Rusted Flatbed Farm

Advancing black walnut syrup production through research and report on optimal tapping practices

FNC23:1372

A SARE Project Report

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Executive summary

This project aims to advance black walnut (*Juglans nigra*) syrup production by testing sustainable tapping practices and collecting performance data from two sap collection systems, buckets and vacuum tubing, at Rusted Flatbed Farm in Indiana. Black walnut syrup offers a high-value product but faces challenges such as lower sap yield, reduced sugar content, and tap-sealing difficulties. The study expands limited research on walnut syrup by analyzing sap volume, sugar content, and vacuum efficiency under field conditions to identify optimal tapping methods and improve producer outcomes.

In 2024, stainless-steel spouts failed to hold vacuum during an unusually poor sap season, limiting production across the region. In 2025, new vinyl spouts and improved vacuum management restored performance and yielded reliable comparative data. Over a 23-day collection period (February 7–March 11, 2025), 61 black walnut taps were monitored across both systems alongside 71 maple taps for comparison.

Key findings demonstrate substantial advantages of vacuum tubing over bucket collection:

- Sap yield: Tubing systems collected 6.7× more total sap, with per-tap yields of 2.45 gal/tap (tubing) compared to 0.60 gal/tap (buckets), a 4.1-fold improvement.
- Sugar content: Weighted average sugar concentration was higher in tubing sap (1.72%) than bucket sap (1.42%).
- Syrup production: Tubing systems yielded 2.42 gallons of finished syrup compared to 0.30 gallons from buckets, an 8-fold increase.
- Optimal vacuum pressure: Black walnut trees performed best at 6–10 inches Hg, with sap yield declining at higher pressures (11–21 in Hg), contrasting with maple's optimal range of 20–26 in Hg.

These findings provide a quantitative baseline for black walnut syrup production and demonstrate that vacuum tubing systems offer substantial advantages for operations with 30+ taps.

1. Background and Objectives

Black walnut syrup is a natural, locally sourced sweetener with a rich, nutty flavor that commands a premium price compared to maple syrup. Despite its potential, commercial production of black walnut syrup faces significant challenges. Black walnut trees typically yield less sap with lower sugar content than maples, and many forest owners hesitate to tap high-value timber trees. However, this creates an opportunity for urban and small-scale agroforestry operations, where trees of limited timber value can be productively used for syrup production while maintaining forest health and biodiversity.

Unlike maple syrup, relatively little research exists on black walnut tapping and sap flow dynamics. Prior studies, such as the Future Generations University SARE project (2019), indicated that black walnut trees should be tapped later in the season, may require modified spout designs, and can significantly increase sap collection under vacuum. However, these studies left gaps in understanding how tree size, site conditions, and equipment performance affect yield and syrup quality. Expanding this body of research is essential to developing reliable best practices for walnut syrup production and promoting it as a sustainable niche enterprise within regional agroforestry systems.

The primary goal of this project is to advance knowledge and refine best practices for black walnut syrup production through on-farm experimentation and producer engagement. Specifically, the project seeks to:

- Quantify sap yield and sugar content from black walnut trees using two collection systems, vacuum tubing and buckets.
- Evaluate system performance and equipment efficiency under real-world farm conditions.
- Compare sap flow timing and volume between black walnut and maple trees to contextualize species-specific differences in productivity.
- Develop practical recommendations on optimal tapping time, vacuum settings, and equipment configurations for small and mid-scale producers.

Together, these efforts aim to build the research foundation needed to make black walnut syrup a viable, sustainable, and profitable addition to local and regional agroforestry production systems.

2. Methods

Data were collected at Rusted Flatbed Farm in Indiana, where the study compared sap production between 61 black walnut and 71 maple trees using both bucket and vacuum tubing collection systems. The goal was to assess how different tap designs and collection methods influenced sap yield, sugar concentration, and overall syrup production efficiency under field conditions.

During the 2024 season, a total of 23 black walnut and 15 maple trees were tapped using buckets. The tubing system trial that year experienced significant failure due to stainless-steel spouts that did not form a proper vacuum seal. Retaping the trees with vinyl spouts created air leaks through the old tapholes, resulting in negligible vacuum and low sap flow. Compounding the issue, 2024 was an unusually poor year for sap production across the region, with most producers reporting yields at roughly 40 percent of normal levels. Throughout the season, sap volume, and sugar content (°Brix) were recorded daily to establish baseline data for subsequent comparisons.

In 2025, a fully functional vacuum tubing system was installed and tested, using 38 black walnut and 56 maple taps connected to a high-vacuum network. Vinyl spouts replaced the failed stainless-steel models, improving seal quality and reducing air infiltration. The system operated at 8–21 in Hg of vacuum for black walnut and 20–26 in Hg for maple, reflecting differences in species tolerance and xylem structure. Daily measurements included sap volume per tap (gal tap^{-1} day^{-1}), sugar concentration (%), and vacuum pressure (in Hg).

Data were analyzed to determine average sap yield per tap, sugar content, and sap-to-syrup conversion using the “Rule of 86”. This rule can be used to estimate the amount of sap required to produce one gallon of syrup. By dividing 86 by the sugar content of the sap, the approximate sap-to-syrup ratio can be determined. This value was applied in calculations to estimate sap-to-syrup conversion ratios.

$$\text{Gallons of Sap per Gallon of Syrup} = \frac{86}{\text{Sugar Content (\%)}}$$

As an example, with a sugar content of 2.30%, the calculation is 86 ÷ 2.30 = 37, meaning about 37 gallons of sap are required to produce one gallon of syrup. This calculation was used to estimate syrup yield efficiency for both species and collection methods.

To account for variable daily sap flow, weighted average sugar content was calculated rather than simple arithmetic means. This method ensures high-volume collection days contribute proportionally more to the average, accurately representing the sugar concentration of total sap collected:

$$\text{Weighted Average Sugar Content (\%)} = \frac{\sum(\text{daily sap volume} \times \text{daily sugar content})}{\text{Total Sap Volume}}$$

3. Results

3.1. Sap Yield and Sugar Content by Species and Collection Method

The maple and black walnut syrup operation utilizes 132 taps across four collection systems, with maple tubing being the most productive method. The 56 maple tubing taps, averaging 11.80 inches in diameter, generate the highest daily sap volume at 29.44 gallons with a 2% sugar content. In contrast, the 38 black walnut tubing taps produce 3.44 gallons daily at 1% sugar content from trees averaging 12.98 inches in diameter. Traditional bucket collection methods show lower yields, with 23 black walnut buckets averaging 0.59 gallons per day from larger 18.95-inch diameter trees, while 15 maple buckets from 13.79-inch trees produce 6.87 gallons daily at 2.14% sugar content. Overall, the operation demonstrates that maple trees consistently outperform black walnut in both sap volume and sugar concentration, with tubing systems proving more efficient than bucket collection methods.

Table 1. System overview and preliminary sap collection statistics for maple and black walnut

Systems	Number of Tap	Average Diameter (inch)	Average Daily Sap (gallons)
Black Walnut Bucket	23	18.95	0.60
Maple Bucket	15	13.79	6.87
Black Walnut Tubing	38	12.98	3.44
Maple Tubing	56	11.80	29.44

3.2.Bucket System

Figure 1 below displays the average daily sap collection per tap relative to tree diameter to examine the relationship between diameter and sap volume for black walnut and maple trees. The highest sap yields were 0.05 and 0.07 gallons per day, occurring at diameters of 16 and 27 inches, respectively. The lowest yield of 0.01 gallons per day was recorded for trees with a 20-inch diameter. Similar to black walnut, no clear correlation exists between tree diameter and sap production. The peak average sap volume of 20 gallons per day was achieved by trees measuring 20 inches in diameter, demonstrating that larger diameter does not necessarily correlate with higher sap yield for either species.

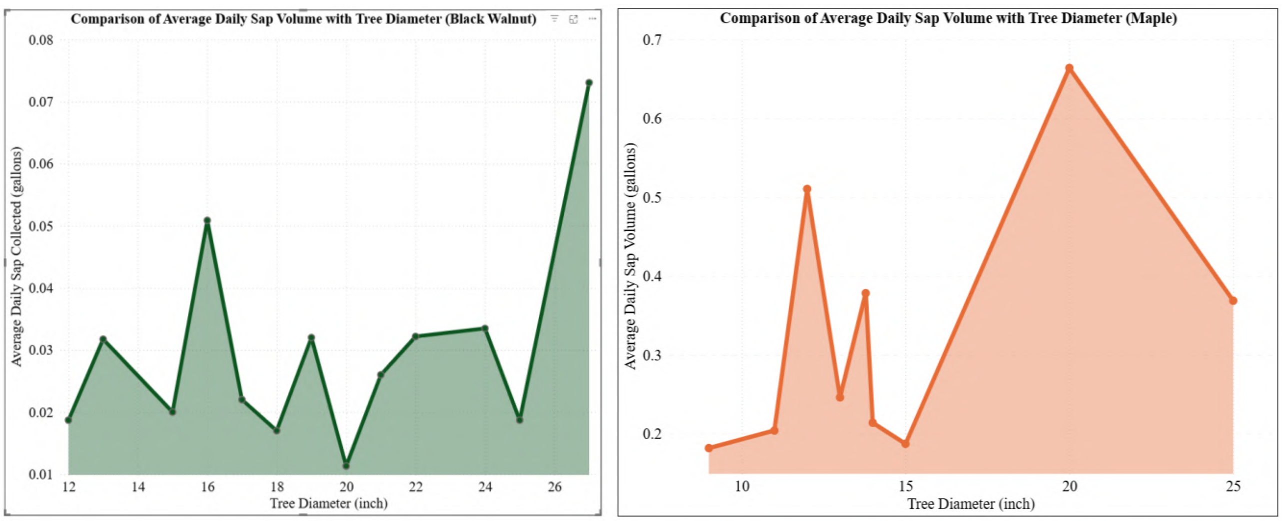


Figure 1. Average daily dap volume and tree diameter of black walnut (left) and maple (right)

3.2.1. Sap Flow Comparison

Figure 2 compares daily sap flow volumes between black walnut and maple trees. Maple consistently produced higher sap volumes than black walnut, with peak flows of approximately 15 gallons and 1.8 gallons respectively occurring on February 20-21. Both species showed minimal flow during February 7-15 maybe due to unfavorable weather conditions, followed by increased production mid-to-late February before declining into March. According to the figure, Maple seems to run and have increased sap volume earlier than black walnut in most days.

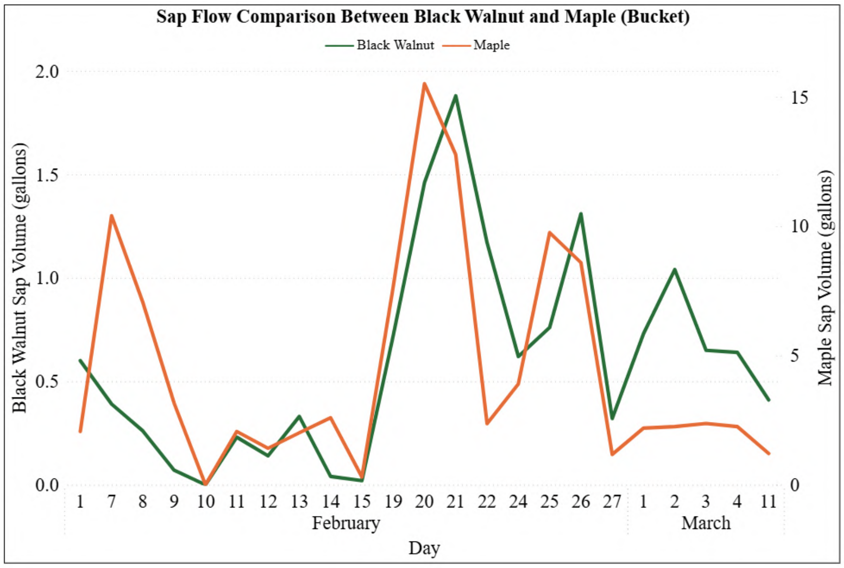
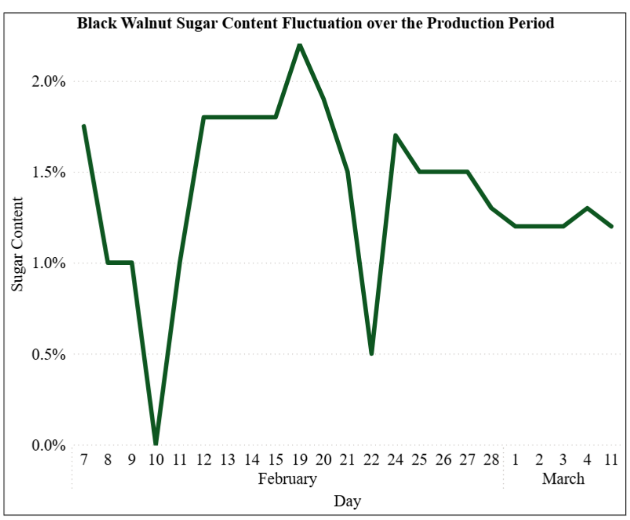


Figure 2. Sap Flow Comparison between black walnut and maple (bucket system)

3.2.2. Sugar Content Fluctuation

Figures 3 shows the fluctuation of sugar content in black walnut and maple sap over the production period. Maple sap consistently showed higher sugar content than black walnut, with maximum values reaching approximately 2.7% compared to 2.2% for black walnut. Both species exhibited sharp drops to 0% on February 8-10, 2025, which are attributed to measurement artifacts caused by adverse environmental conditions (rainwater dilution or frozen sap) rather than actual physiological changes in tree sap content. Following this period, maple sugar content stabilized around 2.5%, while black walnut maintained levels between 1.2-1.5% through the remainder of the collection period.



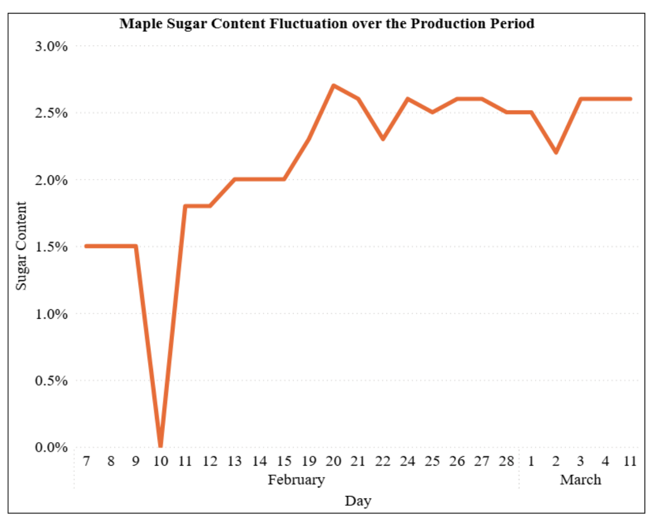


Figure 3. Black walnut (left) and maple (right) sugar content fluctuations

3.2.3. Relationship between sugar content and sap volume over time

From the figure 4 below, there is no clear correlation between sap volume and sugar content over time. However, a pattern emerges where sugar content tends to peak or drop one to two days before corresponding changes in sap volume occur.

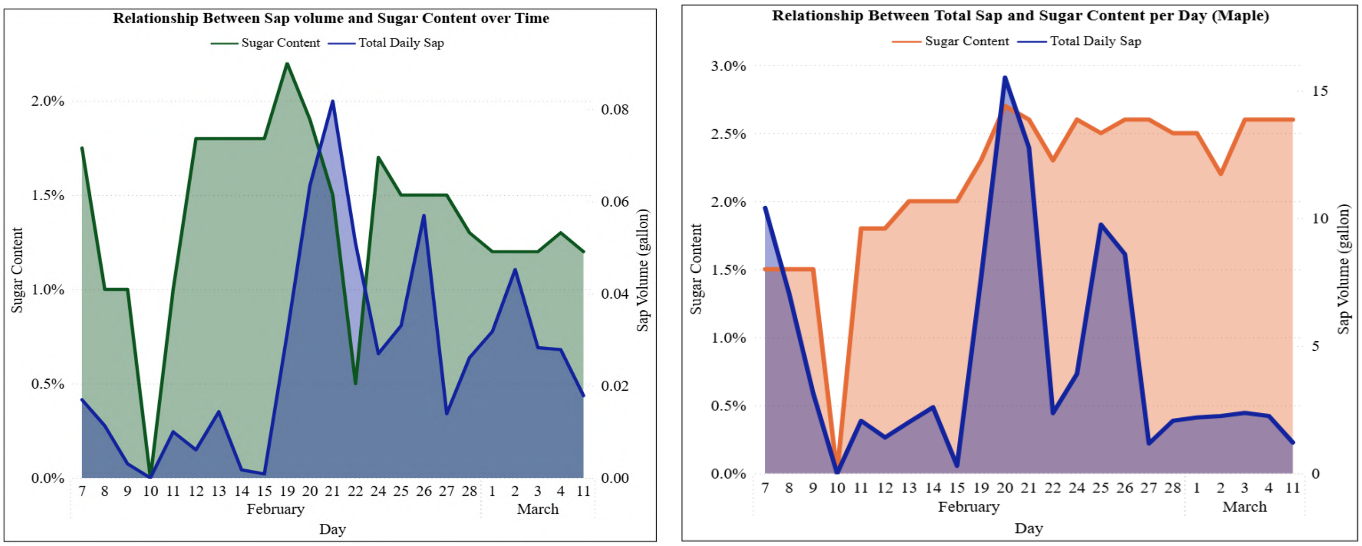


Figure 4: Relationship between black walnut (left) and maple (right) sap volume and sugar content

The sap flow from maple trees closely mirrors their sugar content patterns, with both metrics exhibiting highs and lows on the same days. Peak performance was observed on February 20, 2025, when the sugar content reached 2.70% and the sap volume peaked at 15.51 gallons (Figure 3). Conversely, the lowest values for both sugar content and sap volume were recorded on February 10 and 15, 2025.

Both maple and black walnut trees ceased sap production entirely on February 10 and 15, 2025. Throughout the February 15-27 period, both species exhibited similar sap flow fluctuation patterns, suggesting they respond to the same environmental conditions. However, maple trees consistently demonstrated superior productivity, generating significantly higher average daily sap volumes compared to black walnut trees.

3.3.Tubing System

Comparing the sap volume collected and the sugar content on a daily basis. Figure 4 shows that sugar content and sap volume fluctuate in the same pattern for the black walnut. The highest daily sap volume collected was 11 gallons with 2% of sugar content on March 5, 2025. The highest sugar content was 3% on February 24, along with a sap volume of 6 gallons.

Unlike the black walnut, the maple tubing system collected 90 gallons as the highest sap volume with a sugar content of 2%. Sugar content appear to be approximately the around 2.3 % and 3 % during the period of operation while sap volume appears to fluctuate a lot (figure 4).

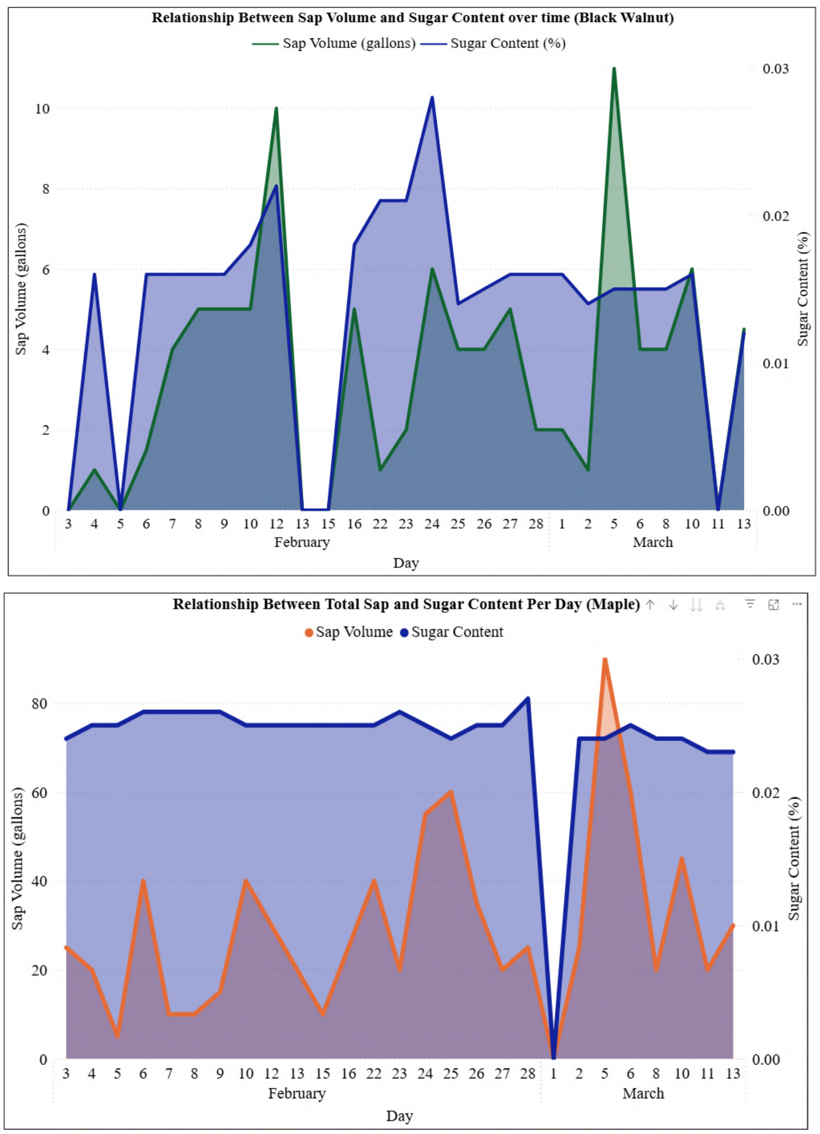


Figure 5. Relationship between black walnut (top) and maple (bottom) sap volume and sugar content

3.3.1. Sap Flow Comparison

Figure 6 shows sap flow comparison between black walnut and maple using tubing collection methods. The two species exhibited loosely coordinated flow patterns throughout the production period, with variable timing in their responses to environmental conditions. The species that peaked first varied depending on the specific conditions: maple started to run on the February 3 while black walnut started on February 4. Maple peaked before black walnut on February 9-10 (versus February 10-12), and then peaked together on March 5. This variable lag pattern, with leads ranging from one day, suggests that while both species respond to similar environmental triggers such as freeze-thaw cycles, each species exhibits different sensitivity and response timing depending on the specific environmental conditions present. Neither species consistently responds first; however, maple tends to respond first more often

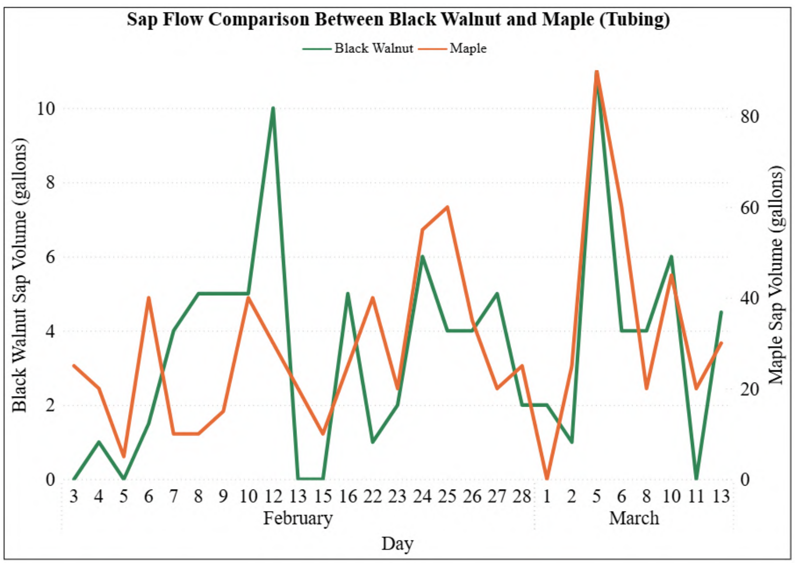


Figure 6. Sap Flow Comparison between black walnut and maple (Tubing system)

3.3.2. Hg measure between

The inches of mercury measure the negative pressure produced when air leaves the line while collecting sap. It is one way to monitor the performance of a vacuum pump. Different values were collected from both maple and black walnut trees under the tubing system. Maple Hg values ranged from 11 to 26 Hg. The black walnut values ranged between 8 and 21 inches, with the highest values recorded on February 12, 2025. These numbers show how strong the maple sap is, with higher yields collected from the maple trees compared to the black walnut trees.

There is some missing data due to the gauge that broke on March 2, 2025. Refer to Figure 7 for a visual.

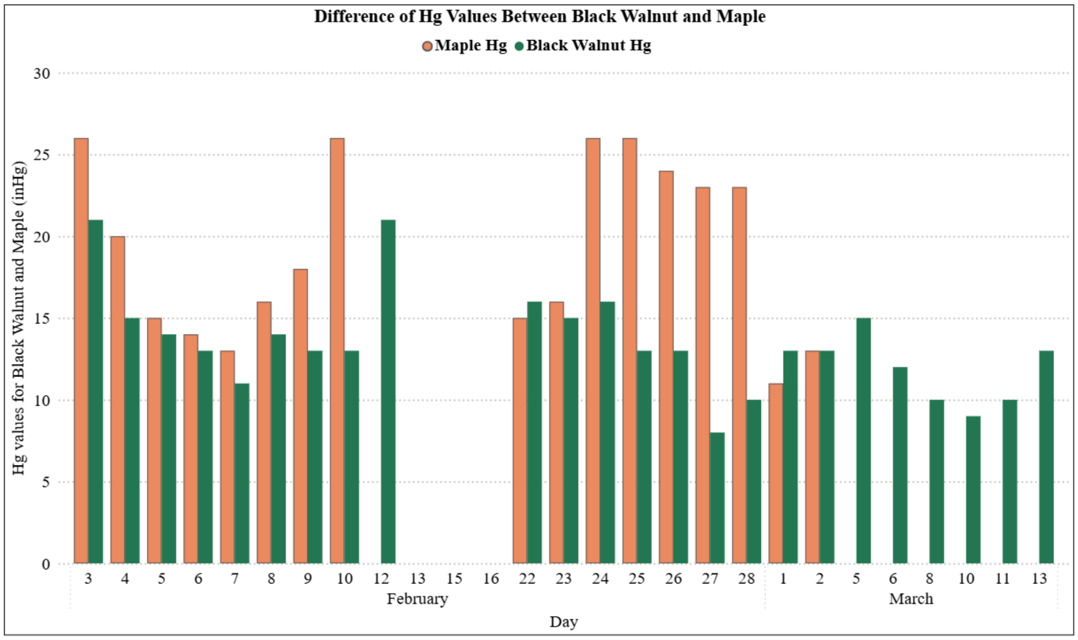


Figure 7. Difference of Hg values between black walnut and maple

3.3.3. Sugar Content Baseline

Higher sugar content in sap results in more syrup after boiling. This underscores the importance of measuring and tracking sugar concentration when collecting sap from both black walnut and maple trees. Data collected from the tubing systems showed clear differences between the two species. Maple sap contained higher sugar concentrations than black walnut sap. Maple sugar content ranged from 2.30% to 2.70%, with an average of 2.49%. Black walnut sap ranged from 1.20% to 2.80%, with an average of 1.69%.

A more detailed breakdown of these calculations is presented in Table 2.

Table 2. Gallon of syrup estimation using sugar content and Brix

Black Walnut (tubing)		**Maple (tubing)**	
Sugar Content (%)	**Ratio Sap-Syrup**	**Sugar Content (%)**	**Ratio Sap-Syrup**
1.20	55:1	2.30	29:1
1.40	47:1	2.40	28:1

1.50	44:1	2.50	26:1
1.60	41: 1	2.60	25:1
1.70		2.70	24:1
1.80	37:1		
2.10	31:1		
2.20	30:1		
2.80	24:1		

Ratio = 66%/sugar content%

3.3.4. Average Sap Yield Per inch of Hg

Vacuum pressure is a critical operational parameter in modern maple syrup production as it directly influences the rate and volume of sap extraction from tapped trees. Table 3 shows a clear and distinct vacuum pressure difference between black walnut and maple trees that has significant implications for the potential optimization of syrup production efficiency across different species. Black walnut trees demonstrate optimal sap yield at relatively low vacuum pressures, with peak performance occurring in the 6-10 inches of mercury range, where an average of 3.88 gallons of sap is collected. As vacuum pressure increases beyond this optimal range, black walnut shows a clear pattern of diminishing returns, with sap collection declining to 3.57 gallons at 11-15" Hg and further dropping to 3.03 gallons at 16-21" Hg, representing a 22% decrease in yield from the optimal to the highest vacuum ranges. In contrast, maple trees not only tolerate but actually benefit from significantly higher vacuum pressures, achieving their best performance at 20-26" Hg with an average collection of 26.57 gallons of sap. This fundamental difference in vacuum pressure response between species would suggest that maple trees have a more robust vascular system that can maintain sap flow under higher suction. In contrast, black walnut trees appear to experience reduced flow or potential tissue damage at elevated vacuum levels. These results can establish a critical baseline for syrup production operations, suggesting that producers may implement species-specific vacuum management strategies, maintaining 6-10" Hg for black walnut trees and 20-26" Hg for maple trees to maximize sap yield and overall production efficiency. However, the limited number of observations in this preliminary analysis necessitates additional experimentation to validate these findings and establish statistically robust operational guidelines for commercial implementation.

Table 3. Inches of Hg values and Average Gallons of Sap collected

Black Walnut (tubing)		Maple (tubing)	
Inch of Hg Intervals	**Sap Collected (gallons)**	**Inch of Hg Intervals**	**Sap Collected**
0-5	No data	0-6	21.25
6-10	3.88	7-13	25.88
11-15	3.57	14-19	22.08
16-21	3.03	20-26	26.57

4. Production Estimates

Table 2 and 3 provided sufficient data to estimate the number of gallons of syrup and sugar content for black walnut considering sap yields from both tubing and bucket systems. The comparison between bucket and tubing collection systems reveals significant differences in both sap yield and production efficiency (Table 4). Over the 23-day collection period, the vacuum tubing system collected 93 gallons of sap from 38 taps, while the bucket system collected 13.79 gallons from 23 taps. This represents a 6.7-fold increase in total sap volume for the tubing system. This demonstrates the advantage of vacuum-assisted collection for black walnut syrup production.

Sugar content analysis shows that the tubing system achieved a slightly higher weighted average sugar concentration of 1.72% compared to 1.42% in the bucket system. The tubing system's sap-to-syrup ratio of 50:1 (66 ÷ 1.72) is more favorable than the bucket system's 61:1 ratio (66 ÷ 1.42), meaning less sap is required to produce each gallon of finished syrup.

Total syrup production estimates reflect the combined effects of higher sap volume and improved sugar content. The tubing system is projected to yield 2.42 gallons of syrup, compared to just 0.30 gallons from buckets, an 8-fold difference in syrup output. On a per-tap basis, tubing taps are expected to produce approximately 0.064 gallons (8.2 ounces) of syrup compared to 0.013 gallons (1.7 ounces) per bucket tap, representing a 5-fold efficiency gain per tap.

Table 4. Production estimates of sugar content and gallons of syrup

System	Number of Taps	Total Sap Volume (gallons)	Average Sap per Tap (gallons)	Weighted Average Sugar Content (%)	Sap-to-Syrup Ratio	Total Syrup Production (gallons)	Syrup per Tap (gallons)
Bucket	23	13.79	0.60	1.42	46:1	0.30	0.013
Tubing	38	93.00	2.45	1.72	38:1	2.42	0.064
Difference	+15 taps	**6.7× more**	**4.1× more**	**+0.30%**	**17% better**	**8.1× more**	**4.9× more**

Note: Calculations based on 66°Brix

5. Conclusion

This report summarizes field observations showing that maple trees consistently produced higher sap yields and sugar concentrations than black walnut during the monitoring period. However, results from this project indicate that black walnut syrup production is technically feasible under field conditions and that vacuum-assisted systems were associated with greater sap collection efficiency than bucket methods. The tubing system produced approximately 6.7 times more sap and 8 times more syrup than the bucket system, with the most favorable performance for black walnut observed between 6–10 inches of Hg and for maple between 20–26 inches. These observations suggest that vacuum settings may need to be adjusted by species to improve collection outcomes. Although black walnut sap generally contained lower sugar concentrations, the results highlight its potential as a high-value niche product for small-scale and urban agroforestry operations. Further field trials will be important to refine tapping practices, evaluate tree responses under different conditions, and strengthen guidelines for sustainable black walnut syrup production.