UNIVERSITY OF MISSOURI CENTER FOR AGROFORESTRY

# GROWING AND MARKETING CHINESE CHESTNUTS

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Chinese chestnut (*Castanea mollissima*) is an emerging tree nut crop for Missouri and throughout the eastern half of the United States. Chestnut cultivation for nut production in the Midwest and eastern U.S. is accelerating, with the number of farms increasing 57% between 2012 and 2017, and more than 600 orchards reaching bearing age (USDA, 2018).

The Chinese chestnut tree is a spreading, medium-sized tree with glossy dark leaves bearing large crops of nutritious nuts. Nuts are borne inside spiny burs that split open when nuts are ripe. Each bur contains one to three shiny, dark-brown nuts. The nut shells are "scored" then microwaved, roasted or boiled to help remove the leathery shell and papery seed coat, revealing a creamy or golden-colored nut meat. Chestnuts are a healthy, low-fat, gluten-free food ingredient that can be incorporated into a wide range of dishes – from soups to poultry stuffing, pancakes, muffins and pastries (using chestnut flour, see "Why Chestnuts" guide). Historically, demand for chestnuts in the United States has been highest in ethnic markets (European and Asian, for example) but as Americans search for novel and healthy food products, chestnuts are becoming more widely accepted.

The University of Missouri Center for Agroforestry (UMCA) conducts a multi-state participatory chestnut breeding program focused on the improvement of chestnut into a profitable orchard crop for nut production in the Midwest and eastern U.S. There are multiple field studies, including an expanding germplasm repository currently with 65 cultivars, a yield trial with 8 cultivars, and a commercial production orchard and seed orchard composed of three cultivars that have been evaluated in replication at the UMCA's Horticulture and Agroforestry Research Center (HARC) in New Franklin, Mo. Chestnuts are an exciting high-value option for growers to consider that can add valuable diversity to the agroecological landscape. However, their successful cultivation requires a solid understanding of the tree's biology, management requirements, and limitations.

*Chinese chestnut is a medium-sized tree with spreading habit and is covered with burs filled with nuts stretching from September into October in Missouri.*

## Chestnut Species

Three Castanea species are native to the U.S. – American chestnut (*C. dentata*), Allegheny chinkapin (*C. pumila var. pumila*), and Ozark chinkapin (*C. ozarkensis*), but all three are highly susceptible to chestnut blight and phytophthora root rot. In fact, the devastation caused by chestnut blight (*Cryphonectria parasitica*) stem cankers and phytophthora root rot (*Phytophthora cinnamomi*) has reduced American chestnut from a major timber species to a rare understory tree often found cankered in sprout clumps. Major efforts are ongoing to breed genetically diverse, disease-resistant populations of the American chestnut to restore it as a forest tree (see www.acf.org/). The Allegheny and Ozark chinkapins are multi-stem shrubs to small trees that produce small, tasty nuts and make interesting (but blight susceptible) landscape trees that are also valuable for wildlife.

Three species of chestnut provide the basis for worldwide chestnut production—Chinese chestnut (*Castanea mollissima*), European chestnut (*C. sativa*) and Japanese chestnut (*C. crenata*). Chinese chestnuts are a medium-sized (40 ft.) tree, often multi-branched and wide spreading with good cold hardiness (-20 °F), and adequate tolerance to chestnut blight and phytophthora root rot. Of the three species, Chinese chestnut is best adapted for Missouri and the surrounding states.

The European chestnut is a larger, wide-spreading tree (65 ft.), but it is generally too susceptible to chestnut blight and phytophthora root rot to grow east of the Rocky Mountains. It is also not as cold hardy as the Chinese chestnut. Most chestnuts found in U.S. grocery store chains are European chestnuts, imported primarily from Italy.

The Japanese chestnut is a small- to medium-sized tree (35 ft.) with some phytophthora root rot resistance, but it lacks the chestnut blight tolerance and winter hardiness of the Chinese chestnut. European and Japanese chestnuts are grown commercially in West Coast states where chestnut blight is not as pervasive and the climate is milder. Chestnut species hybridize freely, resulting in many selected hybrid cultivars that have combinations of desirable traits from multiple chestnut species.

At the UMCA HARC chestnut germplasm repository, EST-SSR markers (DNA finger-printing) have been used to verify the identity of grafted cultivars and accessions residing in the collection (McCleary et al., 2013). Descriptions of individuals in the collection are published in Revord et al. (2021). Updated information and data on the repository is maintained on ChestnutImprovementNetwork.org.

A majority of the collection is comprised of Chinese chestnut cultivars, which is generally considered the species of greatest relevance to breeding and commercial production in the Midwest region. Some cultivars with features similar to those of pure Chinese chestnut have other *Castanea* species with their genetic backgrounds. A number of complex hybrids (combinations of Chinese x Japanese x European x American) are maintained at HARC in New Franklin, MO. Long-term observations have shown that these complex hybrids offer the opportunity to combine the unique characteristics respective to each species into single offspring, which can greatly increase the yield of nut production, such as male sterility, nut size, and abiotic/biotic tolerance. At present, some of the existing complex hybrids suffer from severe chestnut blight susceptibility and frost susceptibility.

## Site, Soil & Water Requirements

Chinese chestnut trees perform best in well-drained, loamy to sandy loam soils. Heavy, poorly-drained soils or soils that have a perched water table during wet seasons promote phytophthora root rot, a devastating disease of chestnuts.

Soils should be slightly acid (pH 5.5-6.5). Most Chinese chestnuts can tolerate -20 °F temperatures when fully dormant, but it is strongly recommended that frost pockets be avoided as planting sites to avoid injury to vulnerable swelling and emerging buds in the spring. Similar to the requirements for peaches, sites should be selected where summit and shoulder slopes allow for good air drainage, would be the best choice to safeguard from winter and early-spring frost injury.

Chinese chestnut trees are rather drought tolerant once established, but ample water throughout the growing season promotes good tree growth and regular nut production. Maximum chestnut yields and nut size are obtained only under optimum soil water conditions; therefore, irrigation is recommended both for the orchard establishment years (years 1-4) and during years of commercial production. During bearing years, a lack of water in mid-August will result in smaller nut size, while a lack of water in September can prevent burs from opening normally. Micro-irrigation techniques (drip and/or micro-sprinklers) are best suited for chestnut orchards.

## Flowering, Pollination, and Fruit Development

Flower buds are initiated during late summer on shoot growth above the developing burs. During the following spring, new shoots emerge from these buds with catkins appearing midway along the shoot (Figure 1). Chestnuts produce two types of catkins: catkins with only male, pollen-producing flowers (staminate catkins) and catkins that contain both male and female inflorescences (bisexual catkins). The first few (basal) catkins are staminate catkins, producing pollen around 10 weeks after bud break. The last (most distal) catkins to develop along the current season's growth are bisexual, containing one to three pistillate inflorescences at the basal end of a catkin (see catkins image).

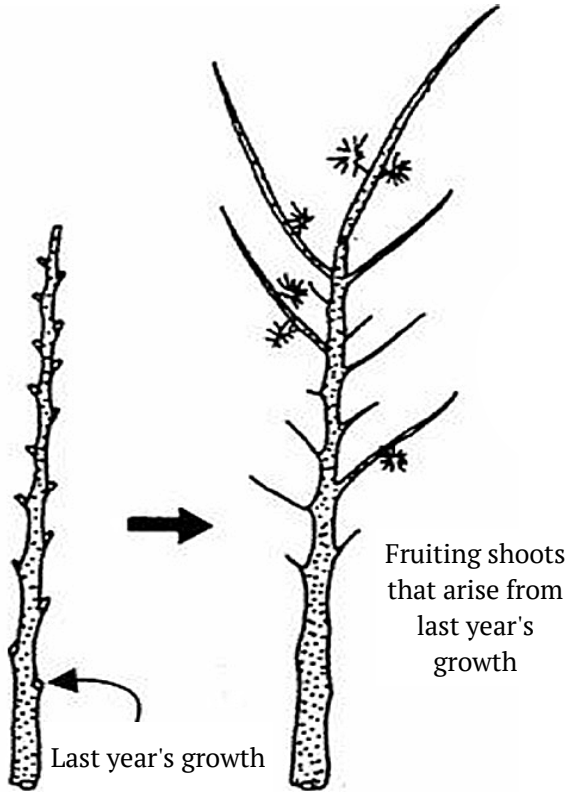
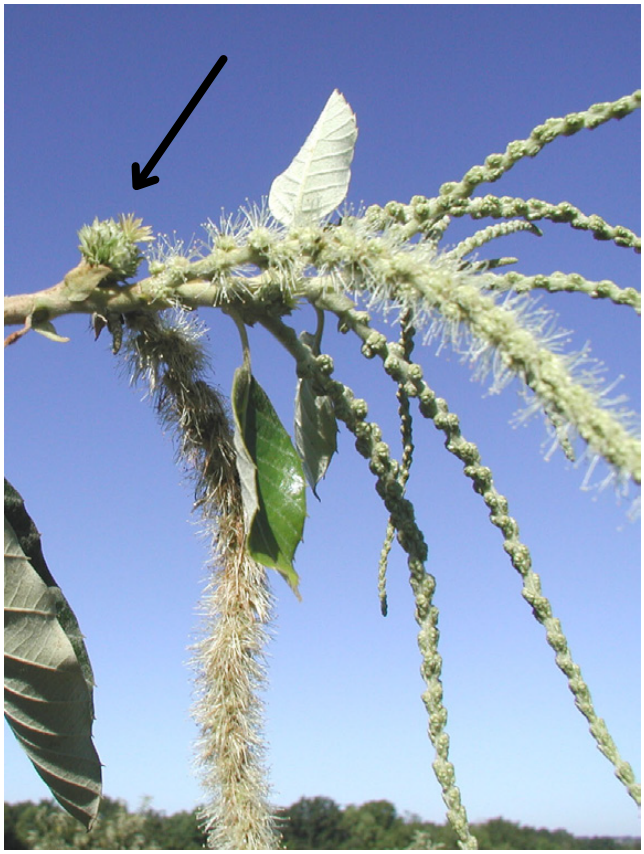



*Figure 1: Fruiting shoots arise from previous years' growth.*



*Catkins releasing pollen. The distal catkin is bisexual with a receptive female inflorescence (arrow).*

At the end of May to mid-June in Missouri, pollen is released from the most basal staminate catkins. Pistillate flowers on bisexual catkins become receptive a few days later and are receptive for one to two weeks. Once pistillate flowers become receptive, the bisexual catkins begin to release pollen. Flowering times of most Chinese chestnut cultivars are similar enough to ensure that any two cultivars will be able to pollinate each other, although some trees are pollen sterile and will require a pollinizer tree to bear fruit. Nearly all chestnut trees are self-incompatible and require another tree of a different cultivar for pollination. Pollinizer trees should be within 200 feet of each other to ensure adequate pollination. Numerous insects visit chestnut catkins, feeding on the abundant amounts of pollen produced by this tree. However, chestnuts are primarily wind pollinated and do not require insect pollinators for adequate fruit set.

There are normally three pistils in each bur (involucre). If all three ovaries are pollinated, then three nuts develop in the bur. The middle nut is flattened on two sides, while the outside nuts are flattened on one side (see image below). If only one nut develops, then the nut is round in shape.

*A dehiscing bur. The nut in the middle position is flattened on two sides. Some cultivars drop nuts within the bur, while nuts from other cultivars drop free from the bur, speeding harvest.*

## Methods for Establishing Chinese Chestnut Trees: The Choice between Cultivars and Seedlings

Chinese chestnuts can be established by planting grafted cultivars, by planting seedling trees then field grafting one to two years later, or by planting seedling trees at a high density then using culling criteria to select for quality, high-producing seedlings. Each of these methods has advantages and disadvantages. Prospective growers should choose the orchard establishment method most suited to their skills, economic situation, and environmental conditions and understand the respective trade-offs.

*One-year-old container grown seedlings ready to be planted out in the field.*

Grafted trees of proven cultivars bear earlier, provide more uniform ripening, predictable nut quality, larger nut size and more consistent yields. Evaluation of chestnut cultivars best suited for the Midwest is underway. MU Center for Agroforestry chestnut cultivar trials were established at HARC in Mid-Missouri in 1996. These are the only long-term cultivar trials in the region and provide long-term data on tree form, annual yields, nut size, nut quality, and ease of harvest. Additional yield trials are reported by Mextas et al. (2013) in Chattanooga, TN. Table 1 lists the Chinese chestnut cultivars that have shown excellent potential for nut production in Mid-Missouri.

Chinese chestnut seedlings are widely available in nurseries across the Midwest and eastern U.S. and are typically a more affordable option than grafted trees. Seedlings do not produce the same quality of nuts as the maternal parent cultivar they were born from, and seedling orchards usually have a variable, long-lasting harvest window that makes an efficient harvest logistically more challenging. However, for many growers, Chinese chestnut seedlings offer opportunity for successful chestnut production despite the disadvantages of growing seedlings. Seedlings often show greater vigor than grafted trees with much greater tolerance to extreme weather fluctuations, particularly in more northern climates, even though they typically take longer to come into production than grafted trees. Many growers are finding that some grafted cultivars typically produce superior seedlings, and growers are planting whole orchards at high densities composed of only a handful of cultivar parents with the intention of culling poor-producing trees. Research at UMCA is also underway to determine the best parental combinations for the most productive and resilient seedling orchards.

**Check out more chestnut resources on the "Mizzou Agroforestry" YouTube channel!**

*Table 1. Recommended Chinese Chestnut Cultivars for Missouri.*

| Cultivar | Nut Fall | Nuts/lb. | Growth Habit | Comments |
|---|---|---|---|---|
| 'Gideon' | Oct. 3 - 6 | 28 - 38 | Spreading | Uniform attractive nuts. More cold-hardy than many Chinese chestnuts. Bears consistent high yields of easy peeling nuts with excellent flavor. Grown at Empire Chestnut Company in Ohio. |
| 'Sleeping Giant' | Sept. 24 - Oct. 1 | 28 - 35 | Upright | Hybrid – Chinese x (Japanese x American). A larger tree with proven blight resistance. Excellent nut quality and flavor with a short season length. |
| 'Qing' | Oct. 1 - 3 | 21 - 35 | Spreading | Compact crown. Good branch angles. Shiny medium to dark mahogany nuts. Excellent sweet flavor. Stores well. Heavy producer. Can set too many nuts. |
| 'Mossbarger' | Sept. 20 - Oct. 1 | 27 - 35 | Spreading | Consistent moderate yields of large, dark brown nuts. Early ripening, nuts fall free from the bur. Excellent flavor and peeling. Stores well. |

Missouri Growers: Make sure you purchase Chinese chestnuts, not European or Japanese varieties. They may not be cold hardy in Missouri, they may get blight, and their nuts often exhibit internal rot. **Do not plant American chestnut because they will die from chestnut blight.** The 'Peach' cultivar, producing consistently large-sized nuts did not begin commercial production until age 15, longer than the other recommended cultivars. 'Eaton', also producing excellent quality nuts, is no longer recommended due to a high percentage of delayed graft failure, usually evident 7-8 years after grafting (or later) with no obvious sign of failure at the graft union. Instead, you will see the male catkins "hang on" after flowering.

***Planting grafted trees*** Grafted trees come into bearing two or three years following establishment, depending on tree growth rate. Commercial production of grafted cultivars (at least 750 lbs./acre, with 50 trees planted per acre) begins between the sixth and ninth year after the grafted cultivar is planted. It is reasonable to expect production reaching 2,000+ lbs./acre in a well-managed orchard by age 12-15. By providing optimum weed control, proper fertility and ample water in ideal growing sites, you will ensure vigorous tree growth and early fruiting. Grafted trees can be purchased as bareroot or container-grown trees. Currently, large quantities of trees of recommended cultivars are not widely available from commercial nurseries unless custom ordered a year in advance, making it difficult to obtain large numbers of grafted trees on demand. Bareroot trees are more widely available but suffer a greater degree of transplant shock. Transplant shock is a major contributing factor in delayed graft failure following establishment and is reported to be exacerbated by prolonged cold weather and other stressful conditions. For this reason, spring planting of grafted trees is preferred.

Delayed graft failure occurs when established grafted trees enters into a rapid decline for no apparent reason, usually evident 7-8 years after grafting (see graft failure image, right side). Certain cultivars seem to have a greater likelihood of delayed graft failure, but more cultivar specific research is needed to make regionally specific recommendations. Delayed graft failure has also been reported in higher incidences in areas that experience prolonged cold and harsh winters, such as in northern climates. Grafted trees may have limited suitability to some environments where prolonged cold stress is common from year to year. In these environments, seedling orchards offer an alternative although they have their own considerations.

***Propagating seedlings and field grafting*** Chinese chestnuts are easily grown from properly stratified nuts. Freshly harvested nuts

*Swollen graft union on 'AU Super' showing signs of delayed graft failure.*

can be stratified in moist sand by placing them in layers about three inches deep and holding them in a cool room or refrigerator (35 to 40 °F) for 60 to 90 days. The nuts also can be stored in resealable plastic bags with slightly moistened sphagnum moss and kept in the vegetable bin of a refrigerator. Stored chestnut seed are prone to rotting so inspect the bag of nuts periodically and remove any spoiled nuts. The taproot (radicle) will slowly emerge during storage, similar to acorns in the white oak family. Care must be taken not to injure the taproot when it is time to plant the nuts in the spring after the danger of frost passes. Homegrown seedlings can be grown in a nursery row in your garden and transplanted the following year or planted directly in the final tree location. Soil drainage is critical so mound the soil into a small hill at each seed plant location to help prevent nuts from rotting. Newly planted chestnut seed and young seedlings must be protected from rodent damage.

Desired cultivars can be grafted to seedling trees one to two years after the seedlings

emerge. Chestnuts can be grafted using the three-flap, bark, arrowhead, or whip-and-tongue graft. Nut production should begin one to three years after field grafting. Starting a chestnut planting with seedlings offers the advantages of low initial costs and the opportunity to establish cultivars not readily available from commercial nurseries. Disadvantages of establishing a chestnut orchard with seedlings include delaying the onset of profits from nut production and adding the expense/labor of grafting your own trees.

***Planting seedling orchards*** Seedling Chinese chestnut trees are widely available and are relatively inexpensive compared to grafted trees. When purchasing seedlings, it is important to source them from reliable nursery operations, where the maternal parent is well-evaluated and verified and where nursery practices result in well-developed root systems (e.g., root ball image, right side). To date, there are not standard maternal seedling families recommended for respective regions.

Seedlings from cultivars such as 'Qing', 'Peach', 'Mossbarger', and 'AU Super', among others, have produced outstanding seedling orchards. It is recommended to plant a diverse variety of families in seedling orchards. The UMCA chestnut breeding program and the Chestnut Improvement Network are currently conducting research to determine cultivar parents and cultivar parent combinations that lead to the best performing, least variable seedling families. This will enable the next-generation's seed orchards to produce large quantities of high performing seedlings should challenges with grafting and other means for clonal propagation persist. It is recommended that seedling orchards be planted at a high-density layout, and culling criteria be applied once trees have produced nuts for several years and/or tree crowns begin to touch. Culling criteria can be used to thin trees to reach the intended final spacing with only the best

*Properly stratified chestnuts with emerged radicle ready to be sown into individual containers.*

*Well-developed root ball on a one-year-seedling.*

trees. Seedling orchards can be planted at densities of 20 x 40 feet (54 trees per acre) or even as close as 15 x 20 feet (145 trees per acre) with the plan to progressively thin to a final density (e.g., 30' x 40' or 40' x 40') to allow the most productive trees ample room to grow.

***Culling and Selection Criteria for Seedling Orchards*** When planting an orchard composed of seedlings at a high-density it is important to

have a plan on when to begin removing poor performing trees to ensure that high performing trees have enough space to thrive. Often thinning will occur between 5 and 10 years after orchard establishment once trees begin producing nuts, but this will depend on the orchard layout. Table 2 presents a set of selection criteria to prioritize when making the decision of what to keep and what to remove. High-density orchards that are neglected and never thinned, grow tall and straight with lateral bearing branches dying back from overcrowding and productive branches becoming squeezed at the very top of the canopy, reaching for light.

These neglected orchards are only a fraction as productive as well-managed and thinned orchards with deep crowns full of bearing branches, even though there are more trunks/acre. Seedling performance will be unpredictable at the time of planting, and it is rare that seedlings orchards can be thinned in a uniform manner. Thinning poor quality and unproductive trees will allow space to be available in the orchard. Good quality trees will fill any available space they are given in an orchard and seedling orchards do not need to be uniform.

Important culling and selection criteria include: consistent bearing from year to year, tree vigor compared to other trees the same age, disease and pest resistance, whether nuts drop free of the bur, and overall nut quality (size, color, peeling, flavor) (Table 2).

We suggest using spray paint to mark the trunks of high quality and producing seedlings during harvest for the first few bearing years. Multiple colors could be used for different attributes. Accumulating marks over the years will serve as a valuable indicator and record of the seedling's production value.

## Transplanting Trees

In Missouri, transplant bareroot stock in March as soon as the soil can be easily worked. When planting bareroot seedlings, care should be taken to keep the roots moist. Prune the top of each tree to a single stem and prune off broken or rotten roots. Dig your planting hole large and deep enough to fit the entire root system. Hold the tree in position and fill soil around the roots, making sure the fibrous roots are spread out in their natural positions. Plant the tree at the same depth as in the nursery. Water in the tree after transplanting and do not place soil amendments or fertilizers in the planting hole. Bare root seedling trees survive well but above-ground growth may be slow in the first season. Growth is better the second growing season and in subsequent years.

In central Missouri, container-grown stock can be planted in early October or in late March (although spring planting of grafted trees is recommended). Dig your planting hole twice as wide as the container, but no deeper than the depth of the pot. After removing the tree from

**Seedling Orchard Selection Criteria**

| Select trees for: | Descriptions: |
|---|---|
| Precociousness | Begins producing nuts at a young age |
| Consistent bearing | Produces a crop of nuts every year |
| Disease and pest resistance | Resists chestnut blight, PRR, BER, gall wasp, weevils, leaf hopper, etc. |
| Nuts drop free of the bur | Nuts ripen falling free of the bur, not needing to pry the bur open on the ground |
| Nut quality | Size (12 g or larger), color of the shell, color of the kernel (yellow), ease of peeling, good flavor |

***Table 2: Seedling orchard selection criteria. Prioritize this list of attributes when making the decision of which seedlings to keep and what to remove when it comes time to thin your orchard***

## Tree Transplanting Tips

- Transplant bareroot seedlings and any grafted trees in March
- Water in the tree after transplanting and do not place soil amendments or fertilizers in the planting hole
- Container-grown stock can be planted in early-October or in late-March

*Properly scored Chinese chestnut shells pop open upon cooking, revealing attractive golden nutmeats. The nutmeat should be easy to extract from the shell while hot.*

the container, gently tap or shake the root ball to remove some of the potting media, then inspect for encircling roots. Gently pull out the encircling roots and spread out into natural positions in the planting hole. Fill in the planting hole with topsoil making sure the tree is at the same depth as it was in the container. However, be sure to cover the root ball and potting soil with an inch of soil to prevent drying out the root ball.

*Containerized newly-grafted cultivars ready to be hardened off and planted outside in the fall.*

## Care During Establishment

The trunks of young chestnut trees are susceptible to sunscald. To prevent injury, paint trunks white with 50/50 mixture of white latex interior paint and water or wrap the tree with a white, plastic, spiral tree wrap. Keep all vegetation controlled in up to a six-foot circle around the tree by using mulch or herbicides. If the tree makes several inches of new growth by early June, spread a half-cup of ammonium nitrate fertilizer around the tree evenly over the entire weed-free area. During the summer following tree establishment, it is especially important to keep the soil around the tree moist (but not soggy) at all times. Installing a micro-irrigation system will help provide optimum soil water conditions throughout the life of the orchard.

## Chestnut Culture: Planning Your Orchard

Chinese chestnut is a very adaptable crop. Chinese chestnut can be grown as a backyard nut tree, a small-scale, low-input orchard tree, or an intensively managed, high-density orchard crop. Tree spacing and pruning systems differ under each of these management regimes requiring the grower to choose a cultural system before setting out a single chestnut tree. The three basic cultural systems are described below.

***Backyard trees*** Chinese chestnuts make an excellent nut tree for home production. Planting at least three trees (different cultivars if grafted trees) will ensure pollination and produce enough nuts for a family. Chinese chestnut trees naturally form wide spreading crowns that grow to a height of 35 to 40 feet. Spacing your trees at least 40 to 50 feet apart will allow ample room for tree growth and allow easy access to all sides of the tree at harvest time. Homeowners should plant their chestnut trees in a location where children and pets can be kept away from the spiny burs that fall to the ground at harvest. Chestnuts require

full sun for best nut production so they should not be planted adjacent to large shade trees.

Young trees should be trained to the central leader system to develop a strong framework of lateral branches along the main trunk. After the trees come into bearing, begin pruning off lower limbs—one or two each year until there is enough clearance for mowing and harvesting. Once the trunk is developed, allow the tree to develop its natural spreading form. If branches with "narrow crotches" arise, prune them out. Branches with narrow crotch angles tend to form bark inclusions, which can lead to limb breakage under the weight of a heavy crop or ice storm. Mature trees require minimal pruning.

***Low-input orchard*** Chestnut plantings of 50 to 250 trees (one to five acres) are large enough to provide landowners with a reliable source of supplemental income but are small enough to manage with hand labor. For these growers, minimizing capital expenditures for machinery is the key to profitability.

To maximize nut yield, initial tree spacing for the small-scale orchard should be 30 by 30 feet, or roughly 50 trees per acre. As trees grow and limbs of adjacent trees start to touch (age 15+), remove every other tree on the diagonal to leave trees on a 42 by 42 foot spacing (26 trees/acre). ***NOTE:*** A well-managed, irrigated, 5-acre chestnut orchard of 250 grafted cultivars may yield up to 10,000 lbs. of chestnuts by age 12-15.

A second thinning may be necessary before chestnuts attain their final spacing of 50 by 50 feet (17 trees/acre). Thinning the orchard is crucial to providing optimal sunlight to the trees and ensure maximum nut production. Crowded trees create excessive shade on lower branches allowing flower and nut production only in the tops of the trees. Severe shading causes lower branches to die out and compromises general tree vigor. Young trees should be staked and pruned using

*Mature chestnut orchard planted at 30 x 30 ft. spacing.*

*A strong crotch showing pronounced bark ridge for the upper right branch. The lower left branch does not show a pronounced bark ridge and is inherently weaker and should be removed.*

the modified central leader pruning system.* Many cultivars do not naturally grow vertical central leaders but must be staked to provide a structure for training the young trees. A strong stake should be placed near each tree and a leader chosen and loosely tied to it. Central leaders grown vertically develop leaves and buds in a spiral fashion allowing good choices for scaffold branches growing in the proper directions.

Central leaders allowed to bend over will develop buds on opposite sides of the shoot, not in a spiral fashion. The scaffold branches are selected during the second through sixth growing season, allowing for good spacing between branches in a spiral fashion along the main trunk.

**Modified central leader method is used in peach orchards and should work with chestnuts.*

The height of the lowest scaffold branch depends on the individual grower's equipment needs.

***Intensively managed orchard*** Large nut size is one key to profitable chestnut farming. Large chestnuts command premium prices. To maximize the production of premium quality nuts, chestnut trees can be grown as a high-density, intensively managed orchard crop. This level of management requires a skilled grower willing to plant sufficient acres of chestnuts to justify investments in trees and the mechanization of orchard operations.

Research in Japan has shown that chestnuts require high levels of light intensity to be able to set and develop fruit. In addition, there is a direct relationship between the intensity of sunlight within the tree canopy and the number of female flowers per cubic foot of canopy. High light intensity stimulates nut-bearing shoot growth, which in turn promotes large fruit size.

To achieve needed tree structure, pruning needs to start in the first year and continue regularly throughout the tree's life. The target initially should be to promote a leader and two main branches. The third year, the aim should be to encourage the tree to spread out. Thinning the inward growing branches is necessary to further encourage branch spreading into the alley.

By approximately the fifth growing season, commercial production should begin. Cut out the central leader in the winter, leaving the two permanent structural branches that reach out into the alleyways to become the tree's permanent framework. Removing the central leader also reduces tree height. Subsequent tree growth will fill the gaps left by removal of the central leader. From this point forward, thin out interior branches as they begin to crowd, and also remove branches to maintain a reduced tree height and elliptical tree shape.

*LEFT: Keep all vegetation controlled in a six-foot circle around trees using mulch or herbicides (spread fertilizer evenly over this entire six-foot vegetation-free area). RIGHT: Sunscald injury to a chestnut trunk that has been pruned heavily. Painting the trunk after pruning with 50 percent interior white latex paint would have prevented the damage.*

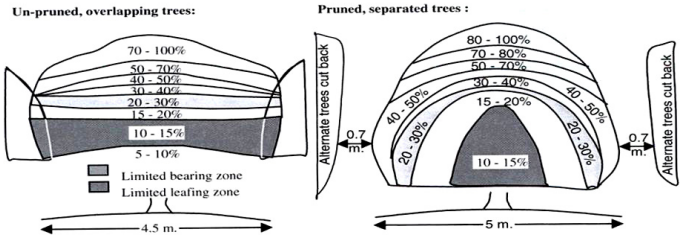



*Figure 2: Measurements of relative solar radiation within the tree canopy.*

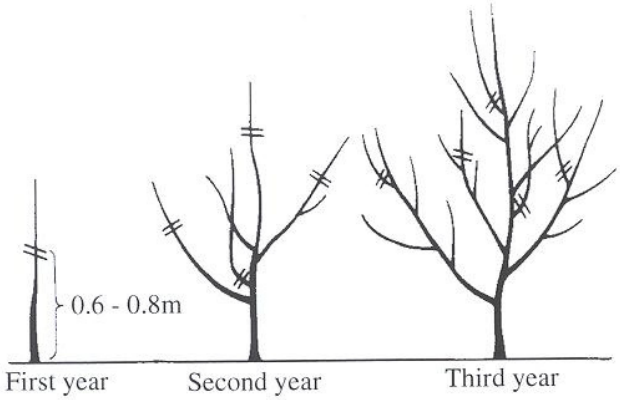



*Figure 3: Pruning a young tree in three successive years.*

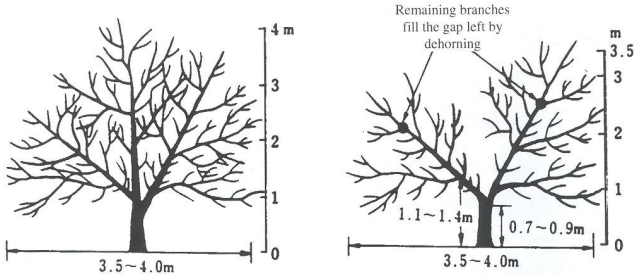



*Figure 4: De-horning the central leader.*

## Fertilization

Conducting a soil analysis and incorporating the necessary soil amendments (fertilizers such as lime, sulfur, potassium, and phosphorous, depending on the analysis results) is recommended BEFORE planting any chestnut trees. Amendments particularly are necessary if pH is non-optimal (between 5.5 and 6.5). Information on how to collect and submit soil samples, as well as other helpful resources can be found at the MU Extension Soil and Plant Testing Laboratory (https://extension.missouri.edu/programs/soil-and-plant-testing-laboratory).

***CAUTION:*** *Do not incorporate fertilizer directly into the planting hole.*

***NOTE****: The calculated amount of fertilizer should be split into two applications.*

Trees should be fertilized with nitrogen annually. However, the optimum nitrogen rate will vary depending on the soil type, orchard floor management, crop load, etc. Soil nitrogen leaches more readily in sandy soils than in heavier types. Thus, nitrogen rates may need to be increased slightly on sandy soils. Sites in which alfalfa was previously grown may contain high levels of residual soil N and require less fertilizer the first year. Sodded orchards may require 20 to 50 percent more N than those where the ground beneath the tree is kept free of vegetation. The nitrogen rates presented in this guide can be used as an initial recommendation but should be adjusted based on annual new growth and leaf color.

Non-bearing trees should produce 18 to 24 inches of new growth annually. In contrast, bearing trees should produce about 12 to 15 inches of new growth each season. To achieve this type of shoot growth, apply 0.1 lb. actual N per tree per year of age. For example, a 3-year-old tree should receive 0.3 lbs. actual N per tree. To calculate the amount of fertilizer product needed, divide the actual N by the percent active ingredient. Thus, if ammonium nitrate (34% active ingredient) is used, then the amount of this product applied per 3-year-old tree would be 0.1 x 3 years ÷ 0.34 = 0.88 lbs. per tree. The calculated amount of fertilizer should be split into two applications. Two-thirds of the calculated fertilizer amount should be applied before bud swell (April 1) and the other third should be applied at the end of flowering (June 20). Apply the fertilizer within the dripline of the tree. The following growing season, if shoot growth is less or greater than the recommended lengths, nitrogen rates can be adjusted based on the site conditions.

*Winter pruning to thin the tree canopy, training the structure of the tree to spread out.*

## Pest and Disease Management

Chinese chestnut is a relatively pest-free orchard crop. In carefully managed, well-scouted, small-scale plantings, chestnuts can be successfully grown without pesticides. However, no chestnut tree is safe from insect pests or the browsing of deer, rabbits and voles.

***Rodents*** When trees are young, the smooth, thin bark of a chestnut tree is especially inviting to rabbits and voles. Remove all vegetation and mulch from the tree during winter. Bare soil provides a beautiful backdrop for hawks and owls to spot daring rabbits and voles trying to attack your chestnut trees. Raptor poles or owl boxes will promote the

establishment of natural predators to rodents keeping the rodent populations in the orchard under control. Place tree guards around each tree, pressing the guard into the soil can prevent voles and rabbits from digging under them. Once chestnut trees develop rough bark, the threat from rabbits and voles diminishes.

***Deer control*** Deer not only browse chestnuts, but bucks also often rub all the bark off of trees during late summer and early fall. Installing a permanent 8' fence around your chestnut planting to prevent deer damage can be cost-effective, as it will protect your trees and crop from year one onward. These fences require regular maintenance. The next best option to fencing the property would be creating woven wire tree cages for each individual tree. These cages are a cylinder of fencing anchored with two pieces of 4' long 1/4" rebar. Tree cages will last for at least the first ten years of an orchard's life but, with good tree growth, should no longer be needed after the fifth year.

An additional option for deer control would be to use specialized four to five foot tree tubes, that also add sunscald protection. These tubes will need to be removed once the trees are several years old to avoid obstructing tree growth. There are reports of tubes blowing over in the wind, being knocked over by deer, difficulty weeding around the base of the tube, and frustration of clearing leaf debris from inside the tubes as the trees age. A solid stake or anchor is necessary for each tube. However, these tree tubes have been reported to direct the tree growth upward, promoting vigorous growth and precocity. The choice on which deer protection system to employ depends on the orchard site conditions, the local deer pressure, and each grower's financial resources, but typically ensuring reliable deer protection is considered a necessary orchard establishment cost.

***Chestnut weevil information and management***
Two species of weevils (*Curculio spp.*) pose the greatest risk of injury to a Midwest-grown

*Exit hole and larvae of the small chestnut weevil. Photo courtesy of R. Bessin, Univ. of Kentucky.*

chestnut crop. These weevils lay eggs inside chestnut burs still up in the tree crown starting in August and continuing until harvest.. Larvae of the chestnut weevil are white, leg-less grubs that can devour the entire contents of a nut. Because native chestnut tree species (especially *C. dentata*) have been killed by the chestnut blight fungus, chestnut weevils became somewhat rare. As more commercial chestnut orchards are established, weevil will become much more commonly encountered in new chestnut plantings. ***NOTE:*** It often takes 10 to 15 years before chestnut weevils find new chestnut plantings and build up to economically damaging populations.

Small chestnut weevils (*Curculio sayi*) emerge from the soil in late May through July. Adults feed on chestnut foliage until nut kernels enter the dough stage in mid- to late-August. Although they can lay eggs any time after kernel filling, most eggs are laid after the bur begins to open. The female weevil uses her long proboscis to drill a hole through the shell before turning around and placing her ovipositor into the nut and laying five to seven eggs. Eggs hatch in about 10 days and larval development is completed two to three weeks later. Mature larvae chew a small round hole through the shell, exit the nut, and then burrow into the ground under the chestnut tree. The insect remains in the soil for two to three years before re-emerging as an adult.

Large chestnut weevils (*C. caryatrypes*) emerge from the soil in late-July and August. Because of their larger size, large chestnut weevils are more successful in laying eggs in nuts before burs open. The long proboscis of large chestnut weevils enables females to drill oviposition sites among the spines of the bur. Eggs hatch in

five to seven days producing large, legless grubs. The life cycle of the large chestnut weevil is similar to that of its smaller cousin, but the larger weevil spends only one to two years in the soil.

Nut Curculio (*Conotrachelus carinifer*) is a sporadic pest of chestnut. This curculio is primarily an acorn pest but has been observed to invade chestnut orchards when the acorn crop in nearby forests is low. The nut curculio is related to chestnut weevils and the damage inflicted to chestnut kernels is similar. Curculios have a much shorter proboscis and must wait until the burs open to lay eggs inside the nut. The nut curculio has a one-year life cycle. Good sanitation practices can help keep weevil damage under control. Prompt harvest followed by a hot water treatment (122 °F for 20 minutes, then immediately cool to ~32 to 34 °F) will kill weevil eggs before they have a chance to hatch. In large orchards. Control weevil populations by making three applications of carbaryl (Sevin® or Warrior®) at 10-day intervals starting in mid-August. The adult weevils can be scouted and monitored for their presence by jarring the tree and counting fallen weevils.

***CAUTION:*** Both Sevin® and Warrior® are highly toxic to honeybees and other pollinators.

***Chestnut gall wasp (Dryocosmus kuriphilus)***

Chestnut gall wasp (*Dryocosmus kuriphilus*) was inadvertently introduced into Georgia in 1974 and has spread north across the eastern United States since (it has not been officially reported in Missouri yet). Adult gall wasps lay eggs in chestnut buds in early summer; larvae remain dormant until buds expand the following spring. Gall wasps induce the formation of greenish red, 1/3rd to ½-inch leaf and twig galls that suppress shoot elongation, reduce fruiting and cause twig dieback. Adult wasps, 1/8-inch long, then begin emerging from the galls during early summer, continuing

***TOP**: Galls appear on a chestnut tree. **RIGHT**: Adult chestnut gall wasps.*

*Dead branch tips following severe gall wasp infestation in previous year.*

the cycle. Severe infestations can result in mortality of young trees. Parasitic wasps move with chestnut gall wasp populations and have been an important natural biological control to aid in gall wasp population decline. At present there are no documented chemical control method(s) in the literature.

Caution should be exercised to not spread gall wasp-infested scion. A similar hot water bath treatment to that used to control chestnut weevil can be used on scion. However, growers sharing scion should first verify that their hot water treatment does not damage the scion before disseminating material.

***Yellow neck caterpillar (Datana ministra)*** The yellow neck caterpillar (*Datana ministra*) is an occasional pest of chestnuts. These insects feed in large colonies and can completely defoliate a young chestnut tree. Scout your orchard regularly starting in late-June and look for newly hatching colonies. Although this pest is frequently kept under control by beneficial insects, an insecticide can be used to control outbreaks of yellow neck caterpillars. Recommended insecticides include carbaryl and Bacillus thuringiensis.

***LEFT**: A young chestnut tree defoliated by yellow neck caterpillars. **RIGHT**: Branches defoliated by the insect.*

***Potato leafhopper (Empoasca fabae)*** Potato leafhopper is a regular pest of many agricultural crops, including chestnut. Leafhoppers feed on the veins on the underside of developing leaves in May and June, causing deformation. Young leaves show cupping and curling and may fall off of the tree. As weather becomes hot and dry, the leaf hoppers disappear, but the resulting leaf damage and defoliation may affect nut yield and quality. An orchard spray with carbaryl at the first signs of leaf cupping and curling is recommended.

***Chestnut blight (Cryphonectria parasitica)*** Chestnut blight is caused by the fungus *Cryphonectria parasitica* and was introduced to North America in the early 1900s. Chestnut blight infects susceptible chestnuts such as the native American chestnut, European chestnut, and other chestnut species, while species such as Chinese chestnut and complex hybrids with a mix of species show a degree of resistance to chestnut blight. Chestnut blight causes canker formation and dieback leading to a decline in production and ultimately death of susceptible trees. Resistant trees will avoid chestnut infection or tolerate chestnut blight cankers with little detrimental effects to production. Chinese chestnuts and complex hybrids will tolerate chestnut blight pressure and will continue to produce, making it an ideal choice for production in areas with high blight pressure. When chestnut blight is found in the canopy of trees, infected limbs may be pruned out to minimize the spread of the infection throughout the orchard.

Some success in slowing disease progression has been reported when small chestnut blight cankers near the root collar of a trees are packed with mud. Use only enough mud to cover the canker and avoid covering the entire circumference of the trunk to prevent smothering the tree bark. This method will not cure the infection, rather it may slow disease progression and prevent the area of the bark drying out. Other biological control methods include hypovirulence. Hypovirulence is achieved by infecting the chestnut blight fungus with viruses that reduce its virulence making the tree able to fend off chestnut blight infection. Successful treatment is dependent on the natural spread of the viruses that attack the chestnut blight fungus.

*Swollen, orange-colored cankers are evidence of chestnut blight.*

This control method has been successful in some areas of Europe but has had limited success in North America. The use of fungicides to control chestnut blight is not recommended in Missouri.

***Phytophthora root rot (PRR) (Phytophthora cinnamomi)*** Phytophthora root rot (PRR) is caused by an aggressive and virulent oomycete pathogen called *Phytophthora cinnamomi*. *P. cinnamomi* has a wide host range and often causes infection beginning as necrosis in the root system. As necrotic tissue expands in the root system it will spread through the vascular system causing leaf wilting in the canopy, stem dieback and potentially mortality. Prevention and control of PRR begins will orchard site selection and planting PRR resistant chestnut species.

Chestnuts should be planted in well-drained, loamy to sandy loam soils. Heavy, poorly-drained soils or soils that have a perched water table during wet seasons will promote PRR because *P. cinnamomi* requires highly saturated conditions to thrive and infect trees. Chinese and Japanese chestnuts have a degree of resistance to PRR, and plant breeding efforts are under way to exploit these PRR resistance sources to develop PRR resistant chestnut cultivars and seed sources. European and American chestnut species are highly susceptible to PRR and are not recommended to be planted in PRR prone areas.

***Blossom End Rot (BER)*** Blossom end rot on chestnuts (BER) (also referred to as "Chestnut Anthracnose") is a nut quality defect where the proximal end of the nut (end nearest to the flower) on the outer shell and inner kernel becomes black and rotten. The brown spot on the tip is highly undesirable, for both appearance and flavor, so nuts with BER are sorted out during the nut grading process, reducing yields and nut quality. It is considered one of the most impactful diseases facing the chestnut industry. Some growers have noted more than 10% of their crop lost to BER in a single season. BER is caused by a fungal pathogen species complex known as *Colletotrichum gloeosporiodes*. Currently not enough is known about the disease cycle of *C. gloeosporiodes* in chestnut, although it seems to infect the nuts while still in the orchard before the nuts drop.

Preliminary reports suggest that there is a significant genetic component involved with BER incidence in an orchard. Some seedlings and cultivars are reported as having BER incidences in over 10% of nuts on a single tree, while other seedlings and cultivars do not have a trace. BER incidence is recommended as an important culling criterion to use when thinning a seedling orchard. The UMCA is currently evaluating BER incidence as a selection criterion in their nut breeding program. At present there are no known fungicides or spray methods to control BER infection.

## Harvest, Handling and Processing

Harvest in the Midwest occurs in September and October, depending on cultivar and the growing season. Ripe chestnuts should be harvested promptly once they have fallen to preserve quality and prevent excessive predation by deer, opossums, turkey, mice and other wildlife. Individual trees generally drop nuts for a week to ten days. Manual harvest is most efficient with a tool like the Nut Wizard (see image on page 17, left side), a rolling basket used for collecting items such as fruits, nuts, and golf balls. One person can harvest upwards of 400 lbs. of chestnuts per day using the Nut Wizard when chestnuts consistently fall free from the bur and when the orchard floor is properly prepared.

For mechanical harvesters: Prior to harvest the orchard floor must be prepared by 1) removing

all debris (e.g., twigs) or using a flail mower to break up debris into very small pieces as twigs and debris can slow down manual harvest or jam up mechanized harvesters, and 2) the orchard floor must be mowed very short prior to harvest to avoid nuts getting tangled up in the grass while operating a Nut Wizard and to enable the harvester vacuums to easily suck up all the chestnuts and burs.

*"Nut wizard" used for harvesting smaller tonnage.*

*Mechanized nut harvesting is essential in commercial-sized orchards.*

***Efficient Handling of Burs*** Managing the volume of burs in an orchard can become an overwhelming task whether harvesting manually or with a mechanized system.

Depending on the tree, some nuts will fall free from the bur while others will remain held in the bur. The ratio of burs to nuts that fall in an orchard is about five to one; greatly exceeding the number of nuts held in those burs. Use heavy leather gloves when handling chestnuts in the bur. The prick of a chestnut bur can be very painful. In home plantings, roll the bur under your foot until the nuts pop free before picking up chestnuts.

The efficient handling of burs and maintaining a clear orchard floor throughout the harvest season will save time and money on the cost of harvest, especially at a commercial level. The results from one study showed removing burs and debris from under the trees and starting each day of harvest with a clean floor showed a reduction in harvest costs from $0.40/pound to $0.30/pound using a mechanical harvester (DeKleine, 2015). Fewer burs or fragments of bur and debris among the harvested nuts will also streamline the nut sorting process post-harvest. Burs, leaves, and debris that are removed from the orchard floor can be composted until they are fully broken down, then reincorporated into the soil as organic matter when preparing sites for further orchard expansion and other horticultural activities.

***Commercial Chestnut Harvesters*** In large plantings (>5 acres), highly efficient large-scale mechanical harvesting equipment is available specifically designed for chestnuts and other nuts harvested from the ground. These are typically built in Europe. Some harvesters are self-propelled, and others are operated using a PTO, towed behind a tractor. Mechanical chestnut harvesters use a vacuum system to pull the chestnuts up off the ground. The pieces of bur are separated from the chestnuts within the harvester, blowing the refuse out from the side or back of the machine to then be removed from the orchard.

UMCA purchased a "pull behind" mechanical chestnut harvester and Michigan State has

been using a self-propelled mechanical harvester. Both machines are manufactured by the Italian company FACMA (shown in photos below), and this equipment ranges from $30,000 to $100,000. The FACMA harvester works well, enabling harvest of over 1,000 lb. of chestnuts per hour.

Nut harvesters used in other nut industries can also be used on chestnuts. Harvesters used to collect hazelnut, walnuts, or pecans will also harvest chestnuts, but because chestnut have a "flat" side, these harvesters are less efficient than vacuum harvesters. These alternative nut harvesters tend to collect all the debris from the orchard floor as well, which will need to be sorted out from the nuts.

*Two FACMA chestnut harvesters.* ***BOTTOM:*** *Tractor pulled (using PTO).* ***TOP:*** *Self-propelled harvester. /Photos courtesy M. Gold, UMCA.*

***Post-harvest storage conditions*** Unlike most tree nuts that are high in oil content and low in water content, ripe chestnuts are high in carbohydrates (49%) and water (44%) making these nuts subject to molding and decay. Pick up nuts at least every other day (ideally every day) to preserve nut quality. Promptly store nuts in a refrigerator (32 °F or slightly above) in sealed plastic bags (one to two gallon bags work well) to prevent kernel molding. Ventilated plastic bags are needed for larger quantities to allow some air movement while still reducing excessive moisture loss. The lack of oxygen during long-term storage can give the chestnuts an undesirable fermented flavor profile.

Research has shown that nuts treated with a 10% chlorine solution (household bleach) prior to storage immediately following nut sorting will delay the development of exterior storage molds during long term storage. There have been observations supported with research studies that different cultivars will store longer than others. Recent research at the UMCA found that nuts from 'Qing' and 'Mossbarger' and to a lesser extent 'Peach', 'Gideon', 'Sleeping Giant', and 'AU Homestead' offer a degree of protection from long-term storage mold (Webber et al., 2022).

Kernels of fully dry chestnuts (dried to less than 8% moisture) are rock hard and inedible. However, dry chestnuts can be ground into gluten-free chestnut flour and used as a substitute for corn meal. Dry chestnuts also can be rehydrated in boiling water much like dry beans. Fully drying chestnuts provides chestnut enthusiasts a way to preserve nuts if refrigerator space is limited.


*Chestnuts are sorted to size, bagged in 25-pound "onion bags" and then stored at 27 °F until ready to be shipped*

Although dry chestnuts are not susceptible to molding, they are subject to attack by stored grain pests such as the Indian meal moth (*Plodia interpunctella*) and confused flour beetle (*Tribolium confusum*). Store dry chestnuts in tightly sealed containers to prevent insect attack.

## Markets and Marketing

UMCA's long-term objective is to create a thriving domestic chestnut industry focusing its efforts on five key areas: production techniques/orchard management; selection and breeding; market research; enabling local grower cooperatives; and increasing consumer awareness and demand. Over the past 20+ years, these efforts have helped to support hundreds of producers and established a multi-million-dollar chestnut industry across Missouri and the eastern U.S. Through annual market and consumer research, UMCA strives to increase adoption of chestnuts by producers, retailers and consumers.

***Consumer research*** A longitudinal study (2003-2008) revealed that high quality, locally grown, and nutritional health benefits were consistently perceived as the most important attributes influencing chestnut purchase decisions. Another study explored preferences for different characteristics including nut size, production process and geographic origin. Results suggest consumers strongly prefer locally and U.S. grown compared to imported chestnuts with additional preferences for chestnuts that are medium-sized and organically certified. Growers that provide the market with chestnuts meeting these characteristics are likely to capture price premiums.

Consumer research studies have shown that familiarity with chestnuts increased over time. Compared with people that attended the Missouri Chestnut Roast festival for the first time, repeat visitors demonstrated higher interest and consumption of chestnuts and a gain in knowledge regarding three key chestnut attributes: need for refrigeration, low fat content and a source of gluten-free flour. The Missouri Chestnut Roast provided a forum for interested people to ask questions and receive pertinent written information to take home and read, furthering the education process. These results demonstrate that the Missouri Chestnut Roast is having an impact on consumers' familiarity and interest concerning chestnuts and that public events of this nature are an effective tool to educate consumers and help create a viable chestnut industry in the region.

***Describing the U.S. chestnut market – an analysis from the University of Missouri Center for Agroforestry.***

The following is an excerpt from the survey results. The entire report is published as the Chestnut Market Analysis and Producers' Directory and is available for viewing or downloading from centerforagroforestry.org. (See Chestnut Resources section).

**Key Findings:**

General information about the respondents and the chestnut industry:

- The majority of U.S. chestnut producers have been in business less than 10 years and are just beginning to produce commercially.
- Current production volume is less than 2.0 million pounds nationwide.
- U.S. chestnut producers are mainly part-timers or hobbyists producing under 10,000 lbs. annually with gross sales under $25,000.
- Most production operations are small, i.e. less than 10 acres. With 50 trees per acre, commercial production (at least 10 lbs./tree) can be reached in 6-9 years after grafted trees are established under proper management.
- Full-time chestnut producers are able to sell their entire crop immediately following harvest.

Information about the market:

- The majority of respondents sell their chestnuts locally, 38% sell regionally, and 21% sell nationally.
- Results of a grower survey in 2021 (2020 harvest) indicated that 41% sold chestnuts on-farm, 41% sold direct to consumer, 30% to wholesalers, 26% to grocery stores, 19% to marketing co-ops, 4% sold to farmers markets, 4% sold fresh chestnuts to restaurants, 4% to distributors and brokers, and 4% to health and natural food stores.

Most respondents produce and sell fresh chestnuts in bulk (92%). Some producers act as small nurseries and produce seedlings (21%), grafted cultivars (10%) or chestnuts for seed (20%). Eight percent of respondents sell value-added products like chestnut flour, dried chestnut kernels, frozen chestnuts, chestnut honey, soup mix and jam, jellies or preserves, while 13% sell chestnut-related products (e.g., roaster, mug, cap, knife).

- Demand for quality chestnuts exceeds supply. Demand for fresh chestnuts is expected to continue to increase by 10% - 25% in the next five years.
- Grower retail prices range from $4 to $8 per pound at farmers markets; $4 to $8 a pound at on-farm sales; and $6 to $10 per pound at restaurants, retail grocers, health food stores, and online.
- Overall, wholesale prices average $3.10 - $5 per pound.
- Producers who grow chestnuts from cultivars, grow organically, sell under a brand name, or sell nuts to grow seedlings achieve the highest prices.

Further details on these findings were published in HortTechnology (Gold et al., 2004, 2005, 2006; Aguilar et al., 2009) and the Journal of Extension (Cernusca et al., 2008). Members of the Chestnut Growers of America (CGA) receive up-to-date market information annually from the CGA member grower survey. See the Chestnut Resources section for full citations.


*Chestnuts sold by the bag at a local market*

## The Missouri Chestnut Roast: A Festival of Culture and Agriculture

The Missouri Chestnut Roast, held annually on the first Saturday in October, has become one of the premier family-oriented events for mid-Missouri and the MU College of Agriculture, Food and Natural Resources. The event is an outstanding opportunity to introduce families and landowners to the broad range of possibilities and benefits agroforestry practices can provide. Thousands of visitors enjoy their first sample of sweet, Missouri-grown roasted chestnuts, along with a variety of products including locally grown black walnuts and pecans and recipes and nutritional information to pique interest in purchasing local nut products.

*Pan-roasted chestnuts at the 2019 Missouri Chestnut Roast.*

# Chestnut Value-Added Products: Unique Niche Market Opportunities

| *Product* | *Description* |
|---|---|
|  | **Fresh, roasted, or raw in-shell chestnuts:** Best if sold immediately after harvest. Market opportunities include internet sales, farmers markets, local festivals, restaurants, and specialty grocers. Attractive packaging, such as a fabric drawstring bag, should include preparation and storage instructions. Roasted or fresh chestnuts can sell for $4.50 to $6.50 per pound at the retail or direct-to-customer level. Organic and locally grown chestnuts receive the highest prices. |
|  | **Chestnut flour:** This gluten-free, finely-ground product is a gourmet ingredient in pastries, pastas and desserts. Chefs may purchase chestnut flour for these purposes; consumers with gluten allergies or special diets also are increasing demand for chestnut flour. Due to the starchy consistency of chestnuts, specialized equipment may be necessary. Chestnut flour producers include: High Rock Farm in North Carolina, www.high-rock-farm.org/; GroverWinery & Vineyards in North Carolina, http://grovewinery.com/chestnut_flour.html; and Ladd Hill Orchards in Oregon, http://www.laddhillchestnuts.com/. |
|  | **Mixes/gift packs:** : Dried chestnuts, chestnut flour and other gourmet ingredients are featured ingredients in specialty food mixes, such as chowder, bread, scone, wild rice, pasta, cornbread and pancake mixes. These mixes are attractively packaged by Ladd Hill Orchards, http:// laddhillchestnuts.com/. |
|  | **Sweet chestnut puree/marron glacés:** Sweet chestnut puree is used in desserts like crepes, for example. Marron glacés are candied chestnuts that are eaten on their own or used as a garnish for other desserts. Both are common in Europe and imported here, but rarely produced in the United States and might be an interesting niche for a grower. Product shown is from Australia: Cheznuts, https://cheznuts.com.au/store/. |
|  | **Dried chestnuts:** Dried chestnuts are excellent for long-term storage and can be rehydrated to be ground and used as a base for pasta, breading for fish, or sprinkled on your potato for a sweet topping. |
|  | **Chestnut snack packs**: Gefen produces an array of different roasted and peeled chestnut snack products including this 35-gram pack of peeled, whole-roasted and ready-to-eat chestnuts, https://www.kayco.com/brands/gefen/. |
|  | **Chestnut honey:** Chestnut honey is a popular and high-demand product in France, Italy, Turkey and other European regions. Made from chestnut flowers, the honey is delicious in flavor and excellent in color. Chestnut honey, dark in color, has a strong aromatic taste, not very sweet, with a slightly bitter aftertaste. As additional chestnut orchards come on in in the USA, this is a value-added byproduct opportunity for chestnut producers (or a great opportunity for a partnership with beekeepers). |
|  | **Chestnut beers, wines and liquors:** These are enjoyed across Europe, with small-scale production existing in the U.S. Available chestnut beers include "Fuego del Otoño," a seasonal beer produced by Jolly Pumpkin Artisan Ales in Michigan, http://www.brewery.jollypumpkin.com. In addition, the Urban Chestnut Brewing Company in St. Louis, Missouri, brews "Winged Nut" chestnut beer, https://www.urbanchestnut.com/. |
|  | **Frozen, peeled chestnut meats**: The Australian Chestnut Company sells peeled chestnut meats under the "Cheznuts" brand name with the tagline: "Chestnuts made easy." The product is quick and convenient for everyday cooking, www.cheznuts.com.au. |

## Chestnut Orchard Establishment Costs

**Supplies for Orchard Establishment (1 acre, 50 trees, 30' x 30' spacing)**

| Item | Cost | Quantity | Total |
|---|---|---|---|
| Drip irrigation (1,250' tubing, shutoff valve, filter, pressure regulator, air vent, PVC manifold, risers and fittings) * | $445.50 | 1 | $445.50 |
| Fertilization costs (ammonium nitrate) | $45 | 1 | $45 |
| Herbicide strip at base of trees | $130 | 1 | $120 |
| Grafted chestnut trees – 50 wholesale | $16.95 | 50 | $848 |
| Shipping costs | $0.75 | 50 | $38 |
| 10' support stakes | $6 | 50 | $250 |
| Fencing – 100' welded wire fence 60" tall – cut to make tree cages ** | $138 | 5 | $690 |
| Rebar for staking cages down | $195 | 1 | $195 |
| Leaf analysis – 3 samples | $40 | 3 | $120 |
| **Year 1 Orchard Establishment Total** | | | **$2,810.50** |
| Fertilization costs (ammonium nitrate) | $90 | 1 | $90 |
| Herbicide strip at base of trees | $130 | 1 | $130 |
| Leaf analysis – 3 samples | $40 | 3 | $120 |
| **Year 2 Supplies Total** | | | **$340** |
| Fertilization costs (ammonium nitrate) | $135 | 1 | $135 |
| Herbicide strip at base of trees | $120 | 1 | $130 |
| Leaf analysis – 3 samples | $40 | 3 | $120 |
| **Year 3 Supplies Total** | | | **$385** |
| ***Total costs for orchard establishment (1 acre, 50 trees, 30' x 30' spacing)*** | | | **$3,535.50** |

*Does not include costs to establish water source (well or pond) or pumps.

## Chestnut Grower's Calendar

Attention to your markets is a year-round activity. National Chestnut Week, typically the third week in October, is a great opportunity to promote your crop through festivals, retail sales, farmers' markets or on-farm events. Learn more about National Chestnut Week at Chestnut Growers of America (CGA) online, www.chestnutgrowers.org.

| Month | Non-Bearing Trees | Bearing Trees | Pest Management |
|---|---|---|---|
| January | Plan grafting efforts | Maintain equipment | Maintain equipment |
| February | Collect scion wood; Prune trees | Prune orchard | |
| March | Fertilize trees; Plant bare-root or grafted trees | Prune orchard; Fertilize trees | |
| April | Apply weed control | Apply weed control | |
| May | Graft trees to recommended cultivars | Keep groundcover mowed | Field survey for potato leafhopper damage; apply carbaryl as needed |
| June | Water newly planted trees; Stake new grafts | Keep groundcover mowed | Field survey for caterpillars |
| July | Prune off suckers below new grafts | Keep groundcover mowed | Field survey for caterpillars; Install protection at planting |
| August | Make sure newly planted trees have adequate water | Keep groundcover mowed; Irrigate as needed | Scout for weevils; Apply carbaryl as needed |
| September | Establish cool season cover crops | Harvest promptly; Clean and market nuts; Irrigate as needed | Refrigerate nuts to retard mold development; Hot water treatment for weevil control |
| October | Plant container-grown trees | Finish nut harvest; Market crop | Install rabbit and vole protection |
| November | | Market crop | |
| December | | Market crop | |

## Additional Chestnut Resources

### *Mountain Gentry Chestnut Research Farm and Nursery*

2333 State Highway 1025
Olive Hill, KY 41164
(606)547-8090
www.mountaingentry.com

### *Forrest Keeling Nursery*

PO Box 135
Elsberry, MO 63343
800-356-2401
www.fknursery.com

### *Empire Chestnut Company*

3276 Empire Rd. SW
Carrollton, OH 44615
330-627-3181
www.empirechestnut.com
empire@eohio.net

***NOTE:*** Caution should be exercised on buying any chestnut plant material from areas of known gall wasp infestation (Georgia, North Carolina, Ohio, Tennessee, for example).

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### *On the Web*

**University of Missouri Center for Agroforestry:**
Chestnut Market Analysis Producers' Perspective and Market Directory; chestnut nutrition information and recipes; Chestnut Roasting 101; current research; orchard irrigation layout example; chestnut weevil hot water bath treatment parts and assembly
www.centerforagroforestry.org

**The Chestnut Improvement Network**
A collection of farmers furthering chestnut breeding research for orchard nut-production. CIN is a collaboration between the UMCA and its partners
chestnutimprovementnetwork.org

**Agricultural Marketing Resource Center:**
Chestnut Market Opportunities - Assessing Upscale Restaurant Interest in Value-added Chestnut Products,
www.agmrc.org/agmrc/commodity/nuts/chestnuts/

**Chestnut Growers of America:**
http://www.chestnutgrowers.org/Calculating_the_Costs_of_Bur_Management_web.pdf

**The American Chestnut Foundation:**
www.acf.org

**Connecticut Agricultural Experiment Station: Chestnut Fact Sheets**
https://portal.ct.gov/CAES/Fact-Sheets/Plant-Pathology/Connecticut-Chestnut-Research-Breeding-and-Biological-Control

**University of Kentucky: Nut Weevils**
https://entomology.ca.uky.edu/ef206

Great Lakes Fruit, Vegetable & Farm Market EXPO Michigan Greenhouse Growers EXPO December 6-8, 2011. DeVos Place Convention Center, Grand Rapids, MI Chestnut Production Summary.
http://glexpo.com/summaries/2011summaries/webChestnut_Production.pdf#:~:text=Michigan%20State%20University%20fulbrig1%40msu.edu%20The%20long-term%20objective%20of,highly%20respected%2C%20professional%2C%20and%20entrepreneurial%20commercial%20food%20industry

***Informative Growers' Web Sites (selected):***

**University of Missouri Center for Agroforestry Resources:**
www.centerforagroforestry.org

https://centerforagroforestry.org/researchers/research-programs/

https://centerforagroforestry.org/mizzou-nut-breeding-lab/

https://centerforagroforestry.org/landowners/resources/marketing-economics/

**Chestnut Growers of America (a national network of growers):**
http://www.chestnutgrowers.org/

Chestnut Growers of America represents chestnut growers, researchers and others throughout the United States and Canada involved in the chestnut industry. The organization advocates the delivery of high quality chestnuts to the marketplace and the family's table.

**MSU Extension – Chestnuts:**
https://www.canr.msu.edu/chestnuts/

**The American Chestnut Foundation,**
www.acf.org

**Route 9 Coop (OH),**
https://route9cooperative.com/

**Chestnut Growers, Inc. (MI)**
https://www.chestnutgrowersinc.com/

**Red Fern Farm (IA)**
www.redfernfarm.com

**Cedar Hill Farms (MO)**
https://www.cedarhillfarms.com/about-us

**Cheznuts (Australia)**
www.cheznuts.com.au

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**The Chestnut Improvement Network**
With Dr. Ron Revord, UMCA and Dr. Greg Miller, Route 9 Cooperative

*Listen wherever you get your podcasts.*

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