Research: Other trees

Tapping Walnut Trees: Studies on Walnut Sap Flow

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Tapping tree species other than maple and boiling the sap provides syrup producers the opportunity to apply their skills, and capitalize on their existing equipment, to expand into new and potentially lucrative markets. Just as bourbon barrel aged and various flavor infused syrups are opening new markets for maple syrup, the unique tastes of alternative tree syrups, and their maple blends, are finding a place in today's "foodie" economy.

Black Walnut (Juglans nigra) is a tree to consider tapping, and Butternut (Juglans cinerea) has similar characteristics and can produce syrup. When considering tapping, however, it is good to understood that walnut trees and not just maples with compound leaves and big edible nuts. Walnuts have anatomical and physiological characteristics that affect tapping and syrup making.

A different tree

Wood anatomists classify maple as a "diffuse porous" hardwood. In maple trees small vessels, commonly called pores, carry water and nutrients up the tree in the summer and carry sweet sap to your tap during the sugaring season. These vessels are diffused or evenly distributed throughout the tree's annual growth ring. Walnut, on the other hand, are classified as a "semi-ring porous" species. They have small, diffused pores like maple, but also large pores – similar to true "ring porous" species such as oak and hickory – that are more prominent in the early annual growth or springwood. As anyone who has ever looked at the end of a walnut log can tell you, walnut trees have a large very dark heartwood area, with a small band of white sapwood. A young healthy maple tree, on the other hand, can have mostly sapwood. Maple, and especially sugar maple, also called "hard maple" or "rock maple," is a very hard wood, whereas walnut wood is comparatively soft.

Finally, walnut sap, with a brix of 1.0 to 1.5, also contains pectin. Pectin is a natural constituent of plant cell walls where it helps bind adjacent cell walls together. And, as anyone who has made fruit preserves can attest, when boiled in an acid environment, pectin forms a gel. When present in high enough concentrations this pectin can gum up an RO, inhibit filtering, and make walnut syrup into walnut jelly.

Tapping walnut trees

We know a lot about tapping maple trees and making maple syrup. We've been at it a long time and there is an extensive body of research that has led to improved practices and increased production. The same is not true for walnut. In 2006, Gary Naughton at Kansas State did a tapping study on

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the University's walnut plantation. He correlated various physical and biological factors to sap flow and found that thickness of the sapwood was the best predictor of sap flow volume (Naughton et al., 2006). 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 faster growing tree, which is often a younger tree, may produce more sap than an older, slower growing tree. Ferrell and Mudge (2014) looked at walnut sap production from four locations under varying sap collection systems. They found, much to their surprise, that the trial under vacuum produced the least sap, but qualified this result by stating that it was a preliminary study and needed replication.

There are also several studies by a research team in France that looked at sap flow physiology in walnut trees. Ewers published a paper in Tree Physiology, titled the "Seasonal variation of xylem pressure in walnut trees: root and stem pressures." In this study it was found that 7% of osmotic potential was (like with maple) due to stem pressure, whereas 55% of osmotic pressure was (like with birch) due to root pressure (Ewers et al.,2001). Osmotic pressure is at least partly responsible for sap flow in maple. This then begs the question of when to tap; during the period of freeze/thaw cycles when maple sap runs, or after the period of freeze/thaw cycles, when birch sap runs?

For the past three years, Future Generations University's (FGU) Appalachian program has been studying various aspects of walnut sap flow and syrup production. This paper presents a synopsis of the results of that work and relates those findings to the unique anatomical and physiological characteristics of walnut.

2019 Season

During the 2019 field season we put in 107 walnut taps, about half on sap bags and half on 3/16" tubing. This was our first year of tapping walnut and it was a season of trial, error, and observation (mostly error). Our seasons average sap collected per tap was 1.6 gallons. Certainly nothing to write home about, especially for a maple sap collector. Even though we had over 20 feet of elevation change on the 3/16 lines between our last tree and the collection tank, we were never able to develop more than 9 inches Hg of natural vacuum. Theoretically we should have been closer to 18 inches.

We noted that the straight-barreled polycarbonate spouts were seating deeply in the soft walnut wood, potentially cutting off sap flow (Rechlin, 2019, mapleresearch.org). The deep spout seating combined with the thick walnut bark meant that many spouts were buried up to the shoulder. We also noticed that the 3/16" tubes were mostly filled with gases, whereas maple sap collection tubes are mostly filled with sap. By analyzing a series of photos, we determined that walnut tubes contained only 9% sap compared to 85% sap in maple. This lack of a continuous sap column was most likely why we failed to develop any appreciable vacuum.

Figure 1. 7/16-inch spout and a longer barreled walnut spout.

2020 Season

In 2020, we worked with the Robert C. Byrd Institute for Advanced Manufacturing to develop a longer barreled more highly tapered, to seat at less depth, walnut spout (Figure 1). Working with four walnut syrup producers collecting with buckets we found that the spouts they were using produced an average of 1.7 gallons of sap per tap whereas the new walnut spouts produced 2.6 gallons of sap per tap.

That year we also reached back to the Ferrell and Mudge study and tried our

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hand at applying artificial vacuum to our lines. We established two lines with 20 taps on each line on trees in a similar streamside environment. Without vacuum the A line outproduced the B line in three of the five collections, with both lines producing equal amounts of sap in the other two collections. A Shurflo DC diaphragm pump was then installed on the lower producing B line. With an average of 8 inches of vacuum the B line produced 0.74 qt/hr., double the sap production of the A line with 0.37 qt/ hr.

2021 Season

Which brings us to this past sap flow season, 2021. Having shown that a low level of vacuum significantly increases sap production, the next question is what could you achieve with higher levels of vacuum? We attempted to answer that question.

The walnut syrup producer we were working with installed a vacuum pump allowing us to regulate the amount of vacuum on each of our research lines. Figure 2 shows the amount of sap collected in vacuum chambers with each line at 15 inches Hg vacuum. As in the previous season with gravity flow, when both lines received the same level of vacuum the A line, producing 1.4 qt/hr., outproduced the B line which av-

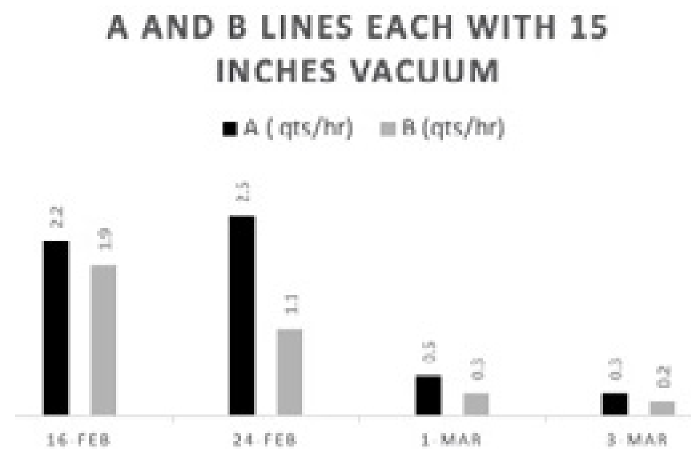

Figure 2. Sap collected in qt/hr. with equal vacuum applied to each line

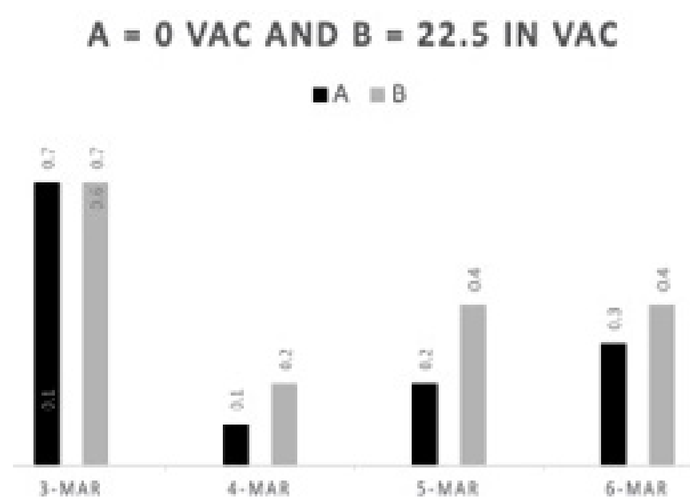

Figure 3. Sap collected in qt/hr. without vacuum on the A line and 22.5 inches of vacuum on the B line.

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eraged 0.9 qt/hr. From this we can gather that the A line trees are intrinsically more productive than the B line trees.

We then dropped the vacuum to zero (gravity flow only) on the A line and applied 22.5 inches of Hg vacuum, the maximum this system would provide, to the B line (Figure 3). The B line trees now produced 0.5 qt/hr., outproducing the A line at 0.3 qt/hr. As with the previous year, the application of vacuum increased sap flow. March 3rd is an unexplained anomaly, where the gravity line produced as much sap as the line under vacuum.

Next, we raised the vacuum on the A line to 10 inches, which reduced the maximum achievable vacuum on the B line to only 17 inches. With maple, higher vacuum positively correlates to greater sap flow. However, here the relatively lower vacuum level A line averaged 0.4 qt/hr., whereas the higher vacuum level B line produced only 0.2 qt/hr. Again, March 11th was an unexplained anomaly, with B outproducing A (Figure 4).

Interesting, but what might be happening and how does it relate to the anatomical characteristics of walnut? Diffuse porous hardwoods, like maple, create stem pressure in the spring to dissolve gasses in their xylem allowing growing season sap to flow up the tree to support bud break. Ring porous species followed a different evolutionary strategy. They just grow new large vessels in the spring to transport water and nutrients, not bothering to develop pressure to dissolve the gases in their older vessels. Which, by the way, is why you should not bother tapping an oak or hickory tree. Walnut, being semi-ring porous, is somewhere in the middle. They do create pressure to clean out their small vessels, but that may not apply to their large vessels, which then would remain filled with gas. This could account for the large quantity of gas we recorded in 2019 as present in the walnut sap. It could also explain why, in this study, more vacuum did not lead to more sap flow, just be pulling of more gas from those large vessels.

I liken it to trying to get those last drops off the bottom of your milkshake. You can suck really hard on a straw and just swallow a lot of air or reduce the vacuum you are applying to the straw and finish off the shake.

Summary of walnut tapping lessons:

1. With the soft wood it is important not to over-drive the spouts. The familiar hammer bounce and pitch rise on a straight barreled maple spout is too far. Choose a spout with as much taper as possible. Hopefully soon we will have a commercially available walnut specific spout.

2. Vacuum does increase sap flow. Relatively low levels of vacuum nearly doubled sap output in the 2020 and 2021 studies.

3. Unlike what is expected with maple, in this study, higher levels of vacuum in walnut did not result in corresponding increases in sap flow. However, it should be stated that as a preliminary study this result should be corroborated in future research.

FGU's Appalachian program continues to research and promote the tapping of alternative tree species. In this coming season we will be working with the Byrd Institute to develop and commercialize a more productive spout for tappable species with softer wood, and with Marshall University on the pectin issue. Our work also includes expansion of preliminary work we have been doing with American sycamore (Paltanus occidentalis). Whether in addition to tapping maple or as an expansion of tree syrup production beyond the commercial sugaring range of maple, the unique flavors of alternative tree

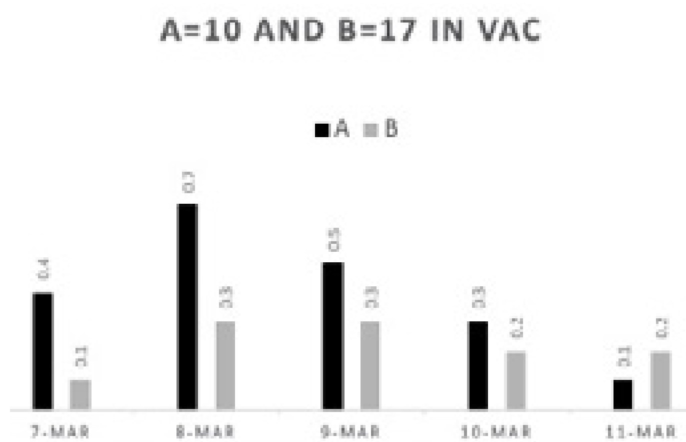

Figure 4. Sap collected in qt/hr. with 10 inches of vacuum on the A line and 17 inches of vacuum on the B line.

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syrups are helping expand our industry and serving niche markets for the sweet flavors from our forests.

Acknowledgements

This work was supported through a WVDA specialty crop block grant, NE SARE Partnership grant ONE19-374, and by the Claude Worthington Benedum Foundation.

Citations

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