



Commercial Chinese Chestnut Production in Virginia

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Introduction

The mighty American chestnut tree (*Castanea dentata* [Marsh], Borkh.) was once a dominant figure in hardwood forests throughout the eastern United States. An iconic source of food, chestnuts were sold by the ton every year, until the chestnut blight nearly brought this tree crop to extinction in the early to mid-20th century. Although this nut has disappeared from the American diet (Wahl 2002), consumer interest and demand is on the rise once more and the opportunity for commercial Chinese chestnut (*Castanea mollissima* Blume) production in Virginia is increasingly apparent (Gold, Cernusca, and Godsey 2006; Aguilar, Cernusca, and Gold 2009; Cernusca, Aguilar, and Gold 2012). This publication serves as a “how to” guide for establishing, maintaining, harvesting, and marketing chestnuts in Virginia. Recommendations are based on interviews and orchard visits with established regional chestnut growers and researchers, as well as a literature review of publications pertinent to chestnut production in the United States. Additional resources highlighted in this publication include nurseries, grower networks, design templates, management calendars, and enterprise budgets.

Establishment

Site Selection and Preparation

The first and most important step for chestnut orchard establishment is choosing a well-suited site. If an incompatible site is chosen, the orchard’s survival and vigor will be compromised.

Chestnuts require sandy-loam soils with a pH of 5.5-6.5 and full sun for optimal nut production. Planting sites should be located on or near a ridge-top to ensure adequate drainage and protection from frost (Hunt et al. 2012).

To prepare the site, it is crucial to first control weed competition, especially perennial species. A combination of rotational crops, cultivation, and herbicides are most effective. Rotate and mix approved herbicides to control for a broader spectrum of weeds. Use a boom sprayer to ensure uniform herbicide application in the fall when grasses are at least 8 inches tall (Masabni et al. 2007). A subsoil plow set at 36 inches deep can be used to turn up the soil, followed by disking to loosen large soil clumps, and finally a box blade to level the ground for planting.

Orchard Spacing

There are a variety of spacing options for chestnuts depending on orchard objectives. If space is limited and high early yields are desired, chestnut trees can be planted at a 20-30 foot by 20-30 foot spacing. As tree branches begin to touch around year 15, the orchard should be thinned to every other tree to reduce shading and overcrowding, which causes lower branches to die (Hunt et al. 2012).

If minimizing labor is desired, chestnut trees should be planted at a 40-by-40-foot spacing (Figure 1). This diminishes high early yields, but reduces the need for thinning and excessive pruning.



Figure 1. Chestnut Spacing at 40 by 40 feet.
(Photo by Priya Jaishanker)

Planting Stock

Chestnut planting stock is available in many forms, although **grafted containerized trees** can be the quickest way to establish an orchard for commercial nut production. Planting stock is expensive, at \$17-\$40 per tree depending on the size, but production begins only two to three years after planting, with chestnut production increasing up to 2,000 pounds per acre by year 12-15 (Hunt et al. 2012). Grafted cultivars offer the predictability of yield, nut size, color, quality, time to production, and ripening times (Payne, Jaynes, and Kays 1983).

However, delayed graft failure can occur if the scion and rootstock are not compatible. This is especially true for American X Chinese hybrids. To increase grafted tree survival, ensure the scion and rootstock are both from the same cultivar (Masabni et al. 2007), and nurseries use a modified two-flap graft in spring as bud break begins (R. Stehli, personal communication, May 9, 2015).

Bare root seedlings with known mother cultivars should be planted in the spring to reduce winter injury. Since the father tree often remains unknown, seedlings offer less predictability than grafted trees. However, hardy seedlings are found in the majority of commercial chestnut orchards in the U.S. today, with high survival rates reported. With an average cost of \$4-\$8 per tree for 1- to 2-year-old seedlings, startup costs remain low (G. Miller and R. Stehli, personal communication, May 9, 2015). Scion wood from recommended cultivars can be field-grafted on 1- to 2-year-old seedlings, with nut production following in one to three years (Hunt et al. 2012). Excessive

Recommended Cultivars

- **Gideon.** Spreading, cold hardy Chinese cultivar that produces attractive, easy to peel, uniform nuts that average 28-39 nuts per pound. Nuts are harvested beginning early October (Hunt et al. 2012), with high, reliable yearly yields even in sub-optimal weather (H. Craddock, personal communication, Feb. 25, 2015).
- **Sleeping Giant.** Chinese-Japanese-American hybrid cultivar that produces an attractive and flavorful light brown nut of excellent quality. With an early harvest occurring the last week in August of roughly 28-35 nuts per pound, this cultivar can sometimes produce a second harvest in October (H. Craddock, personal communication, Feb. 25, 2015). This large upright tree is often grown for timber, as well (Hunt et al. 2012).
- **Shing.** Vigorous high-yielding Chinese cultivar that produces misshapen but good-tasting nuts. Its large upright form also makes it suitable for timber production (H. Craddock, personal communication, Feb. 25, 2015).

rainfall after grafting and poor site conditions can increase tree stress that leads to graft rejection (R. Stehli, personal communication, May 9, 2015).

Seeds

Seeds are the most cost-effective option for orchard establishment. Stratified nuts from recommended parent cultivars can be purchased for \$14 for 35 nuts. When known cultivars are the parent trees, these seeds offer the same predictability as grafted trees, but with increased delay of nut production and associated profits (G. Miller and R. Stehli, personal communication, May 9, 2015). Seeds should be planted 2 inches deep in plowed rows in the fall within tree tubes or tin cans to suppress wildlife pressure (Masabni et al. 2007).

Chinese Chestnut Nurseries

Empire Chestnut Company: 3276 Empire Road SW, Carrollton, OH 44615, 330-627-3181, empirechestnut@gmail.com, http://empirechestnut.com

Forrest Keeling Nursery: 88 Forrest Keeling Lane, Elsberry, MO 63343, 800-FKN-2401, info@fknursery.com, http://fknursery.com

Nolin River Nut Tree Nursery: 797 Port Wooden Road, Upton, KY 42784, 270-369-8551, john.brittain@windstream.net, http://nolinnursery.com

Maintenance

Fertilization

Adequate nitrogen is important for good annual tree growth of 18-24 inches in young trees and 12-15 inches in fruiting trees (Hunt et al. 2012). To achieve this, apply nitrogen within the drip line of each tree at a rate of 0.1 pounds multiplied by the age of the tree, divided by the active ingredient percentage in the fertilizer (for example, divide by 10 if the fertilizer's active ingredient percentage for nitrogen is 10 percent). Split this calculated rate into two applications, one prior to bud swell and one towards the end of flowering.

Alternatively, if organic matter rates are below 4 percent, blood meal can be applied within the drip line during tree establishment to quickly release nitrogen. Moderate levels of slow release nitrogen are also available from alfalfa straw and meal, compost and manures, feather meal, fish emulsion, and cottonseed meal. Clover, beans, and peas can also be grown prior to establishment and turned into the soil as a green manure crop (Barney 2013).

If the site has a high pH, elemental sulfur can be applied to moist soil to lower pH levels (Barney 2013). Lastly, if zinc levels are low, zinc sulfate can be sprayed on foliage after pollination and two additional times two and four weeks later. For soil application, zinc chelate 10% can be applied in conjunction with liquid fertilizers in ammonium phosphate or nitrogen solutions (Masabni et al. 2007). Soil tests should be done regularly to determine annual soil amendment needs and appropriate application rates.

Pruning

Although mature trees involve very little pruning, young trees require some training to ensure proper structure. Stake young trees to train upright growth and a central leader structure.

Once production begins, low limbs should gradually be pruned so an orchard mower and sprayer can maneuver around each tree (G. Miller and R. Stehli, personal communication, May 9, 2015). Weaker branches should also be pruned to avoid breakage during heavy fruiting, ice, and snow (Hunt et al. 2012). For information on pruning, see VCE Publication 430-456, *A Guide to Successful Pruning, Pruning Deciduous Trees*.

Weed and Pest Control

Active weed control using a program of integrated techniques is especially important before planting and in the first three years for successful tree establishment. A decrease in yield and nut quality can result if competition is allowed to persist (Rowley et al. 2011). During the growing season, frequent mowing in rows and in between trees will combat competition temporarily. However, mowing should be combined with other techniques for best control.

Integrated Pest Management is a preferred strategy for reducing pest damage. Hong and Day (2017) define IPM as an ecological approach to pest control, based on the life cycle and habitat of the pest. Producers should consider IPM for managing pests in alignment with the tree and site conditions.

Tillage

Soil tillage is a common weed management technique used in commercial orchards. This effective method not only reduces weed competition, but also rodent habitat. Tillage during the winter months will reduce potential negative impacts, such as root damage and loss of organic matter (Granatstein and Sánchez 2009). Using precision equipment, tillage treatments can average \$114 per acre annually (Granatstein, Andrews, and Groff 2014). Operators should take care when tilling because it can alter soil structure and increase risk of erosion.

Flaming

Steam and flame weeding have been found to control 95 percent of weeds one week after application, with suppressive effects remaining for up to three to four weeks (Shrestha, Moretti, and Mourad 2012). As a result, treatments, averaging \$14 per acre for propane, should be applied monthly for best control (Granatstein, Andrews, and Groff 2014).

However, care should be taken not to damage trees during treatment. Since flame and steam are less effective at combating mature weeds and perennials, it may be best to begin treatments early on in the season before weeds mature (Granatstein and Sánchez 2009).

Synthetic Herbicide

Herbicides are an effective weed control method, but not a cure-all as many only target selective weeds. As such, it is important to not only integrate herbicide applications with other weed control methods, but also mix two or more approved herbicides to target a wider spectrum of weeds.

There are a variety of approved synthetic herbicides for chestnuts. Pre-emergent herbicides include: Goal 2XL, Prowl 3.3EC, Sandea 75DF, and Surflan 4AS. Post-emergent herbicides include: Aim 2EC, Amine4, Gramoxone, MSMA-6 Plus, Poast 1.5EC, Recoil 3.2E, and Select 2EC. These herbicides should only be mixed if approved on the product label.

To avoid injuring trees during application, a boom sprayer should be used for precise and uniform spraying. Caution should also be taken to stay within the recommended annual application rates (Masabni et al. 2007). For more information on synthetic herbicides, see the University of Kentucky Cooperative Extension Publication ID-77, Nut Tree Growing in Kentucky.

Organic Herbicide

If operating an organic orchard, there are only a handful of approved herbicides, including acetic acid, lemon grass oil, and clove oil. Unfortunately, they are considerably more expensive than conventional herbicides and are not consistently effective in controlling weeds unless applied frequently and at a high rate (Rowley et al. 2011).

D-limonene, for example, has effectively controlled 95 percent of weeds within the first week of application, but needs to be reapplied every five to six weeks for continuous weed control. At \$111/acre, this can add up quickly (Shrestha, Moretti, and Mourad 2012). If applied broadly, rather than in spot treatments, acetic acid can cost up to \$144 per acre; lemon grass oil, up to \$130 per acre; and clove oil, up to \$171 per acre. To reduce costs, it is recommended to apply herbicide in spot treatments in conjunction with mulch (Rowley et al. 2011).

Mulching

Mulching can significantly increase tree growth and productivity by suppressing weeds, retaining moisture, and adding nutrients. Wood chips, for example, have been shown to suppress weeds for up to three years, while also decreasing watering needs. Similarly, hay and straw mulch has been shown to increase fruit size (Granatstein and Sánchez 2009) and effectively suppress weeds (Rowley et al. 2011). Since chestnuts prefer a slightly acidic soil, local sources of pine straw or wood chips could be gathered and used as a free source of mulch. Grass, alfalfa, or legumes within the alleyways can also be mown and dispersed into the tree rows as a free, on-farm mulch and a source of nitrogen (Granatstein and Sánchez 2009).

Still, there are several limitations of mulch to consider. It's important to lay mulch down prior to weed development and select mulch free of weed seed. Even then, however, wind- or tractor-carried seeds can grow within the mulch, making it necessary to supplement with spot applications of herbicides (Rowley et al. 2011). Mulches can also unintentionally create ideal vole habitat, and too much water retention can lead to *Phytophthora* root rot (Granatstein and Sánchez 2009).

If purchased, mulch can become expensive; up to \$239 per acre of straw and \$717 per acre of wood chips. This can add up if reapplied every one to two years, which is required for best results. The affordability of mulch will largely depend on availability of local and free resources (Rowley et al. 2011).



Figure 2. Deer Fencing. (Photo by Priya Jaishanker)

Pest and Disease Control

Deer have been known to kill young trees due to browsing and antler rub, and reduce harvest yields as much as 600 pounds per acre (R. Stehli, personal communication, May 9, 2015). As a result, 8 foot woven wire fencing with an electric strand on top should be installed to keep deer out of the orchard (Figure 2). Materials for fencing cost approximately \$1,992 per acre, but provide long-lasting benefits (M. Gold, personal communication, Feb. 24, 2015).

Small and large chestnut weevils are the most common insect pests. They surface from the soil and oviposit eggs inside of the chestnut where larvae feed on the nut. Once mature, the larvae will leave the nut and return to the soil, where they will emerge one to three years later to restart the cycle. This makes them one of the most devastating pests to commercial nut production. Fortunately, populations were dramatically reduced as a result of the chestnut blight (Hunt et al. 2012). If an infestation does occur, however, it is essential to stop the cycle by quickly harvesting fallen nuts before weevils hatch and burrow into the soil once more (Keeseey and Barrett 2008).

Synthetic or organic pesticides can also be applied to control for weevils. Pyrethrin, a primary compound

in Pyganic, is a useful organic control (R. Stehli, personal communication, May 9, 2015). The registered synthetic insecticide, Sevin, can also be applied for four weeks straight starting in late July (Masabni et al. 2007).

Potato leafhoppers emerge in late spring and prey on the veins of leaves. The result is leaf deformation and defoliation that reduces nut yield and quality (Hunt et al. 2012). Registered synthetic pesticides, such as Imidan and Sevin, are effective at combatting leafhoppers (Masabni et al. 2007). Organic pesticides, such as Pyganic and Neemix, and insecticidal soaps can also be applied to the foliage (R. Stehli, personal communication, May 9, 2015).

Oriental chestnut gall wasp was accidentally introduced to Georgia and has since made its way to Virginia. Eggs are deposited into chestnut buds, forming galls (Figure 3) that disrupt shoot growth and survival (Hunt et al. 2012). Death can result in young trees, while yield can be reduced as much as 50-75 percent in mature trees for several years (Payne, Jaynes, and Kays 1983). Biological control from parasitic wasps, which are present in Virginia, is the only known form of control (G. Miller, personal communication, May 9, 2015).



Figure 3. Galls from Chestnut Gall Wasp.
(Photo by Priya Jaishanker)

Phytophthora root rot is a devastating disease that attacks and kills roots, spreading underground from one tree to the next. It is recommended to purchase trees from a single nursery source free of root rot. A combination of gypsum and chicken manure have been found to reduce root rot in evergreens, and is now being tested on chestnuts (R. Stehli, personal communication, May 9, 2015).

Harvest

Chinese chestnuts will drop nuts for a two- to four-week period from September through November (R. Stehli, personal communication, May 9, 2015). Exact timing depends largely on the weather and cultivar. Chestnuts can be harvested using two methods — manual and mechanical — depending on orchard size.

Manual Harvest

Manual harvest may be manageable for orchards under 3 acres (D. Fulbright, personal communication, March 10, 2015). One person can harvest up to 30 pounds of chestnuts in one hour. With an average payment rate of 36 cents to 50 cents per pound and mature yield at 1,500-2,000 pounds per acre, manual harvest costs average \$753 per acre (G. Miller, personal communication, May 9, 2015).

Alternatively, a manual nut-harvesting tool called the Nut Wizard can be purchased for only \$65. It has the ability to harvest a mature acre of 2,000 pounds for \$600 with labor costs at \$8 per hour (Warmund, Biggs, and Godsey 2012). Since chestnuts have high water content, they should be harvested every other day to prevent rot and predation from wildlife (G. Miller, personal communication, May 9, 2015).

Mechanical Harvest

As an orchard reaches 25 acres and up, high-volume nut production makes manual harvest impractical for those without an adequate labor force. Instead, mechanical chestnut harvesters can be purchased. Although the Italian FACMA Vacuum Harvester costs anywhere from \$65,000-\$80,000 depending on the model, it can harvest 8,000 pounds of nuts daily and has the ability to separate burs from nuts (Figure 4) (D. Fulbright, personal communication, March 10, 2015).



Figure 4. Harvestable chestnuts in the bur.
(Photo by Priya Jaishanker)

Greystone Vacuums offers a more affordable Maxi Vac (Figure 5) for \$4,700, which can harvest approximately 17,600 pounds of nuts in 340 hours for \$4,622 with labor costs at \$8 per hour. This vacuum does not sort burs and debris from the nut, so labor requirements post-harvest increase. Since harvesting



Figure 5. Greystone Vacuum's Maxi Vac on a raised trailer.
(Used with permission from Warmund (2012, fig. 1 B).

can account for half of the operating costs of a chestnut orchard, it's important to consider availability of labor and the time efficiency and costs of various harvest methods (Warmund, Biggs, and Godsey 2012).

Post-Harvest Handling

Harvested chestnuts should immediately be placed into a hot water bath (Figure 6) at 118 degrees Fahrenheit to kill weevils (G. Miller, personal communication, May 9, 2015). After washing, chestnuts should be air dried, placed into sealable bags and stored in the refrigerator at 32 degrees for up to three months (Warmund 2011). Since water decreases the sugar content of chestnuts, they should be held for at least 10 days post-harvest before selling to recover the sweetness (R. Stehli, personal communication, May 9, 2015).



Figure 6. Hot water bath (right).
(Photo by Priya Jaishanker)

Market

Consumer Preferences

Understanding consumer awareness of and preferences for chestnuts is critical for successful marketing ventures. Beyond its popularity in Asian markets, chestnuts are generally not well known among consumers; particularly, their nutritional benefits, where to purchase them, and how to store and cook them (Gold, Cernusca, and Godsey 2005). In one study, the majority of participants had previously purchased chestnuts and were familiar with roasting them. However, most were unfamiliar with how to cook with them and consumed them less than once a year (Cernusca, Aguilar, and Gold 2012). Outreach events, such as the Missouri Chestnut Roast, have been linked to increased chestnut interest,

consumption, and awareness over time (Cernusca, Gold, and Godsey 2008), but more consumer education is needed throughout the U.S. to increase the success of chestnut businesses (Gold, Cernusca, and Godsey 2006). Growers who direct market could benefit from providing educational information about chestnut nutrition, storage, and preparation to consumers, as enhanced purchase satisfaction has been shown to encourage continued purchases (Cernusca, Aguilar, and Gold 2012).

A variety of other studies have been conducted to determine U.S. consumer preferences for chestnuts, which can also be used to guide successful marketing (Wahl 2002, Kelley and Behe 2002; Smith et al. 2002; Gold, Cernusca, and Godsey 2004, 2005; Aguilar, Cernusca, and Gold 2009; Cernusca, Aguilar, and Gold 2012). In one study, "locally grown" labels, followed by medium to large chestnut sizes and organic certification influenced chestnut purchases the most, while price had the least impact (Aguilar, Cernusca, and Gold 2009). Another study found that consumers are willing to pay more for chestnuts produced from a cultivar with a brand name and organic certification (Gold, Cernusca, and Godsey 2004, 2005). Studies on upscale restaurants found a preference for fresh, high-quality value-added chestnut products (Wahl 2002) and peeled chestnuts among chefs (Kelley and Behe 2002; Smith et al. 2002).



Chestnuts ready for market.
(Photo by Priya Jaishanker)

Market Outlets and Prices

Most chestnuts in the U.S. are sold locally, with on-farm sales the most preferred, followed by upscale grocery stores, farmers markets, distributors, and restaurants. The price range within each market outlet varies drastically, with locally grown, organic chestnuts produced from cultivars and advertised with a well-known brand name obtaining the highest price tag.

Restaurants pay the highest price for chestnuts at \$2 to \$7 per pound, followed by health food stores at \$2 to \$6 per pound, online customers at \$1.85 to \$6 per pound, on-farm sales at \$1.50 to \$6 per pound and farmers markets at 75 cents to \$6 per pound (Gold, Cernusca, and Godsey 2006). The University of Missouri Center for Agroforestry's Chinese Chestnut Decision Support Tool can be used to determine nut production costs and profit. Ultimately, however, growers will need to assess the best marketing outlets and prices for their area, as market knowledge is a key ingredient to a successful business (Gold, Godsey, and Josiah 2004).

Conclusion

High commodity prices, increasing consumer demand, and relatively low startup costs make commercial chestnut production an appealing venture (Gold, Cernusca, and Godsey 2006). Compatible site selection coupled with recommended maintenance can produce a healthy orchard ripe for picking. With a sufficient understanding of consumer preferences for and awareness of chestnuts, growers can develop targeted marketing plans geared toward fruitful sales and business success.

This publication can be used as a guide for establishing, maintaining, harvesting, and marketing a Chinese chestnut orchard for commercial nut production. If crossbreeding efforts are successful, this guide could also be used for an American chestnut orchard in the future.

Acknowledgements

The authors would like to thank Adam Downing, Virginia Cooperative Extension; John Seiler, Virginia Tech; Hill Craddock, University of Tennessee, Chattanooga; and Matt Brinckman, formerly with the American Chestnut Foundation, for their invaluable assistance in the review and revision process. We would also like to thank Greg Miller, Empire Chestnuts; Robert Stehli, Wintergreen Tree Farm; Michael Gold, University of Missouri, Center for Agroforestry; Dennis Fulbright, Michigan State University; and Hill Craddock, University of Tennessee, Chattanooga, for sharing their in-depth knowledge on chestnut production. Without their valuable experience and research, this publication would have not been possible.

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