepping down from the coordinator's position and our EasternStates Booth Manager changing roles. Both our fair booth and conference would not have happened without the professionalism, collaboration, dedication, and hardwork from the membership. Winton continued to help not only with the conference but to ensure the transition goes as smooth as possible.

Thank you. Looking forward to next year's conference in Maine!

Happy Holidays,
Missy Leab, coordinator
MA Maple Producers Association

Save the date!!

2024 North American Maple Conference, October 21-24, Portland, ME

The 2024 North American Maple Conference will be held October 21-24 in Portland, ME. This annual event draws sugar makers from across the US and Canada for several days of research and practical skills workshops, an industry trade show, tours of sugarhouses and other attractions, and lots of other opportunities for learning and networking with fellow sugar makers. Details are still being developed, but save the dates and watch www.mainemapleproducers.com in late spring for more information and registration.

2023 NAMSC Annual Meeting and North American Maple Conference: Quality from Tree to Table in Sturbridge, Massachussets

The 2023 North American Maple Conference: Quality from Tree to Table was held October 25-28 in Sturbridge, Massachusetts. The NAMSC held their annual meeting on October 24, 2023 before the conference began. The NAMSC Executive Board, Webmaster, 14 Delegates, 7 Alternates and members of the NAMSC were present at the Annual Meeting. The meeting began with a Welcome and Call of order by Howard Boyden, NAMSC President followed by the roll call of Members States and Providences by Joe Polak, NAMSC Secretary. A Secretary report was given with approval of the October 22, 2022 Annual Meeting minutes, May 12, 2023 Semi Annual Meeting Minutes, Zoom meetings: January 12, 2023, September 12, 2023 and a special meeting June 21, 2023.

The NAMSC Committees gave their reports. Eric Randall reported for Kathy Hopkins, the chair of the research committee. The Research committee received 7 letters of intent, two proposals were received and one approved. The funding of $25,000 was approved to fund the project Test Strips for Early Identification of Buddy Maple Syrup, Prof. Maria DeRosa and Prof J David Miller, Carlton University, ON (Department of Chemistry), Dr Justin Renaud, Agriculture AgriFood Canada (London Research and Development Centre) and Ontario Maple Syrup Producers Association. Education Chair, Missy Leab reported that no educational proposals were received. The instruction handout was approved and is available on the NAMSC website. It was also emailed to all associations that are members of the NAMSC to be shared with their members. A Fall of Fame and convention planning report was given the next few years conference will be held: 2024 Maine, 2025 Michigan, 2026 Ontario, and 2027 Pennsylvania. A website, financial and budget report were presented followed by an Executive Director Report by Theresa Baroun and a Nomination Committee Report. Associate Members, Life Members and Committee Members were announced. Associate Members announced for a 3year term: Mary Douglas, MI Dr Jesse Randall, MI Dr Joe Orafice, CT Steve Anderson, WI Dr Abby van den Berg, VT Karl Zander, WI Aaron Wightman, NY Jason Lilley, ME Dave Hall, QC Simon Dore Quellett, QC Genevieve Clermont, QC A report was given that the NAMSC will start looking for a permanent executive director in 2024.

Jean Lamontagne, Executive Director reported on the IMSI. The University of Michigan is still looking for participants for their Acer grant on Life cycle carbon footprint analysis and improvement strategies for US maple syrup. Please contact glewis@umich.edu if you are interested to participate.

The NAMSC members and delegates

approved the NAMSC to be the first US Organization to partner with Centre ACER of Quebec, Lyle Merrifield Invited everyone to attend the 65th NAMSC Annual Conference in Portland, ME on October 21-24, 2024. The meeting was adjourned.

The Conference began the on October 25 with Tours, Extension meeting and the Taste of Massachusetts, followed by Speakers Anna Richards and Bill Corwin, roundtables, and two days of technical sections and Practical Skills Workshops. There were a variety of contest held throughout the conference. A Photo contest, Maple Syrup and Confections contest was held during the conference. People who entered needed to be registered at the conference to submit entries.

The Photo contest classes included Sugarbush scenes, Sugarhouse scenes, maple people and maple products. The winners of each class are listed below.
Sugarbush scenes: Lexi Merrifield, Maine
Sugarhouse scenes: Dave Brown
Maple People: JoAnn Merrifield, Maine
Maple Products: Lexi Merrifield, Maine

There were 121 entries in the Maple Syrup and Confections. Entrants were from 14 states and 1 province. Winners were from 10 states. The list of categories and winners is listed below:
Golden (12 entries)
1: David Dahl, Cedar Valley Maple, Hibbing, MN
2: Larry and Mary Haigh, Haigh's Sugarhouse Farm, Bellevue, MI
3: Howard and Jeanne Boyden, Boyden Brothers Maple, Conway, MA
Amber (37)
1: Jack Brown, Jack and Jills Maple Hill Farm, Pawpaw, MI
2: Dana Goodfield, Stonegate Farm, Conway, MA
3: Harry Hartford, Thurston and Peters Sugarhouse, West Newfield, ME
Dark (28)
1: Ron and Kenna Rhynard, Green River Maple Camp, Shepherd, MI
2: Keith Bardwell, Brookledge Sugarhouse, Whately, MA
3: Carl Hamann, S&C Sugar Shack, Stevens Point, WI
Very Dark (13)
1: Eric Randall, Randall's Heritage Maple Products, Alexander, NY
2: David Yeany, Yeaney's Maple, Marienville, PA
3: Keith Dufresne, Dufresne's Sugarhouse, Williamsburg, MA
Cream (13)
1: Keith Bardwell, Brookledge Sugarhouse, Whately, MA
2: Howard and Jeanne Boyden, Boyden Brothers Maple, Conway, MA
3: Charles Hunt, Hunt's Sugarhouse, Hillsborough, NH
Candy (3)
1: Jacques & Pauline Couture, Couture's Maple Shop and Bed and Breakfast, Westfield, VT
2: Keith Dufresne, Dufresne's Sugarhouse, Williamsburg, MA
3: Howard and Jeanne Boyden, Boyden Brothers Maple, Conway, MA
Granulated Sugar (15)
1: Fred Hervey, Family Roots Farm, Wellsburg, WV
2: Larry and Mary Haigh, Haigh's Sugarhouse Farm, Bellevue, MI
3: Edie Kemp, Maple Row Sugaring, Rindge, NH
Best in Show
Golden: David Dahl, Cedar Valley Maple, Hibbing, MN

A variety of NAMSC awards were presented at the banquet on Friday which included the Special Recognition Award, Life Time Members, and Maple Hall of Fame Inductees. Special Recognition Awards went to Debbi Thomas, Michigan and Winton Pitcoff, Massachusetts. Lifetime Membership awards were presented to 2022 Life time members Jacques and Pauline

The 2024 Maple Hall of Fame Inductees were announced. The 2024 Hall of Fame Inductees are Stu Peterson, Minnesota and Yves Bois, Quebec. Stu and Yves will be inducted in to the Maple Hall of Fame in Croghan, New York on Saturday May 11, 2024.

2023 NAMSC Special Recgnition Award Winner: Debbi Thomas

My Great Grandfather Christopher Reetz was one of the first settlers in Ogemaw County in 1872. Maple would be the first crop that he harvested off his land. Later on my Grandfather took over and then my uncle. Other than approx. 15 years syrup has been made in this sugar bush ever since.

Ron and I started making syrup in 1976 when my dad's cousin introduced my city boy to making Maple Syrup and Ron was hooked. Over the years I was told this would be the last addition to the shack – we know it never was. Ron had gotten a new pan with a steamaway and stated the roof wasn't high enough. On July 3, 2007
wasn't high enough. On July 3, 2007
we lost our shack to a fire. With the help of family & friends we were boiling in the 2008 season.

We currently have approx. 4000 taps which include several neighbors' trees that we tap.

Ron passed away in 2011 and again with the help of family & friends syrup making continued. My nephew Chris who lives on the original property decided he would give it try. Chris was hooked and now runs the operation. I still do the candy, sugar cream as well as helping out when I can.

I serve as Secretary for the Michigan Maple Syrup Association where I have been a board member since 2012 as well as a Delegate to the NAMSC.

- Debbi Thomas

2023 NAMSC Special Recgnition Award Winner: Winton Pitcoff

Winton Pitcoff was coordinator of the Massachusetts Maple Producers Association for 15 years, editor of the Maple Syrup Digest for nine years, and Executive-Director of the North American Maple Syrup Council for a year and a half. It is worthwhile to note that as editor he took a publication that was breaking even financially at best and made it profitable. As Executive Director, he was hired after Mike Girard did a yeoman's job fulfilling the requirements of the job, resigned. A new Strategic Plan was developed with the help of Bill Corwin and many others in this room tonight. Winton continued as Chairman of the Research Committee for the first year and then convinced Kathryn Hopkins to take over the role. As our new Executive Director, he used the Plan and made this organization stonger thanever. Thanks to Winton the has new Alliance Partners of our research funding efforts. He also encouraged many to increase their annual contribution.

Winton was appointed Deputy Commissioner of the Massachusetts Department of Agriculture Resources. He has worked on food and agricultural policy issues at all levels of government as an advocate, lobbyist, and educator, and previously worked as a reporter and editor. He has raised beef cattle, pigs, dairy goats, and bees, owned and operated an ice cream business, and worked for an on-farm yogurt maker and a dairy cooperative. Due to an unfortunate incident several winters ago involving a hungry mink, Winton no longer raises chickens.

2023 NAMSC Special Recgnition Award Winner
Earnest Bieri: Waterlooo

Ernest's interest in the Maple industry first began in the 1970s after he and his wife Lilianne acquired a large farm in the Eastern Townships in Quebec, Canada. Having lived through the war in Europe, both were convinced that owning land and knowing how to cultivate it, would ensure their family's well being in times of need. The modest sugarbush was approximately 4000 taps on buckets, with a wood fired 5x14 evaporator, and sap gathering was done via horses. After installing tubing and boiling day and night, (and being flooded by the sap) he realized that his installation was inadequate. He needed a new sugarhouse and modern equipment.

Diving right in , as he often would do over the course of the next 3 decades, Ernest began visiting 100s of sugarmakers across the country in preparation for the sugaring season. He quickly realized that sugarmaking at the time, relied more heavily on family tradition than defined measurements and protocols. In 1977, walking into Val Royal's equipment manufacturing facilities in Waterloo Quebec, Ernest convinced then manager, Andre Ares, that maple research should be giving it's proper place in the industry, a key enabler in pushing forward higher performance design and innovation. As it so happened , Ernest knew of a perfect spot to set one up.

This momentum quickly snowballed. In 1981, Ernest had become a full time sales rep for Val Royal, expanding the business to the US in 1982, and by 1984 Waterloo Evaporators' new owner with Lilianne at the helm of the finances. Their passion for excellence in customer service brought upon rarities in the industry, like the introduc

tion of 24x7 support during the sugaring season. (Fond childhood memories in the Bieri household, where all were clearly instructed in the evenings to race across the house at top speed to make sure the 1-800 sugar line was picked up in support of sugarmaking families, customers and agents).
During sugaring season Ernest, much like his son Jacques, could just as well be seen day or night, driving (or flying in small aircrafts), across the north east to respond to customers urgencies from Wisconsin to Nova Scotia, or re-opening loading docks late at night at the factory, to squeeze in one more sugaring pan, pallet of tubing or other critical piece of equipment for a client in dire need. Ernest regularly challenged his manufacturing team to innovate, being the first ones to tig weld 24 gauge stainless steel in 1986, eliminating all soldered maple equipment. Their team at Waterloo Evaporators introduced the high efficiency turbo evaporators to market in 1990 and secured an iSO 9000 certification in the push for quality.

Eager to collaborate with their customers and other leaders in the industry, Ernest and Lilianne joined forces with Turkey Hill's Herman brothers in an effort to help producers with a bumper crop in 1991. In 1992 they formed Club Waterloo, the first of it's kind, with a 58000 sq foot facility for sugarmakers. In 1995 Waterloo and Small Brothers teamed up enabling all employees to join the new family.

Ernest recently celebrated his 88th birthday this month, and although he could not be here tonight, the strongest advice he can leave to the next genera tion of sugar makers (such as Guil laume Bieri his grandson who recently started back up the family sugarbush, or Joe Pollock's granddaughter, who is taking over the reigns of the family business as the 5th generation), he has given by example.

In closing, Ernest would offer the following: "Always be on the lookout for improvement, with top quality in mind, and never accept the "statusquo" when striving to satisfy the customer"

Thank you Ernest and Lilianne for being such great role models. And thank you Joe for reaching out, and wanting to highlight their impact on the maple sugaring industry.

Sincerely,
Rich Bieri on behalf of the entire Bieri family.

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Many thanks to all who have been part of the planning process and to CDL Sugaring Equipment for being a Silver Sponsor. January is going to be here before we know it! Let's get those registrations in and, if needed, book your stay. Participating hotels are listed at nysmaple.com/mapleclassic/hotels.

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HAVE QUESTIONS? Helen or Kristina would be happy to answer them! Please call the NYS Maple Producers' Association office at (315) 877-5795 or (315) 960-6890.

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If you're interested in becoming an Alliance Partner, or in making a one-time donation to the fund, contact NAMSC Executive Director Theresa Baroun at maplедigest@gmail.com, or Treasurer Joe Polak at joe.maplehollow@frontier.com.

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