Tapping Walnut Trees

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At the 2018 Southern Syrup Research Symposium, Mike Ferrell (The Forest Farmers LLC) and Abby van den Berg (Proctor Maple Research Center) led a session on tapping species other than maple. From their talk, and discussions afterwards, it became clear that we knew quite a bit about tapping birch, far less about tapping walnut and near nothing about tapping sycamore. Yet it was clear that the markets for specialty syrups, from bourbon barrel aged maple syrup to a maple-walnut blend were on the rise.

During the 2019 sap flow season, the Appalachian program of Future Generations University (FGU), with support from the West Virginia Department of Agriculture, conducted preliminary studies on tapping alternative species. We tapped and made syrup from black birch (*Betula lenta*) Black walnut (*Juglans nigra*); and yes, even American sycamore (*Platanus occidentalis*). This work taught us a lot about sap flow and syrup making from these three species. As can be imagined, it raised even more questions about: How to tap? When to tap? and Why to tap? to get the best results.

The "Why to tap?" question was pretty easily answered. One reason to tap black walnut trees is because of their availability in the central Appalachians and Midwest. In those regions, walnut is an abundant tree, with much of it occurring as relatively young low timber grade stock growing on abandoned agricultural lands. In *The Sugar Makers Companion* (2013) Mike Ferrell estimates that West Virginia has over 5 million tappable black walnut trees, Virginia has another 5 million, and Kentucky has 10 million. That's enough to start a syrup making industry. Another reason is the market. New Leaf Tree Syrups is selling a 12.7 oz maple walnut blend for $18 (https://newleaftreesyrups.com/). A new Virginia producer, *Tonoloway Farm*, will sell you a 1.7oz. bottle of pure black walnut syrup for $10. Except you have to order ahead, because their 2020 crop is sold out (https://tonolowayfarm.com/).

With the "Why to tap?" question seeming obvious, the FGU program focused its attention on the questions of "How to tap?" and "When to tap?" With a NE SARE-Partnership grant (ONE 19-374), we collaborated with four walnut syrup producing farmers and The Robert C. Byrd Institute of Advanced Manufacturing (RCBI) on the 2020 season studies.

People trying out walnut tapping, quite naturally, assume that drilling a hole in one type of tree was pretty much like drilling it in another. However, black walnut is a very different from the

various tapped maple species. From an anatomical perspective, black walnut is semi-ring porous as opposed to the diffuse porous wood of the maples. It has large pores (like oak) distributed within its xylem along with the small pores of diffuse porous species. Physiologically (similar to maple) walnut sap flow relies on the buildup of stem pressure which is initiated by freeze thaw cycles. However, walnut also (similar to birch) relies on root pressure initiated by rising soil temperatures. In a study titled "Seasonal variation in xylem pressure of walnut trees: root and stem pressures" the authors found that walnut trees achieve 7% of their theoretical osmotic potential — leading to pressurization of the xylem or wood — due to stem pressure and 55% due to root pressure (Ewers, et al., 2001). So, when do you tap? In the early spring, like maple, with its freeze thaw cycles or in the late spring, like birch, when the soil temperature is rising? Walnut also differs from maple in that it is a softer wood, it generally grows faster, and it is an early successional species, growing well in the open sunny places (Silvics of North America, 1990).

Also, and this is quite important; when compared to maple, walnut produces very little sap. For maple producers who are used to filling a sap bucket on a good run, collecting two gallons of walnut sap per tap over the course of the season hardly seems worthwhile. If you are one of those, go back and review the above section on economics.

Tapping Walnut trees:

There has been very little research done on tapping walnut trees. Naughton et. al. (2006) did a tapping study on a walnut plantation in Kansas. They correlated various physical and biological factors to sap flow and found that thickness of the sapwood was the best predictor of sap volume. Thickness of the light-colored sapwood in walnut is to a great degree a factor of the tree's growth rate (FPRL, 1976). This would indicate that a younger faster growing tree may produce more sap than an older, bigger, slower growing tree. Farrell and Mudge (2014) looked at sap production at four locations under varying sap collection systems. They found, much to their surprise, that the trial under vacuum produced the lowest amount of sap, but qualified this result by stating that it was a preliminary study and needed replication.

2020 Field season: Our goal during the 2020 field season was to explore ways of increasing walnut sap flow. Because of the positive effect vacuum has on sap flow in maple, we decided to follow-up on Ferrell and Mudge's preliminary work with a controlled experiment on the application of vacuum to walnut sap lines. We were also interested in tapping procedures. In Naughton's work they drilled tap holes all the way through the sapwood. During the 2019 field season we noticed a number of issues with the use of commercially available maple spouts for tapping walnut. They were:

- with the thickness of the bark on walnut trees, the barrel of the spouts was too short, with the shoulder of the spout often reaching the bark prior to achieving a full seal
- with the minimal taper on 5/16-inch spouts the tendency was to overdrive them in the softer walnut wood, and
- we were having trouble developing and maintaining a natural vacuum on 3/16-inch lines even though we had plenty of slope. We assumed that was due to a poor seal at the tap hole and that a more highly tapered spout could overcome that problem.

Due to these perceived problems we worked with RCBI to design and build a limited number of stainless steel 7/16-inch spouts with a longer barrel and more taper. To match Naughton's work, our tap holes were drilled between 2.0 and 2.5-inches deep to try to cut across the entire sapwood region.
Finally, we wanted to look at the issue of timing of tapping. Walnut trees leaf out much later than maple trees. Based on Ewers (2001) quantifying of osmotic potential, it was hypothesized that walnut sap could run better later in the season than does maple.

A brief description of our 2020 research procedures and the results are presented below.

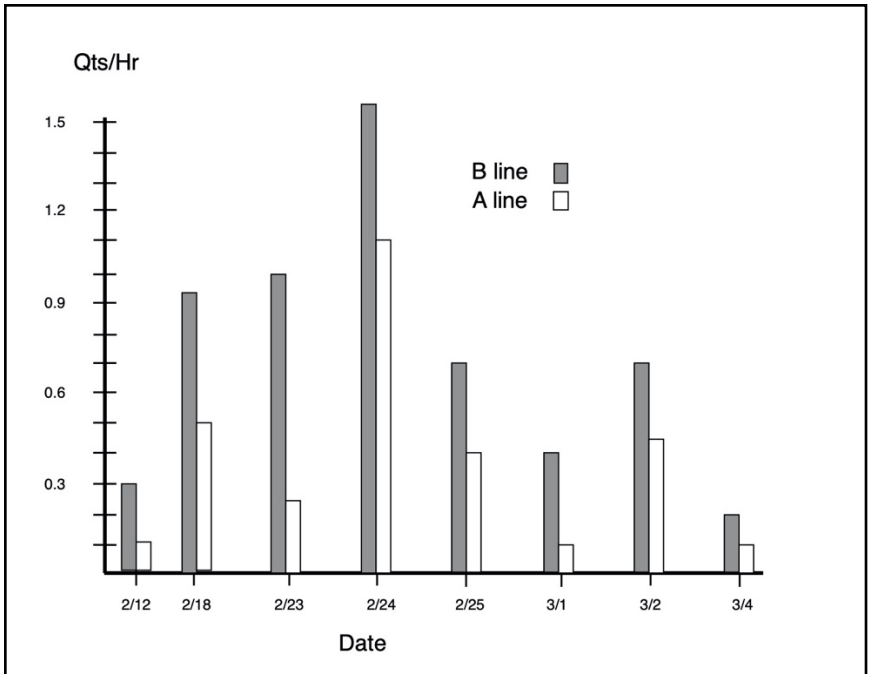
Study #1 - The application of vacuum to sap lines:

Study design: Two 3/16- inch sap lines (A line and B Line) were strung among trees along a stream. Each line had 20 taps, SS 7/16-inch spouts on 5/16-inch droplines. Sap in both lines flowed by gravity into 5-gallon food grade buckets. Sap collections were made on both lines at the same time. Time periods between collections varied.

Results: With both lines relying on gravity flow, the A line out produced the B line in 5 of the collections. B outproduced A in 3 of the collections and they produced an equal amount of sap one time.

We then installed a small Shurflo DC diaphragm pump on the B line and monitored sap flow on both lines for set periods of time. We did 8 runs of this experiment. On average the pump kept 8-inches of vacuum on the end of the B line. We then calculated the quarts/hour of flow on both lines for the 8 runs (Figure 1). As can be seen, the B line with vacuum outproduced the A, gravity flow line, in each of the runs. The line with vacuum (B) produced an average of 0.74 qt/hr. The gravity flow line (A) only produced an average of 0.37 qt./hr. Sap flow doubled ($p = 0.038$) with the application of only 8-inches of vacuum.

Figure 1. Sap flow on A line, gravity flow, and B line with the application of an average of 8 inches of vacuum



Study #2 – Comparative spouts and tapping procedures

In this study we worked with four collaborating walnut syrup producers. They each identified 10 trees on their farms that were large enough to support 2 taps. Each producer was then asked to tap each of the trees "just like they did last year, with the same type of spout." I then went through and tapped each of the trees drilling a deeper tap hole and using the 7/16-inch SS spouts. Each spout was attached to a 5/16- inch dropline and sap collected in 5-gallon buckets.

Results: A compilation of data from the collaborating producers is shown in Table 1. Three of the 4 producers (1,2, and 4) had a statically significant increase in sap collected from the SS spouts. Elton Bowers (number 2) did not. Produces 1,3 and 4 paired the SS spouts tapped with 5/16-inch spouts. At Christoph Herby's (number 2) the SS spouts were paired with CDL 7/16-inch nylon spouts.

With only 3 of the 4 producers showing an increase in sap volume it is hard to conclude that the new spouts and tapping procedures made a difference, even though for those where it did, the increase was significant. However, we do have pretty consistent results indicating that on gravity flow a walnut tap can be expected to yield around 2 gallons of sap over the season. We are also starting to realize that the sap flow season for walnut tends to be short. Elton Bowers had maple tapped in the same hollow as his black walnut. He had 42 days of sap flow on his maple trees and only 22 in his walnut trees.

Table 1. Summary data of comparative tapping procedures on the 4 study farms.

Farm no.	Farmer	Season length	Gallons maple spout	Gallons Walnut spout	t Test p-value	Ave gal/tree	Ave Brix
1	Chip Matheny	35	15	32	0.000002	2.35	1.1
2	Christoph Herby	28	15	27	0.00018	2.15	1.5
3	Elton Bowers	22	20	19	0.34	2.1	1.0
4	Karen Milnes	19**	9	13	0.032	2.1	1.9
	Average	28 (1-3)				2.17 (1-4)	

** Karen Milnes joined the study late when another producer had to drop out.

Study #3 - Timing of tapping and other observations

This third study started out with a well- defined methodology and ended up with a serendipitous observation. Walnut trees leaf out significantly later in the spring than do sugar maples. We started with the hypothesis that tapping later in the season, having fresher tap holes later in the season, would yield more sap. The study design called for selecting 10 study trees each of which would receive 3 taps, tapped at two-week intervals. The first tapping took place on February 12th, each tree was tapped again on February 23rd, the third tapping was on March 8th. Trees were tapped with the tap hole drilled deep enough through the sapwood region, with 7/16-inch SS spouts, 5/16-inch droplines and sap collected in 5-gallon food grade buckets. The study ended on March 31st when sap flow dropped to zero on the first two tappings. It should be noted that sap flow had slowed down but not ceased from the third tapping, but we were ready to quit. This, we learned later, was a mistake.

Table 2. Sap collected from 10 walnut trees with three staggered tapings.

Date	Tap A (qt)	Tap B (qt)	Tap C (qt)
2/12	14.4		
2/16	9.1		
2/18	19.5		
2/23	10.3		
2/25	19.0	18.8	
3/4	17.5	30.5	
3/8	2.5	5.8	
3/15	3.6	5.3	21
3/31	0	0	19.5

Then came April. Taps pulled, equipment cleaned and thinking more about mowing the lawn than making syrup. April 18th I got a call from Christoph Herby at Tonoloway farm in Virginia. I had asked him to drill some 7/16-inch and 5/16 holes in a walnut tree outside his sugarbush so we could study compartmentalization of decay once they healed over. We had a few hard, nightly frosts. The call began, "You aren't going to believe what just happened…." I hung up, grabbed my drill, a bucket and a spout that had not yet been stored and headed for the nearest walnut tree. Before I could get the spout set, a steady stream of sap was running down the bark. At this point I would like to direct the reader to two videos at the YouTube search MapleApril19 Of follow the link https://youtu.be/XvpmFPAoZxw, and MapleSapFebruary23 Link: https://youtu.be/cDhC_rlqNlA.

The video February 23rd is a good walnut sap run with a drip rate of 24 drops/minute. This is what it a good run looks like if you collect 2- gallons of sap per tap over the course of the season. The April 19th video, with a rate of 120 drops/minute, is what it looks like if you collect 2 gallons of sap from a tap in a day. The run only lasted 3 days, after which the flow completely stopped, but the volume of sap collected on this one tree in those three days was more than the average per tree collection for the entire season.

Discussion:

In the course of conducting these studies we made a number of observations that illuminate other issues related to tapping walnut trees.

1. There is a lot more gas in walnut sap than in maple sap. By photographing a section of line, we determined that on average a maple 3/16-inch maple sap line contains 85% sap. A walnut line, on the other hand, only contains only 9.2% sap. The extreme amount of gas in the sap lines could be from vacuum leaks at the tap hole, or it could be from tree gasses transported to the tap hole by the large vessels in the xylem. Either way, it causes real problems in developing a natural vacuum.

2. Collaborating producers Christoph Herby and Elton Bowers had additional walnut trees tapped with nylon CDL 7/16-inch spouts. Much to our surprise those spouts backed out of the trees. Once this problem was recognized Christoph estimated that as many as 25% of his spouts had to be tightened every day. Matt Cabrel estimated that at Elton Bowers farm the spouts had backed out up to ¼-inch. Tightening spouts every day to maintain vacuum does not make for a viable proposition.

The season leaves us with some answers and more questions. Sap flow on walnut trees can definitely be increased with the application of vacuum. Natural vacuum won't work as well as maple, as there is too much gas in the lines to develop the pull. Artificial vacuum works if you can keep the spouts tight. Minimal vacuum doubled sap flow, what could you do with high vacuum? Should it be with 3/16-inch tubing or 5/16-inch tubing? How many walnut trees can

you put on a lateral line? We had a fantastic April sap flow, but for only 3 days. How do you know which three days?

Lots of questions and lots of opportunities. Well I guess that is just what next year is for.

Citations:

Ewers, Frank, Thierry Ameglio, Herve Cochard, Francquis Beaujard, Michel Martignac, Marc Vandame, Christian Bodet and Pierre Cruiziat. Seasonal variation of xylem pressure of walnut trees: root and stem pressures. Tree Physiology (21) 2001.

Ferrell, Michael and Ken Mudge. Producing Maple Syrup from Black Walnut Trees in the Eastern United States. Maple Syrup Digest. December 2014.

Gross Influences on Heartwood Formation in Black Walnut and Cherry. USDA Forest Service. FPL 268. Forest Products Research Lab. Madison. WI. 1976.

Naughton, G.G., W.A. Geyer and E. Chambers IV. *Making Syrup from Walnut Sap*. Transactions of the Kansas Academy of Science. Vol 109, no.3/4. 2006.

Silvics of North America Volume 2: Hardwoods. US Dept. of Ag. Forest Service, Agricultural Handbook 654. Edited by: Russell M. Burns and Barbara H. Honkala. 1990.