Future Generations University

Finding Additional Value in the Black Walnut Trees of Appalachia

Future Generations University Team

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Introduction

Throughout the world, walnut tree species have long been held in high regard, and the predominant native North American species, black walnut or *Juglans nigra*, is considered a prime species for a myriad of reasons. It is native from Massachusetts down to northwestern Florida and as far west as southern South Dakota down to Texas, see Figure 1. While black walnut may be found on a wide variety of sites, it grows best on good sites in the coves, slopes, and well-drained bottomlands of the Appalachian Mountains and the Midwest (Williams 2023). The wood is prized for furniture and cabinetmaking as well as in the production of wooden gunstocks and as a veneer product; it holds such a high value that "Walnut Rustlers" have developed advanced techniques such as the use of helicopters and nighttime operations to remove trees and steal the timber (Dirr 1975).

Plant Culture

Cultivation and Propagation

Habit and Lifecyle

Juglans nigra is a hardwood species that is relatively fast-growing and reaches a medium- to large-mature size. In cultivated settings with appropriate care, it is possible for trees to reach 20 inches in diameter at breast height by the time a tree is 50 years old, though it is notable that annual growth rate in walnuts is not constant and maximum growth happens in early growth and between the ages 40 to 50 years (Williams 2023). Black walnut, whether cultivated or wild-grown, tend to be large trees with typically straight trunks (Goodell 1984). A mature tree can be 75 to 100 feet tall with a canopy spread of 50 feet when grown in the out in the open, see Figure 1 (Williams 2023, Dirr 1975). Walnuts have a definitive tap root when young while also having spreading lateral roots similar to those of a maple, but the specific rooting structure of an individual tree will depend on soil texture and moisture conditions (Williams 2023). Black walnuts have some aesthetic value, though the potential negatives may outweigh the positives. They have a stately form, and the compound leaves create dappled shade, especially the cultivar 'Laciniata' which has leaflets that are finely dissected in a more feather-like manner (Goodell 1984, Dirr 1975). Walnut trees drop their leaves relatively early without a showy display of color and the leaves and decaying nut husks can leave amber stains on concrete, skin, and clothing (Goodell 1984).

Effects on Neighboring Plants

Many members of the Juglandaceae family—walnuts and some hickories—are known to produce a toxic chemical identified as "juglone" which can have an allelopathic effect—a biological phenomenon when one plant produces biochemicals that affect the health of another plant—on neighboring plants attempting to grow within the dripline/root zone of the walnut (Goodell 1984). Black walnuts specifically have the most notorious reputation for this characteristic. Tomatoes, apples, most ericaceous plants (including rhododendrons, mountain laurel, and blueberries), and many conifers are known to be

most adversely affected while many grasses, vegetables and most native hardwoods appear not to be affected (Goodell 1984). Susceptible plants should be located outside of the potential root zone of walnuts if considering interplanting (Goodell 1984).

Propagating

Walnut trees can successfully be grown from seed or transplants/nursery plants, as well as through stump and root sprouting. If growing trees from seed (the nut), stratification—or chilling of the seeds—for anywhere from 90 to 120 days is required for seed germination. However, germination rate increases significantly if stratification is increased to approximately 19 months (Williams 2023). It is worth noting that wild seed and seedlings are rarely equal to cultivated varieties specifically selected for nutmeat production (Goodell 1984). These known cultivars can be grown from seed or grafted with known rootstock and cultivated scionwood and have been cultivated for high nut yields and improved nutmeat to shell ratio as well as thinner shells (Goodell 1984). If desired, a high-quality veneer variety can be grown as root stock and once the seedling reaches over 12 feet in height, scionwood from quality nut-producing variety can be grafted on to the trunk and lateral limbs pruned off (Whipple 2022). While trees with taproots can be more difficult to transplant once established, properly planted young seedlings typically survive well, though they require weed control through the first three years after transplanting (Dirr 1975, Williams 2023). When small trees are cut back or killed by a fire event, the stumps often sprout and can be grown without defect or lasting damage; however, if the sprouts originate higher up on older stumps, the sprouts often develop heart rot or similar decay from the parent stump (Williams 2023).

Figure 1- Large black walnut tree growing along a fence. (Photo credit: E.S. Shipp, USDA PLANTS 2023)

Care

Sun and Soil Requirements

Young walnut trees require at least partial sun but are more successful in full sun; they have been known to survive and thrive under the light shade of black locust (Williams 2023). That may be because of the improved soil conditions supported by the nitrogen-fixing nature of the black locust (*Robinia pseudoacacia*), as interplanting walnut seedlings with locust seedlings has proven to enhance the walnut trees' growth rates (Goodell 1984). Walnuts are common on limestone soils, in well-drained soils along streams, and especially on the deep loam of alluvial deposits and the lowest sections of north- and east-facing slopes (Williams 2023). These soil and topographies are common in the riparian areas of smaller streams found in central Appalachia. If the production goal is syrup production along-side nut collection, it is most advantageous to find an existing stand of native black walnut trees in a moderately sloped area.

Diseases and Pests

Black walnuts are resilient trees with only a few insects and diseases affecting tree health. Defoliation is typically a result of the walnut caterpillar (*Datana integerrima)* or the fall webworm (*Hyphantris cunea)* (Williams 2023). Walnut curculios (*Conotrachelus retentus)* are boring insects that can damage tender growth and cause nut loss (Goodell 1984). Other boring insects that can cause real damage are the ambrosia beetle (*Xylosandrus germanus)*, the flatheaded apple tree borer (*Chrysobothris femorata*,) and the larval stage of the walnut shoot moth (*Acrobasis demotella)*. There is also a walnut lace bug (*Corythucha juglandis)* which is an aphid-like insect that, in both the adult and nymph stages, suck sap from the underside of the leaflets.

The most serious diseases found in walnuts are fungal diseases and while there are only a few, their impact can be significant. The two fungi *Phytophthora citricola* and *Cylindrocladium spp.* are known to cause serious root rot in seedlings in nurseries (Williams 2023). There are three foliage diseases of concern: Walnut anthracnose caused by *Gnomonia leptostyla*, target leafspot caused by *Cristulariella pryamidalis*, and another leafspot disease caused by *Mycosphaerella juglandis* (Williams 2023). There are also currently three stem diseases of concern. These include two types of canker that often occur in the main stem when branches are broken off leaving an open wound: Fusarium cankers caused by *Fusarium spp.* and Nectria canker caused by *Nectria galligena* (Williams 2023). Additionally, Thousand Cankers Black Walnut Disease, which is often fatal within only a few years, is caused by *Geosmthia morbida* and is spread by the walnut twig beetle *Pityophthorus juglandis* (USDA 2023). The Nature Conservancy has created this video resources for identifying Thousand Cankers Disease and other diseases effecting black walnut: https://www.youtube.com/watch?v=Ul7XGvCezXw

Tapping Walnut Trees

Making Walnut Syrup for Fun or Profit

Figure 2 - Jordan Mongold at Mongold's Walnut Farm. (Photo credit: Nikki Bowman Mills, WV Living Magazine)

Introduction

Many people know that it is possible to tap maple trees, boil down the sap and make maple syrup. Maple syrup on pancakes is a classic American breakfast. However, few know that the same is true for other select species of trees. For years, people in the subarctic have tapped birch trees, both boiling the sap to make a sweet syrup and consuming it raw as a health drink. Walnut trees are on the list of select other species suitable for tapping. Members of the *Juglans* genus, black walnut (*Juglans nigra*), white walnut or butternut (*J. cinere*a) and English walnut (*J. regia*) have all been tapped for syrup production.

Each species produces a sap and syrup with unique characteristics and flavor. Although at first thought one might imagine walnut syrup as having that harsh, slightly bitter flavor of the nut, and possibly the allergic reaction many people experience with nuts in general, it turns out that neither is the case. Walnut syrup has been described as having a smooth slightly earthy flavor, getting bolder as the sap flow season progresses. Concerning allergic reactions, research conducted at the Cincinnati Children's Hospital Medical Center (Lierl et.al., 2019) showed that walnut syrup does not contain the allergenic protein causing a reaction in individuals allergic to walnuts.

Walnut syrup is a specialty product, with a special taste, and it is developing a niche market of its own. With a retail price of $7/oz it makes little monetary sense to want to slather it on pancakes (Herby 2022). More often, walnut syrup is blended with other syrups, typically maple, or used in the manufacture of other products to add a unique flavor and increase the market price of those products.

Walnut syrup can be made commercially, but this requires a lot of walnut trees. Accordingly, there are a limited but growing number of commercial walnut syrup producers. It can be made for fun, as a backyard hobbyist, with as few as five walnut trees. As with maple syrup, many people start out as a hobbyist and grow as they "catch the sugaring bug" and find more trees.

A lot is known about tapping maple trees. The University of Vermont's Procter Maple Research Center has been learning and improving maple tapping practices for over 50 years. Much less is known about making walnut syrup; the earliest published study only dates back to 2006. This section of the primer references what is currently known about tapping walnut trees and making walnut syrup. As more studies are conducted on walnut syrup and more people start tapping walnut trees, more knowledge is gained about increasing sap production and processing efficiency. To connect to fellow walnut syrup makers and to add to the collective knowledge, check out the Black Walnut Syrup Makers Facebook page at https://www.facebook.com/groups/2965351326865418

Why Tap Walnut Trees?

Walnut trees have a larger and different range than the sugar maple. Sugar maple is a northern tree, plentiful in New England, eastern Canada, and down the Appalachian Mountain chain at higher elevations and on cool, moist north slopes. Red maple (which can also be tapped) is widely distributed throughout the east. Walnut is not prevalent in the northeast, instead becoming common south of the maple-beech-birch forests of the north. As shown in Figure 3, black walnut is common in the mid-Atlantic states and into the Midwest.

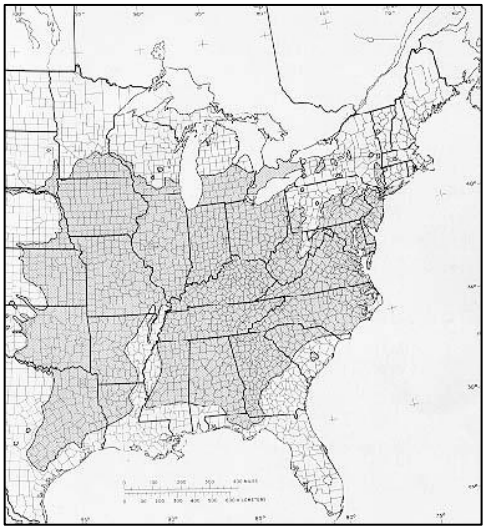

Figure 3 - Black walnut (Juglans nigra) native range. (Image credit: USFS, Williams 2023).

Walnut is a fast-growing tree, and although commonly referred to as a bottomland species, it also thrives higher on the slopes especially on abandoned farmland. As with acorns, the nuts are largely distributed

and planted by forgetful squirrels who make off with the nuts, cache them, then can't remember where they put them. In West Virginia, it is common to find slope side patches of almost monocultural walnut trees on abandoned pasture lands with a heavy grass or brush groundcover. Walnut trees are also prevalent along fencerows, which makes them nicely lined up for running sap collection tubing.

Foresters often pose a slightly different question. They would ask, "Why on earth would someone ever drill a hole in a walnut tree?" That is a good question. Walnut is a high-value timber species. Future Generations University would never recommend tapping a high-value veneer quality walnut log. However, not all walnut trees are high-value veneer quality. If it is sawlog quality, and only the sapwood is drilled, then most—or all—of the tapholes will end up in the slab pile. There are also crooked trees, trees with heavy crowns and short bowls, perfect for tapping but without much timber value, trees along fence lines that might have nails or fence staples in them, or favorite trees one would never think of cutting down but might not mind tapping. One can also tap low on the tree – any cut tree leaves a stump – or tap a low hanging branch. Tapping walnut trees provides an intermediate income while waiting for the tree to mature. It can take 50 or more years to grow a walnut tree with a good sawlog. For those without that much patience, tapping could start at 10 years.

How to Tap Walnut Trees?

Maple tapping has informed practices of walnut and other alternative species of trees, however, walnut trees are a very different species, and researchers and practitioners are just starting to learn how to accommodate that difference when tapping.

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 the tap during the sugaring season. These vessels are diffused, or evenly distributed, throughout the tree's annual growth ring. Walnut trees, however, are classified as a "semi-ring porous" species. They have small, diffused pores like maple, but also large pores – as in true "ring porous" species such as oak and hickory – that are more prominent in the early annual growth or springwood, see Figure 4.

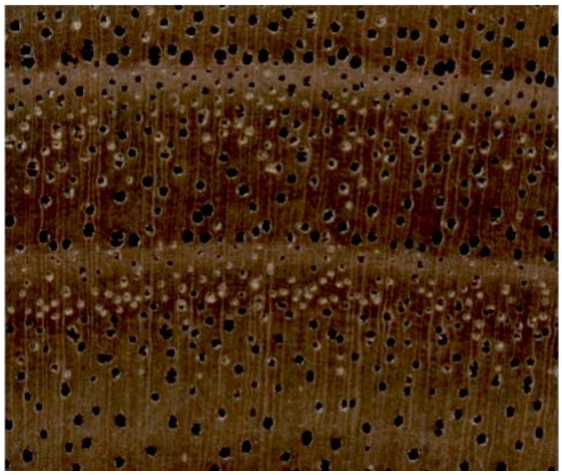

Figure 4 - Walnut heartwood showing vessel structure. (Photo credit: Future Generations University)

Figure 5 - Walnut tree cookie showing heartwood (brown) and sapwood (white). (Photo credit: Future Generations University)

As is visibly apparent when looking at the end of a cut walnut log, walnut trees have a large very dark heartwood area, see Figure 5. This heartwood is the valuable wood in the tree. The heartwood is surrounded with a small outer band of white sapwood. A walnut tree commonly has 11 to 13 annual rings of sapwood: when a new sapwood ring is formed, the innermost sapwood ring begins its conversion to heartwood. Heartwood is dead, whereas sapwood contains dead and live cells. The width of the sapwood layer is propositional to the growth rate of the tree. A fast-growing tree will have a thick sapwood band because each annual ring is thick. Similarly, a slow growing tree will have a relatively narrow sapwood band. This is important because the thickness of the sapwood has been found to be the best indicator of the amount of sap production, thicker sapwood typically results in more sap (Naughton 2006). Studies have found that on the average you can expect to get 2 to 3 gallons of sap/year from a walnut tree, see Table 1.

Table 1- 2020 Walnut season sap production using a gravity bucket system comparing stainless steel (SS) walnut spouts to standard maple spouts (Rechlin et.al., 2020).

Farmer	**SS walnut spouts gal/tap**	**Maple spouts gal/tap**
#1 Christoph Herby	2.8	1.5
#2 Chip Matheny	3.2	1.5
#3 Elton Bowers	3.0	3.2
Average	3.0 gal/tap	2.1 gal/tap

In contrast, a young healthy maple tree can have mostly sapwood, and when tapped can produce over 10 gallons of sap per year.

Sap sweetness is measured in Brix, which is defined as the percent sugar in the sap. The amount of sap needed to make a gallon of syrup finished to 66 Brix, the legal lower limit for maple syrup, is determined through the application of Jones rule of 86 (86 divided by the Brix of the sap = the number of gallons of sap needed to make a gallon of syrup). In West Virginia, numerous studies have shown that walnut sap has been running from 1.5 to 1.0 Brix. This means it takes anywhere from 57 to 86 gallons of walnut sap to make a gallon of walnut syrup.

Finally, maple and especially sugar maple, also called “hard maple” or “rock maple,” is a very hard wood. Walnut is comparatively soft. These anatomical differences from maple – vascular structure, thickness of the sapwood layer, and hardness of the wood – impact how walnut trees are tapped, how much sap can be expected, and how to improve sap productivity.

Future Generations University has been working with walnut syrup producers and studying walnut sap flow since 2018. The tapping and syrup making recommendations that follow are based on that work. The university also draws on other research and the accumulating knowledge of the walnut tapping community.

When to tap

Maple trees are tapped when there is the highest probability of getting the temperature swings (above freezing periods during the day followed by below freezing periods at night, that initiate sap flow. That temperature pattern tends to occur in the waning days of winter and early spring, varying with latitude

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and elevation. Maple sap flows because of a pressure buildup in the trees during that period. The same holds true for walnut, with stem pressure initiating sap flow when tapped. Maple will build up stem pressures exceeding 20 psi. In a study conducted during the 2021 sap flow season it was found that walnut built up to approximately 5 psi of pressure, see Figure 6.

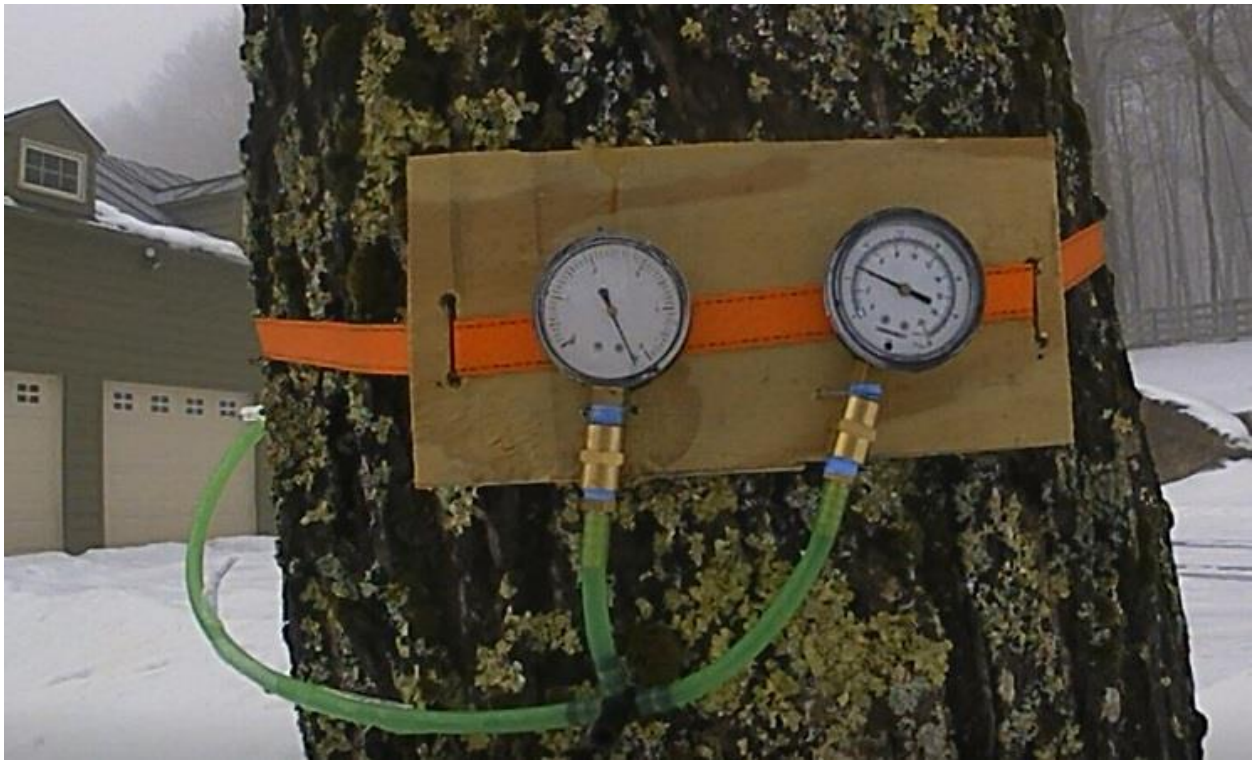

Figure 6 - Pressure gauges on a tapped walnut tree, the left, more sensitive gauge is pegged at 5 pounds and the right gauge reads 4 pounds. (Photo credit: Future Generations University)

To complicate matters, another research team working on xylem pressures in English walnut (*Juglans rigia*) found that walnut trees not only develop stem pressure, but also root pressure (Ewers, et.al. 2000). Root pressure is the mechanism responsible for sap flow in birch trees, where sap flows later in the spring, after the freeze/thaw period. They found walnut root pressure developing in the fall and in the spring, which leaves open the opportunity for walnut sap flow before and after the traditional maple and walnut tapping period. Future Generations University has documented late spring sap flow events, but they tend to be of short duration and when boiled down, yield a syrup that tastes different from that produced by runs from stem pressure (Herby 2022). However, more work is needed before counting out an extended productive sap flow season. Nevertheless, individual producers have reported success in fall tapping.

Depth of the Taphole

Gary Naughton (2006) studied various factors that influence the amount of sap a walnut tree exudes when tapped. His study showed that the best predictor of sap flow was thickness of the sapwood. This differs from maple where the best predictor of sap flow is tree basal area (related to diameter) and proportion to crown size. In maple, larger diameter trees are predicted to yield more sap. However, in walnut trees, sapwood layer thickness is related to tree growth and larger diameter trees are not necessarily faster

growing trees, and therefore not necessarily going to yield more sap. The trees that Future Generations University has worked with tend to have 2-3 inches of sapwood. A walnut tree with a sapwood thickness of 3 inches would be growing close to 0.3 inches of radial growth or almost 2/3 inch of diameter growth per year. That is a fast-growing tree. Trees can be fast growing at different ages; they can be young trees or older, open-grown trees on rich sites.

Standard maple tapping practice has been to drill a 1.5-inch-deep taphole, recent research is suggesting tapholes of 2-inches. In walnut, it is recommended to drill through the sapwood to the heartwood. There is no need to go any deeper, the heartwood is dead and yields absolutely no sap. To do that one must know the thickness of the sapwood of their trees. As a practical measure drill depth is being set at 2.5 inches for walnut trees. It is important to place the drill in a bark crevice. Otherwise, with the thick bark on a walnut tree, an inch of tap length could be used up before even reaching the wood. Reduce the tapping depth if dark brown heartwood shavings are frequently seen.

Spouts, Spiles or Taps (all names for the same thing)

The ideal spout for tapping walnut trees has yet to be developed. In Figure 7, you see a prototype stainless steel walnut spout. Using this spout and modified tapping guidelines, taps are averaging three gallons of sap each.

Figure 7- prototype stainless steel (SS) walnut spout. (Photo credit: Future Generations University)

Figure 8 - Compartmentalization of decay and healing of taphole after one year. (Photo credit: Future Generations University)

Figure 7 shows a 7/16-inch spout with a 3/4-inch longer barrel than the standard maple spouts. In recent years maple syrup producers have switched from 7/16-inch diameter spouts to smaller 5/16-inch diameter spouts called a health spout or a tree saver spout. The smaller diameter spout causes less internal damage to the tree and heals over more quickly. Sustainable tapping guidelines have been developed with the assumption that the producer is using the smaller spout. Future Generations University has a study in progress to develop sustainable walnut tapping guidelines. Initial results, illustrated by Figure 8, indicate that the compartmentalization of decay in walnut results in much less dead wood than in maple, with the taphole sealing over faster due to the faster growth rate of the tree. This may justify the use of the larger diameter spouts.

As shown in Table 1, the prototype 7/16-inch diameter walnut spouts along with revised tapping guidelines led to almost 50 percent more sap. The problem for commercial producers is that these stainless-steel spouts are expensive and heavy for use in the field.

Vacuum

In maple trees the application of vacuum to a tubing system increases sap yields by 5-7 percent per inch of vacuum applied. Research conducted during the 2020 and 2021 sap flow seasons on 20 trees showed that the application of only 8 inches of vacuum doubled walnut sap flow in walnut trees, see Figure 9. Yield also appeared to increase when sap was measured at a commercial walnut syrup producer with 500 plus trees tapped, see Table 2. Here sap flow was greatly increased once the vacuum pumps were installed. It should be noted that Table 2 represents field observations, where many conditions could have influenced sap flow, whereas Figure 9 represents a controlled study. Either way, it seems as if vacuum works to increase sap flow.

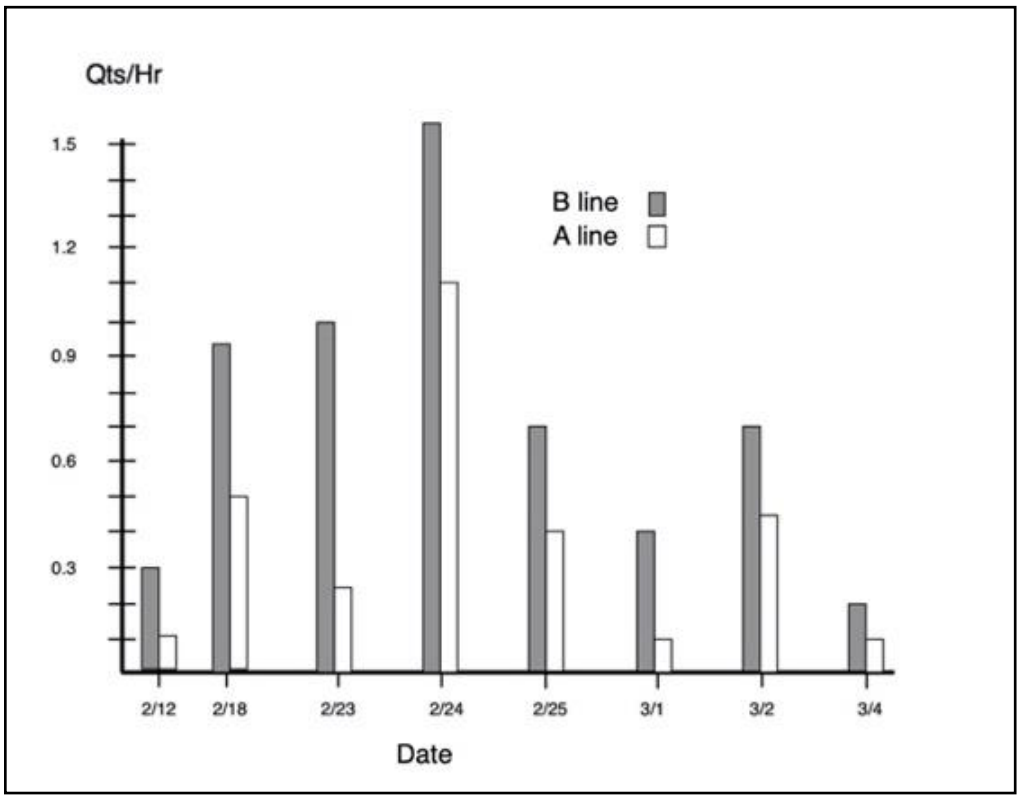

Figure 9 - Controlled study of walnut sap flow Line A – without vacuum, Line B- with vacuum (Rechlin, 2021).

Vacuum can be obtained through a system that uses a vacuum pump and releaser, traditionally using 5/16-inch diameter tubing. Vacuum can also be achieved through a "natural vacuum" system, that relies on elevation change from tree to collection tank, and a tube full of sap to pull the sap out of the tree. The latter is generally achieved in a narrower 3/16-inch tubing system. Some producers combine elements of both, creating a hybrid vacuum system. In a 2021 study, using paired spouts on 20 walnut trees, it was found that when using artificial vacuum 5/16-inch tubing produced 7 percent more sap than 3/16-inch tubing (Future Generations University 2021).

Table 2 - 2022 season sap collection data from commercial walnut syrup producer Gary Mongold, with 500+ walnut trees tapped.

Date	Gal sap	Notes
2/3	110	
2/4	30	
2/8	20	
2/9	80	
2/10	75	
2/11	25	
2/16	100	Vacuum pump on
2/16	100	
2/17	100	
2/20	170	
2/21	150	

However, that leaves the question of whether using "natural vacuum" on 3/16-inch tubing for the collection and augmentation of walnut sap flow is useful. During the 2018 and 2019 sap flow seasons, Future Generations University tried natural vacuum systems with plenty of slope and were not able to develop over 5 inches of vacuum, whereas in maple over 20 inches of vacuum would be expected. During that time, it was noticed that walnut sap has a much higher percentage of gas bubbles in the sap lines compared to maple. Many factors influence the amount of gas bubbles in the sap lines, but in maple the line is primarily full of sap whereas in walnut the sap line is primarily full of gas. It has been the working hypothesis that the excessive gases in the sap are due to the presence of the large pores in the semi-ring porous anatomical structure of the wood (Rechlin, et. al 2019) However, there is another possibility, and that relates to a specific problem with tapping walnut trees.

The Walnut Tapping Problem

Maple, being a hard wood, holds spouts holds spouts tightly if they are properly tapped into the tree. It is unusual to have air leaks on more than 1 percent of spouts. Walnut, however, is different. It is a softer wood with thick bark. Over four years of research, there have been consistent problems with walnut spouts leaking. It's not that they leak sap, but that the spouts do not seal well, causing an air leak in what is a supposedly tight system. Those initially tight spouts that developed vacuum leaks, when tapped in further, sealed well for a while. This is a serious problem for walnut syrup producers. It is impossible to hold a tight vacuum system with leaky spouts. To maintain acceptable levels of vacuum, producers need to spend an inordinate amount of time leak checking their system. Some have noted that by the end of the season some of their spouts are driven in all the way to the back of the taphole. As a spout is driven further into the taphole, more of the vessels that deliver the sap are sealed off, decreasing the sap flow.

Initially, researchers thought the problem was due to sap freezing and backing the spouts out of the taphole, which is something maple tappers have experienced. However, now researchers think the wood surrounding the taphole dries out and shrinks as the season progresses.

At this time the only spouts commercially available have been designed for maple. The present recommendation is to use a maple spout with as much shaft taper as possible; taper is measured as the

change in diameter from the tubing connector end to tip. A more tapered spout should seal better and should reseal without being driven as far into the taphole as a spout with less taper. Currently, Future Generations University research is showing that, of the taps tested, this 7/16 inch tap available from CDL is the least likely to develop vacuum leaks: https://webstore.cdlusa.net/en/716-spout

How to Make Walnut Syrup

Walnut sap boils similarly to maple sap. It starts at 1 to 1.5 Brix, and finished syrup is achieved at 66 Brix. Going from 1percent sugar takes a lot of boiling, meaning a lot of time at the evaporator and a lot of energy to sustain the rapid boil needed to get the job done.

Maple syrup producers have reduced the boiling time needed to make syrup by first concentrating the raw sap in a reverse osmosis machine (RO) consisting of a semi-permeable membrane and a pump. Walnut syrup producers have not been able to use an RO because of the presence of what is a pectin-like goo in the sap.

Pectin-like Goo

Pectin is a long chain, high molecular weight, polysaccharide. The goo found in walnut sap is similar. The Food Science Lab at Virginia Tech has been studying the substance; they have concluded that it is not pectin and are currently referring to it as a pectin-like goo. The problem is that it gums up the pores on the RO's semipermeable membrane, and when trying to filter the final product, it gums up the filter. If the goo isn't removed, valuable walnut syrup can turn into walnut jelly, which has no established market.

Research conducted by Future Generations University, in conjunction with Marshall University and West Virginia State University in 2021, found that this substance could be spun out of walnut sap. A two mL sample spun in a lab centrifuge at 14,500xg for five minutes and produced a visible pellet of a translucent gel like substance that, at that time, was presumed to be pectin (Odell 2021). Further work with a larger centrifuge spinning at 4,700xg for six minutes produced a correspondingly larger pellet. Researchers are in the process of analyzing a composite sample to confirm the presence of pectin. Both these centrifuges were batch processors, spinning a set volume of sample for a defined time.

In the meantime, field tests were conducted with a walnut syrup producer using an off-the-shelf continuous feed "Extreme Raw Power" centrifuge designed for clarifying waste oil and used to remove algae cells from pond water. This centrifuge spun at 2,800xg, and was set to process 1 gallon of sap/minute.

The waste port from the centrifuge drained off a milky substance that was presumed to contain some, but not all, of the pectin-like goo. The final product still contained a substantial jelling agent that had to be filtered out.

The spun sap was then run through a Next Generation single post RO twice and boiled to 66 Brix. Each trial was boiled immediately after concentrating with the RO, see Table 3. Looking at the totals, the 300 gallons of raw sap would have taken 16 hours to evaporate using a 2x4 Next Generation propane fired evaporator with an evaporation rate of 18.6 gallons/hour. Instead, after centrifuging and concentrating to 75 gallons, it only took 4 hours to make the syrup. The fuel cost for the season was $42 per gallon of

syrup produced. Boiling 300 gallons of 1.3 Brix sap would have yielded 4.5 gallons of syrup (Jones rule of 86, as described above). Fuel cost for those 4.5 gallons would be $189. Instead, by concentrating first and only having to boil 75 gallons, the producer used $47.25 worth of propane, or $10.50/gallon of syrup produced.

Table 3 – Walnut sap centrifuged and concentrated with an RO

Date	**Centrifuged sap (gal)**	**Concentrated to (gal)**	**Final concentration Brix**
2/21 +2/22	150	28	4.0
2/23	40	6	3.7
2/27	50	22	4.0
3/1	60	19	5.0
	300 Total	**75**	**4.2 average**

Much of the research cited in this primer, especially work related to tapping walnut, is based on preliminary studies and observations. A sap flow season lasts approximately 6 weeks, and it takes multiple sap flow seasons to substantiate results. Future Generations University and others are committed to continuing this work. There are now three walnut syrup producers with over 500 taps each in West Virginia and Virginia. There is an opportunity to augment the vibrant maple syrup industry in Appalachia with a growing walnut syrup producing industry.

Walnuts for Culinary Use

Harvesting and Processing Black Walnut Nuts

Introduction

Within the right circles, black walnut nuts are considered "black gold" and a "gateway nut" for native Appalachian nut species harvest and processing. Black walnut nuts are oily, sweet, high in protein, and distinct from other nut species because of their unique and robust flavor (Antora 2022). Black walnuts have significant antioxidant and anti-inflammatory properties, and a number of specific cultivars are known to possess antibacterial properties as well (Antora 2022).

Black walnuts also pose a greater challenge to crack and get the nutmeat than other nut types or even when compared to other walnut species. That challenge has increased in *Juglands nigra*'s endemic range since the 1950s because commercial cracking plants have gradually decreased in number and now only one cracking plant remains in operation (Coggeshell 2011). Unfortunately, that plant in Missouri is the closest commercial operation to the Appalachian region as well. Small-scale, local processors such as the Asheville Nuttery in North Carolina will purchase fresh black walnuts before they have been processed, still in shell and husk. Additionally, improved cultivars have changed the potential for renewed commercial black walnut production and processing. Kernel recovery rates, or the volume of harvested nutmeat measured as a percentage of the entire nut, for wild back walnuts are below 15 percent however improved nut cultivars are now yielding over 30 percent kernel (Coggeshell 2011). Whether working with improved cultivars or wild-harvesting nuts, small-scale operations are a realistic option, especially working in a direct-to-consumer market in central Appalachia. Throughout this section, please refence the Equipment, Infrastructure, and Technology lists at the end.

Harvest

Harvest season for black walnuts typically begins in early to mid-fall depending on location and microclimate, which can be especially variable in central Appalachia. Additionally, black walnut trees are alternate bearing, meaning they only produce substantial nut crops some years, and other years they produce few to no nuts at all (Hilgedick 2017). Exact harvest dates year-to-year and location-to-location matter less than paying attention to the status of the husks; harvest should happen as soon as the outer husk begins to soften but is still green, see Figure 10 (Illinois Extension 1999). Another indication of ripeness is the indentation left when the husk is pressed with a thumb (Hart 2017). To ensure a timely harvest, it may be necessary to shake—or dislodge with a pole—mature nuts from the trees (Illinois Extension 1999). In preparation for harvest season, especially when planning to shake, keep grass cut short and other debris cleared from the ground below the walnut trees (Whipple 2022). Depending on the density of the nuts on the ground, they can be collected using a harvesting tool such as the branded "Nut Wizard" or by hand. Once the walnuts are harvested, they should be processed as quickly as possible.

Figure 10 - Walnuts harvested while husks are still green. (Photo credit: Photo Credit: Bruce Marlin Creative Commons Copyright 2.5 Unported, unchanged)

Processing

Processing black walnuts is time and potentially labor intensive. While there are small-scale commercial cleaning machines that can reduce labor input or increase the time efficiency of processing walnuts, they are expensive and are not necessarily designed specifically for black walnuts, which are some of the more challenging tree nuts to process. There are also a number of ways to adapt existing technologies available on a farm/homestead. Future Generations University, in partnership with Bill Whipple of W.T.Farm?, created a how-to video that provides great examples of adaptive reuse of existing resources. Please find that video at https://www.youtube.com/watch?v=U3WcVQ_4fCU&t=5s or look for the "Processing Black Walnuts" video on the Future Generations University Nature-Based Enterprises YouTube channel.

De-hulling, cleaning, and culling

The first step after harvesting nuts off the tree(s) or ground is to remove all of the hull/husk. The volume of walnuts being processed will determine the most appropriate method for removal. At a small-scale, one of the best ways to loosen to remove the husks is to pile them on a driveway and drive back-and-forth over them; the husk will loosen and slip off but the nut's shell will remain intact (Illinois Extension 1999). At a larger scale, a fast-rotating drum with abrasive/knocking surfaces, a means to add running water, and a way for the hull material to wash away can effectively be used to remove the hulls. Bill Whipple has made a dehuller similar to some of the commercial products available on the market. It utilizes the frame, gear system and PTO connection from a lime spreader with a modified 55 gallon steel drum (Whipple 2022). With a garden hose to help wash the loosened hulls off, walnuts are spun around knocking into one another; the angle of the iron bars, which are welded to the inside of the steel drum, provide additional agitation (Whipple 2022). No matter how the hulls are removed, the dehulled walnuts must now be deep cleaned. Again, the best process will be determined by the volume of walnuts being processed.

At the smallest scale, the walnuts in their dehulled shells can be washed in a 5-gallon bucket with water

and agitated against themselves (Illinois Extension1999). To increase agitation to get the shells as clean as possible, a drill with a mixing paddle drill bit can be used. At a larger scale, walnuts can be washed with water in an electric cement mixer; this also decreases the labor input of the washing process (Whipple 2023). The final stage of the process is to test for actual nut meat content. Either before the nuts are removed from a 5-gal bucket with water in it or by dumping them from the concrete mixer into a float trough, assess the nuts for floaters. Any nut that floats likely has insect damage or an improperly developed nut; just toss those out as they do not need to dried, cured, and cracked for the reward of no nutmeat (Hart 2017).

Drying and Curing

Black walnuts must be dried and cured, or aged, for the flavor to properly mellow. They should be dried in a very well-ventilated area and out of direct sunlight for several weeks (Illinois Extension 1999). During the drying and curing process, the nuts can be stored in mesh bags such as those shown in Figure 11, but will also need to be protected from rodents like squirrels and mice (Whipple 2022). On his farm, Bill Whipple has created modular drying and storage crates made from dimensional lumber to make the frames with sides made of heavy-duty rat wire; these crates ensure adequate airflow through his storage bags but also provide the necessary protection (Whipple 2022). The several-week timeline can be challenging when it comes to finishing, marketing, and selling your walnuts. It can be expedited by drying and curing in a warm location such as the loft of a barn or other outbuilding or adding fans for increased ventilation (Whipple 2022).

Figure 11 - Cleaned black walnuts drying and curing in plastic crates stacked inside a crate made of rat wire to protect them from rodent damage during the curing process. (Photo Credit Future Generations University)

Shelling

Black walnuts are known to be some of the toughest nuts to crack. Hand-held, plier-type nutcrackers are rarely up to the task and while a block of wood or a vise and a hammer plus safety glasses will work, if any measurable number of walnuts are being shelled, this is just simply not a practical approach. There are several different styles of specialty nutcrackers designed to crack walnuts end to end and are more likely to keep the kernel more intact (Illinois Extension 1999). Please see the list of specialized

nutcrackers listed below. This list demonstrates several different styles. There are other products available on the market, but these particular options have been researched specifically considering the challenges of black walnuts. Shells can be pre-conditioned for easier cracking as well. Soak the nuts in water for an hour or two, drain, and then store overnight in an airtight container; if the shells are still brittle, soak again in warm water for just a bit before cracking (Illinois Extension 1999). After cracking the shells and removing the kernels, allow the nutmeat to dry for a day before refrigerating (Illinois Extension 1999). Shelled walnuts can be stored in an airtight container in the refrigerator for up to nine months and can be kept fresh in the freezer for up to two years (Hart 2017). To store at room temperature, the nuts should be baked for 10 to 15 minutes at 215º F first (Hart 2017). If walnuts will be sold to the public, it is advisable to bake the nutmeats so that they are stable at room temperature.

Equipment, Infrastructure, and Technology

Future Generations University does not specifically endorse any of the following products. They are examples of products available on the commercial market that Future Generations University researchers and research partners have found to be effective when working with black walnuts. The nutcracker list does include several different styles of nutcrackers designed specifically with black walnuts in mind. Reference to any specific commercial products does not constitute or imply a recommendation on behalf of the U.S. Department of Agriculture (USDA), Forest Service, or the National Agroforestry Center.

Harvesters, Nut Collection

- Large Nut Wizard
  https://www.lehmans.com/product/nut-wizard-tools
- 18” Walnut Harvester
  https://baganut.com/product/18-push-black-walnut-harvester/

Processing

Washing

- Nut Technology Peeling and Cleaning Machine
  https://nuttechnology.com/product/green-walnut-peeling-machine-60-l/
- Small Portable Electric Cement Mixer – there are other brands available on the market, this is just one example, shop around for good pricing OR search for a used mixer on various buy/sell/trade platforms.)
  https://www.northerntool.com/products/klutch-portable-electric-cement-mixer-4-25-cu-ft-drum-58271
- Small-scale hand washing alternative with a 5-gallon bucket, a joint compound mixing paddle for use with a power drill – this is just one example of a functional product.
  https://www.homedepot.com/p/Wal-Board-Tools-24-in-Aluminum-Power-Joint-Compound-Paint-Mixer-for-Fast-Mixing-043-001-HD/100390691

Storage and Curing

- Bag-a-Nut
  https://baganut.com/product/burlap-bags/

Nutcrackers

- Get Crackin'
  https://gardenharvesters.com/Item/GHGetCrackin
- Granpa's Goody Getter
  https://www.grandpasgoodygetter.com/products/black-walnut-nut-cracker
- Master Nut Cracker, made in USA
  https://thebirdtoystore.com/master-nut-cracker-1/
- Quality Nut Cracker, Canadian-made and stainless steel
  https://www.nutcrackernursery.com/nuts-stratified-seeds-other-products.php
- Duke Black Walnut Nutcracker (not to be confused with the lighter weight Duke Pecan Nutcracker)
  https://www.grimonut.com/index.php?p=Products&category=nutcrackers

Marketing and Sales

Marketing black walnuts provides a unique opportunity in Appalachia because the trees are native, have long been a part of the cultural cuisine, and can be wild-harvested/foraged without significant environmental impact. Walnuts can be sold direct-to-consumers at farmers' markets or through online options such as a farm's website or even other online platforms like Etsy, which support small businesses. Additionally, they can be sold through consignment avenues to local food markets and retailers. Direct-to-consumer sales will bring in greater revenue but will also require more time. Currently, black walnut nutmeat is selling in the commercial market for a retail rate of $15.00 per pound and through specialty direct-to-consumer outlets for upwards of $35.00 per pound. However, they are more typically sold in volumes smaller than one pound. Consider packaging that offers multiple sizes and in which the walnuts can be at least partially visible so that the consumer can easily see what they are getting and better appreciate the value of their purchase.

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