Northern New York Agricultural Development Program
2021 Final Project Report

Solving the Dilemma: Alternative Maple Tubing That Prevents Clogging and Increases Sap Production

Project Leaders:

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Background:

There is no question that maple tubing is the most effective and efficient way to collect maple sap. In more recent years, maple producers have been maintaining high vacuum within their tubing system, which has proven to double or even triple yields (Wilmot et al. 2007). Using high vacuum, producers can see an increase of at least $6 per tap in increased syrup. Maple sap flows during freeze-thaw cycles, creating negative pressure (pulls sap up the tree) during freezes and positive pressure during thaws. Sap freely flows out of a maple tree during thaws as pressure within the atmosphere is less than the positive pressure within the tree. Adding vacuum to a tubing system creates negative pressure within tubing allows more sap to freely flow from the pressurized tree.

Industry standard for maple tubing has been 5/16” diameter with a volume capacity that allows sufficient sap flow and air evacuation from the vacuum pump. Although the use of a vacuum pump increases yield, elaborate vacuum systems are expensive, require additional maple mainline tubing, and use a significant amount of energy to run. When 5/16” diameter tubing is applied in a natural gravity (no vacuum pump) system, sap can easily be collected from maple trees, but yields are diminished.

Ten years ago, 3/16” diameter tubing was introduced to the marketplace as an alternative tubing to 5/16” diameter tubing. Tubing with a smaller inner diameter of 3/16” easily allows a full column of sap to form through capillary action. When the weight of the full column of sap in tubing drops as the tubing drops in elevation, natural vacuum is achieved if the tubing is airtight. With every foot of drop, this system can achieve 0.88 inHg (Wilmot 2018). When applied in a

natural gravity system, under appropriate topographical conditions, 3/16” tubing can achieve maximum potential vacuum (often better than a vacuum pump) and even has capability to pull sap over a hill. Thus, maximum yield is achieved without the need for high priced vacuum pumps, energy input to run a vacuum pump, and 3/16” diameter tubing is cheaper to install. Because of this, the use of 3/16” tubing gave producers access to areas previously not available, especially in the hilly terrain of Northern New York.

However, recent research shows that sap production in 3/16” tubing drops off as soon as the second year after installation due to microbial growth. Bacteria and yeast grow within the smaller diameter tubing, over time causing clogging, especially within any fittings where the inner diameter is less than 3/16” (Childs, 2019). This plugging restricts sap flow and diminishes potential yield. Despite the initial gains from 3/16” diameter tubing, by year three of using the smaller diameter tubing, production diminishes to significantly less than when using 5/16” tubing without vacuum, unless the tubing is sanitized.

A replacement for 3/16” diameter tubing in gravity systems could be 1/4” tubing. With almost twice the aperture of 3/16” tubing (0.049 sq inches compared to 0.0275 sq inches), 1/4" inch tubing is less likely to plug from microbes yet is still able to create a full column of sap for gravity vacuum. Quarter inch tubing is currently not available for maple producers but can be procured from other industries and, with modifications, will work for maple production.

Methods:

Thanks to funding from the Northern New York Agriculture Development Program, we were able to test the effectiveness of 1/4” tubing at the Cornell University Uihlein Maple Research Forest in Lake Placid, NY, during the 2020 & 2021 maple seasons. Four replicate blocks were established on a slope of at least 50 feet drop in elevation. Each replicate block contained a 3/16” lateral line, 1/4” lateral line, and 5/16” lateral line with the same length, number taps, and elevation drop. Trees were matched in elevation across the three lateral lines per block. Each tree had only one tap. Block one had 8 taps per lateral, block two had 10 taps per lateral line, block three had 18 taps per lateral line, and block four had 30 taps per lateral line. Each lateral line flowed into its own tank where sap volume could be measured. All lines were on gravity without the use of a vacuum pump. Vacuum gauges were attached to the top of the lateral line at the highest elevation point.

Additionally, a fifth replicate block was established to compare production yields of 3/16”, 1/4”, and 5/16” tubing when vacuum is applied with the use of a vacuum pump. There was minimal elevation drop from the end of the lateral to the collection vessels. In this scenario, the minimal gravity vacuum could help boost the vacuum at the tap hole (especially across the distance of the dropline), but most of the vacuum was initiated by the vacuum pump. Two lateral lines of the same diameter flowed into one vacuum chamber with three taps per lateral line.

Volume of sap per replicate was measured from each collection vessel during each sap flow event. Vacuum levels were read from the top of each lateral during sap flow events. A delayed state funding release along with a shortened maple sap season caused by warm weather in 2021 prevented us from getting great vacuum readings in all the tubing lines early in the season, which turned out to have some of our best sap runs. For this project we were able to utilize sap

collection canister equipment from previous NNYADP grant projects, allowing us to keep equipment costs lower than what was realistically needed for this project.

Results:

Gravity Tubing Results

In the first year of testing with just 8 and 10 taps per lateral, 3/16" tubing achieved consistently high vacuum at the top of the lateral and produced more than three times the amount of sap per tap than 5/16" tubing (Figure 1). Quarter-inch tubing did achieve vacuum at the top of the lateral (as high as 25 in/Hg), but the vacuum was not consistent throughout the season, yet still produced more than twice the amount of sap per tap than 5/16" tubing (Figure 1). The 5/16" tubing produced little to no vacuum at the top of the lateral line. In the second season, spouts were replaced, but droplines and laterals were not cleaned. Similar results to the first season were observed during the second season with no significant plugging on 3/16" tubing (Figure 2). Production in the 3/16" tubing and the 1/4" tubing was slightly lower in relation to the 5/16" tubing in the second season, which is more likely a result of the shorter season.

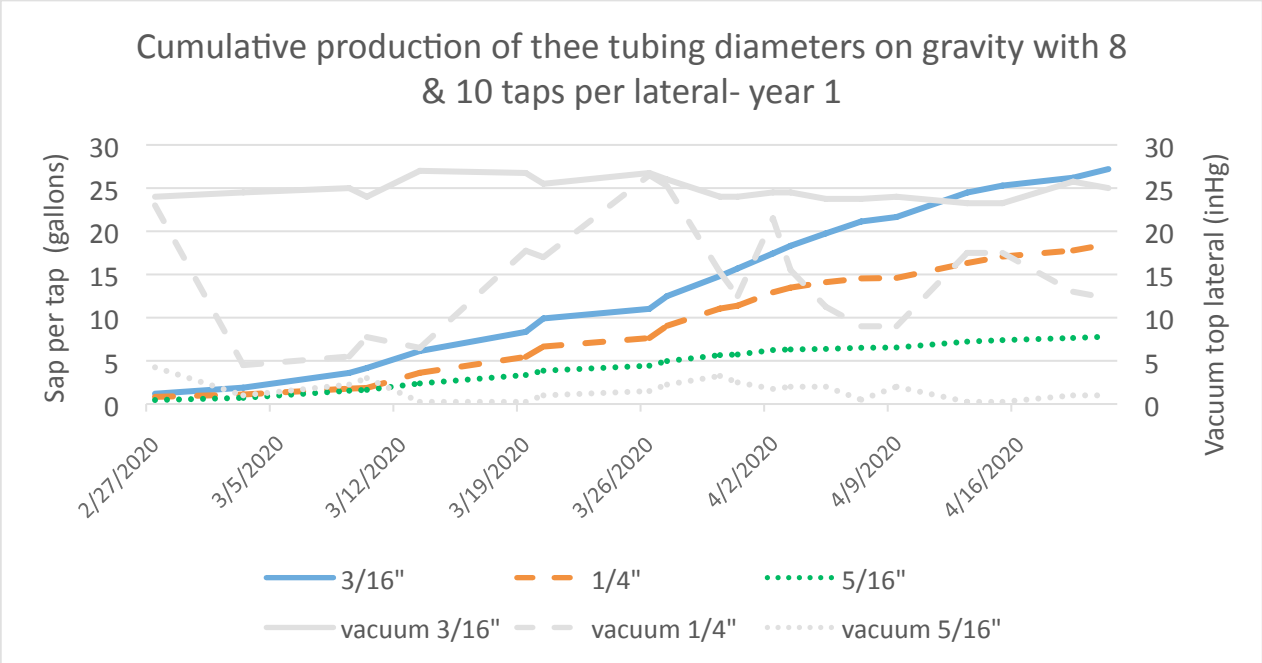

Figure 1: Average cumulative sap per tap on 3/16", 1/4", & 5/16" tubing on gravity during the 2020 season in Northern New York, the first season the tubing was tested, along with vacuum level measured at the top of the lateral throughout the season. Each lateral had 8 or 10 taps. 3/16" tubing maintained high vacuum and produced three times the amount of sap than 5/16". Quarter-inch tubing did create vacuum, although variable, and produced more than twice the amount of sap than 5/16" tubing.

With more trees per lateral, the results were very different. With 18 taps per lateral, all three tubing types produced essentially equal amounts of sap (Figure 3). Vacuum gauges were not added to the 18 taps per lateral and 30 taps per lateral line initially and, with the short season in 2021, most of the heavy flows were missed. In 30 taps per lateral, 1/4" tubing had the highest production with 46%

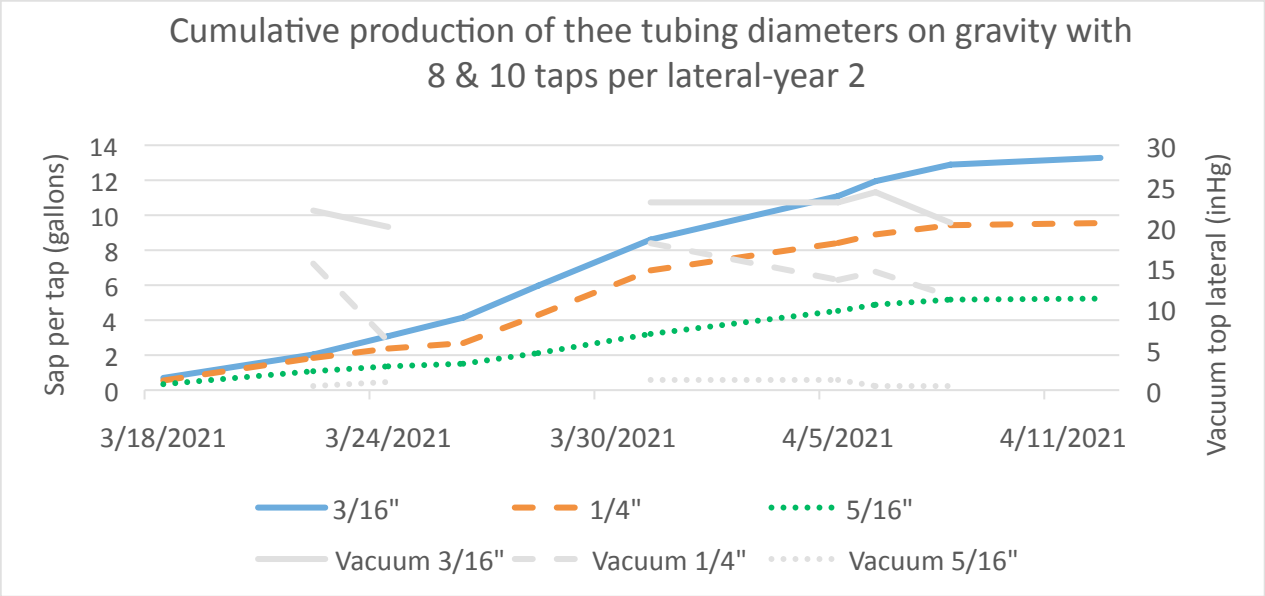

Figure 2: Average cumulative sap per tap on 3/16", 1/4", & 5/16" tubing on gravity during 2021, the second season during which the tubing was tested, along with vacuum level measured at the top of the lateral throughout the season. Each lateral had 8 or 10 taps. Results were similar to year one with no noticeable plugging on 3/16" tubing as it still outperformed 1/4" and 5/16" tubing. Quarter-inch tubing still produced twice the amount of sap than 5/16" tubing.

more sap per tap than 3/16" tubing and 5/16" tubing produced 16% more sap per tap than 3/16% tubing (Figure 4). This confirms previous research that when more trees are added to larger diameter tubing, vacuum can be created (Morrow, 1972). However, it can be challenging to find this many trees in a lot of sugarbush settings unless a very large slope is available.

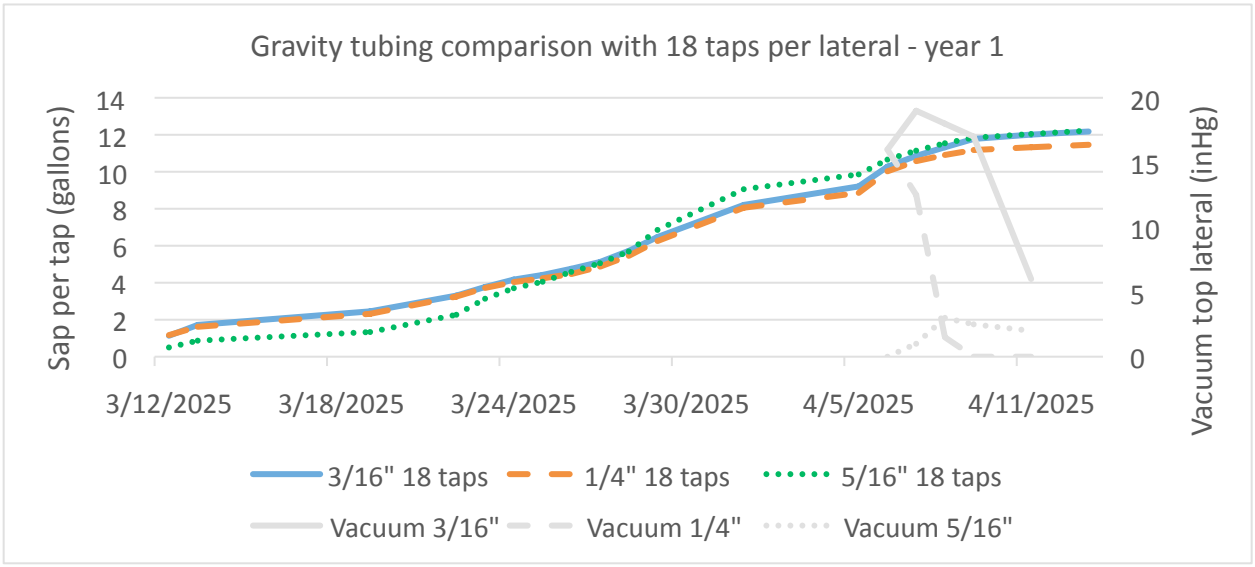

Figure 3: Cumulative sap per tap on 3/16", 1/4", & 5/16" tubing on gravity during the 2021 season, along with vacuum level measured at the top of the lateral throughout the season. Each lateral had 18. All tubing types produced essentially the same sap per tap.

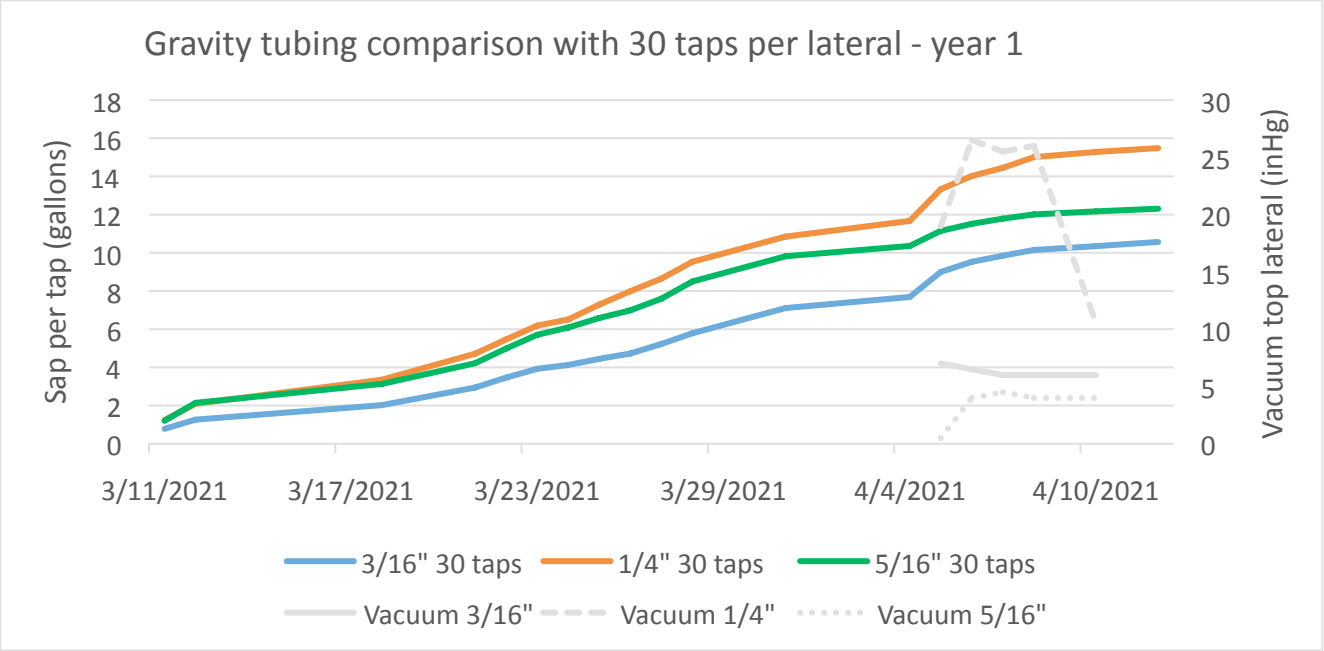

Figure 4: Cumulative sap per tap on 3/16", 1/4", & 5/16" tubing on gravity during the 2021 season, along with vacuum level measured at the top of the lateral throughout the season. Each lateral had 30 taps. Quarter inch tubing produced 46% more sap per tap than 3/16" tubing and 5/16" tubing produced 16% more sap per tap.

Vacuum Tubing Results

In the small trial of all three tubing sizes on a commercial vacuum pump, 1/4" tubing performed equal to 5/16" in year one and slightly less in year 2 (Table 1). In year one, 3/16" tubing performed similar to the 1/4" and 5/16" tubing, but produced 33% less than 5/16" tubing in year 2. Testing production of 1/4" tubing on a vacuum pump was not replicated nor were different number of taps per lateral. Although 1/4" tubing appears to be a viable option on a vacuum pump system, 5/16" tubing is still probably the ideal tubing when a vacuum pump is used. More testing on a vacuum system is necessary, although resources would be better focused on the effectiveness of 1/4" tubing in a gravity system.

Taps per lateral	Gallons of sap per tap on 3/16" tubing		Gallons of sap per tap on 1/4" tubing		Gallons of sap per tap on 5/16" tubing	
	2020	2021	2020	2021	2020	2021
8 taps on gravity	26.5	16.9	18.6	10.9	6.5	4.6
10 taps on gravity	27.9	9.7	18.4	8.2	9.1	5.8
18 taps on gravity		12.2		11.5		12.2
30 taps on gravity		10.6		15.5		12.3
Vacuum Pump	18.5	14.1	20.5	18.0	20.7	21.2

Table 1: Sap yields from year 1 (2020) and year 2 (2021) on three different tubing diameters in a gravity system with different number of taps per lateral along with production on the three different tubing sizes when a vacuum pump is incorporated. When the vacuum pump was incorporated, each lateral had three taps.

Conclusions:

Quarter-inch tubing was shown to be an effective option for sap collection, especially when at least 18 taps per lateral were used. On laterals with more taps, 1/4" tubing had the highest yields

per tap, while, with fewer taps per lateral, vacuum was not as high and 3/16" tubing had higher yields. However, 1/4" tubing produced significantly more than 5/16" tubing, and after two years of comparing yields on 3/16", 1/4", and 5/16" tubing, plugging was not observed in either of the tubing. It is expected that the 3/16" tubing will start to plug in the third year and 1/4" tubing will outperform all the tubing. We will be repeating the study during the 2022 sap season for a third year on 8 & 10 taps/lateral and the second season on 18 & 30 taps/lateral.

More research is needed to determine the effectiveness of 1/4" tubing, but early trials show promising results. We don't want to rush into promoting 1/4" tubing until we are confident plugging will not be an issue; it's anticipated not to be an issue as it can be with older 3/16" tubing that has not been sanitized. Over time, 1/4" tubing will more than likely produce higher yields than 3/16" tubing. If so, 1/4" tubing maybe an alternative tubing option for gravity sap collection systems. Long-term monitoring of the tubing will be necessary to determine whether microbial plugging occurs in 1/4" tubing. Data collection will continue for at least two seasons following the conclusion of this funding.

Education and Outreach:

Project leader Adam Wild presented the results of this research as follows:

- Northeastern NY Maple Association Maple Boot Camp, Lyon Mountain, NY; October 2021
- Lewis County Maple School, Lowville, NY; December 2021
- 2022 New York State Maple Conference, the world's largest gathering of maple producers
- Cornell University Agriculture In-Service Training for county extension agents, November 2021
- Upper Hudson Maple Producers Association, Greenwich, NY; August 2021
- Massachusetts Maple Producers Association, virtual presentation, January 2022.
- "Sweet Talk: All Things Maple" podcast Episode 7: Sweet Talk with Aaron and Adam.
- Articles accepted for Maple News February 2022 edition and for publication via Maple Digest and Mapleresearch.org.

Note: 2021 St. Lawrence County maple school was canceled due to COVID-19 spike.

The Northern New York Agriculture Development Program was identified as the funding source during each presentation, podcast, and publication.

For More Information:

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- NNYADP Maple Research Reports: https://nnyagdev.org/index.php/mapleforest/maple

References:

Childs, S. 2019. It could be the T's: results on 3/16th testing by Cornell researchers find plugged T's might by the cause of second year drop off. Maple News. November 7, 2019.

Morrow, R. 1972. Natural vacuum and the flow of maple sap. Plant Sciences, natural resources, number 1. New York's food and life sciences bulletin no. 14.

Wilmot, T.R., T.D. Perkins, A.K. van den Beg. 2007. Vacuum sap collection: how high or low should you go? Maple Syrup Digest. October 2007 (p. 27-32).

Wilmot, T.R. 2018. 3/16ths guru Tim Wilmot. The gravity of it all. Using 3/16th-inch tubing for gravity sap collection. Maple News. January 13, 2018.

Photos:

Image 1: Nearly 25 inHg of vacuum at the top of a 1/4" lateral line. Quarter-inch tubing was able to achieve high vacuum during good sap runs; NNYADP maple research project 2021.

Image 2: Sap flowing through 1/4" tubing in a NNYADP maple research project at the Cornell University Uihlein Maple Research Forest. Quarter-inch tubing was shown to potentially be a better-sized tubing option to maximize sap collection and yield in gravity systems.