Field Performance of Grafted and Seedling Chestnuts in New York

Ian Merwin, Miranda Kahn, and Rachel Byard

Department of Horticulture, Cornell University, Ithaca, NY 14853

Chestnuts may be a crop worth investigating for NY growers looking to diversify. Several considerations must be examined before embarking in this new direction. This report discusses various cultural practices of interest.

American chestnut (*Castanea dentata*) was once a dominant tree in forests of the Eastern US, where its small but flavorful nuts were an important food staple for wildlife, Native Americans and subsistence farmers. A devastating blight caused by the fungus *Cryphonectria parasitica* was introduced accidentally from Asia into North America around 1900 on trees imported by plant breeders seeking to improve nut quality of the American chestnut through hybridization with its Asian cousins. Chestnut blight decimated our native trees in just 50 years because they had never been exposed to the pathogen and had no genetic resistance to it. Fortunately, the Asian chestnut species (*Castanea mollissima* and *C. crenata*) are resistant to this disease. With European chestnut *(C. sativa*) stands now slowly succumbing to chestnut blight, the Asian chestnut species will continue to provide an important nut crop worldwide.

As fruit growers in the Northeast look for alternative crops for profitable niche markets, there has been renewed interest in chestnuts. Domestic production in the US is small, and most of our $20 million annual market demand is met by chestnuts imported from China, Korea, and Europe. Growers are planting chestnuts from the Southeast to the Pacific Northwest, and there are several chestnut orchards in the Finger Lakes and Hudson Valley regions of NY. Besides a potential cash crop to market, chestnut growers can expect other less tangible benefits as well. Nut trees require fewer inputs than most other fruits, and can be grown in pastures or woodlots that might otherwise not produce a marketable crop. Chestnut wood is highly resistant to decay and can be used instead of pressure treated pine for fence posts and similar purposes. Other benefits are enjoyed by those who plant a small grove of chestnuts for the sake of their pungent flowers, interesting foliage, and wildlife observation or hunting opportunities during autumn.

Because chestnuts are strictly a minor crop in the US, little horticultural information is available to assist growers in successful nut production. Those currently growing or interested in planting chestnuts often have trouble finding answers to basic horticultural questions because little research has been done on this crop in North America. This report describes our attempts to answer some of these basic preliminary questions about the feasibility of chestnut production in the Northeast.

Experimental Procedures

What varieties are best for our growing conditions? After a thorough review of the published information and available sources for chestnuts by Cornell graduate student Miranda Kahn, we selected six cultivars that appeared to be well suited to our climate in Upstate NY, and were available both as grafted and seedling trees. The six commercially available chestnut cultivars, included 'Mossbarger' (*Castanea mollissima*), 'Douglas 1A' (*C. mollissima* X *dentata*), 'Eaton' (*C. mollissima* X (*crenata* X *dentata*)), 'Skioka' (*C. mollissima* X *sativa*), 'Layeroka' (an open pollinated seedling of 'Skioka'), and 'Grimo 142Q' (an open pollinated seedling of 'Layeroka'). These cultivars and their seedling progeny were chosen because they represented a sample of commercially available cultivars thought to have enough cold tolerance and blight resistance to survive in our region. They were also available in adequate numbers of both grafted and seedling trees, a requirement for meeting our other objectives of comparing grafted and seedling tree performance, and estimating heritability in these chestnuts. We planted 25 grafted and 25 seedling trees of each variety in five randomized replicate plots each containing five trees, for a total of 300 trees. Within each plot of five trees, two were pruned and trained to an open-center form and two as central leader trees, while one tree was left unpruned and untrained.

Is it better to plant grafted or seedling chestnuts? With most fruit crops, commercial growers plant trees that are propagated by grafting mature budwood onto rootstocks, because grafted trees will be "true-to-type" and begin to bear fruit sooner than seedlings. Grafted trees are "clones" or genetically uniform populations, their performance is usually more predictable and consistent than that of seedlings. However, with chestnuts the situation is more complicated than with other fruit and nut species. One of these complications is that grafted chestnut trees cost much more than seedlings (about $20 vs. $3 per tree). Also, in the US there have been problems with delayed graft incompatibility in chestnuts that causes stunting or death of grafted trees during their early years in the orchard. This problem may be caused by genetic incompatibilities between seedling rootstocks and some chestnut cultivars. It could also result from improper grafting techniques that are complicated by the vascular anatomy of chestnut twigs, which develop cambium in discrete arched units rather than a simple circle around the stem. There are also unanswered questions about the relative vigor of grafted vs. seedling chestnuts that need to be answered in order to determine the optimum tree spacing that will allow enough row space for each tree in the mature planting.

To evaluate the trade-offs between planting costs and tree performance of grafted vs. seedling chestnuts in our experiment, we obtained trees of six cultivars that were grafted onto their own seedling rootstocks (to avoid genetic incompatibility). At the same time, we obtained seedling trees grown from these six cultivars. By comparing the performance of grafted cultivars with that of seedling trees grown from nuts of each grafted clone, we hoped to learn which of these six cultivars performed best in NY, which of them had problems with graft incompatibility, and whether some of the cultivars could produce seedling trees of comparable horticultural quality to their parents.

Another objective of our study was to estimate the extent to which important horticultural traits in chestnut are passed on from parent cultivars to their seedling progeny. Geneticists call this characteristic "heritability." Cultivars with high heritability can impart many of their desirable horticultural traits to their offspring, and are excellent candidates for selective breeding. They are also "good parents" that are likely to produce seedling trees with the desirable traits of their parents—such as yield precocity and efficiency, good nut size and quality, disease and cold resistance. Knowledge about the heritability of chestnut cultivar traits thus has practical implications for nut growers trying to decide whether it is worth making the extra investment in grafted trees. If some chestnut varieties reliably produce open-pollinated seedlings that closely resemble their mother tree, then growers could save money and avoid graft incompatibility problems by planting inexpensive seedling trees from parent varieties that have demonstrated high levels of heritability for essential horticultural traits.

Where can chestnuts be grown in the Northeast? We located the study at a Cornell research farm near Lansing NY that provided favorable conditions for chestnuts—a somewhat acid soil, good soil and air drainage, a moderating Cayuga Lake effect, and southwest facing slopes. Previous research by Miranda Kahn with seedlings in controlled environment growth chambers had shown that chestnuts would grow and produce best in sites with about 3000 Growing Degree Days (GDD base 50°F); so good exposure to afternoon sun and heat are important for this crop in our region. Chestnuts bear on flowers that bloom in early July upon current year shoots. Considering how late in the season they begin to develop with our short growing season in the Northeast, chestnut varieties that mature too late in autumn may be damaged by frost before their nuts mature. A lake-moderated site that extends the frost-free season will be beneficial for chestnuts, as for wine grapes or late ripening apples like 'GoldRush,' 'Cameo' and 'Fuji.'

How should chestnut trees be managed? Another important management question for chestnuts, pruning and training system, is also one of the least studied. Chestnuts bear on flowering laterals that develop in axillary buds on vigorous shoot growth from the previous year; so mature trees usually fruit mostly in the outer canopy margins. Hence the most productive part of mature chestnut trees is usually an outer layer of the canopy, surrounding an unproductive inner tree volume. Pruning and training systems that increase light penetration into the canopy might increase the proportion of productive wood in chestnut trees. By forming a smaller more open-center tree, such a training system could also improve pest control efficacy. In this study, we evaluated two pruning/training tree-forms—open center, and central leader—for five years during establishment of the planting. We also monitored insect pests and diseases to determine whether they could be adequately controlled.

Our experiment enabled us to make comparisons between grafted and seedling trees, among grafted varieties, among seedling varieties, and among pruning/training systems across varieties. We collected data on the following traits: 1) dates of bud break, bloom, fruit set, and nut ripening for each variety; 2) tree age at first flowering and fruiting; 3) productivity (number and size of nuts); 4) consistency of bearing from year to year; 5) tree mortality and damage from winter cold, insects and pathogens; and 6) tree vigor and form. Nutritional status and fertilizer responses were assessed by leaf analysis. The trees were obtained from commercial nurseries and planted by hand in mid-April 1995, in north-south rows on a west-facing slope close to Cayuga Lake. Tree spacing was eight meters (26.2 ft) between rows and three meters (9.8 ft) within rows. Deer protection was provided by a high fence around the orchard, and trees had plastic mesh trunk guards to protect them from meadow voles and rabbits. Weed and insect control consisted of glyphosate herbicide applications in the tree row during May and July, and carbaryl insecticide applications during June and July. Trees were drip-irrigated as needed.

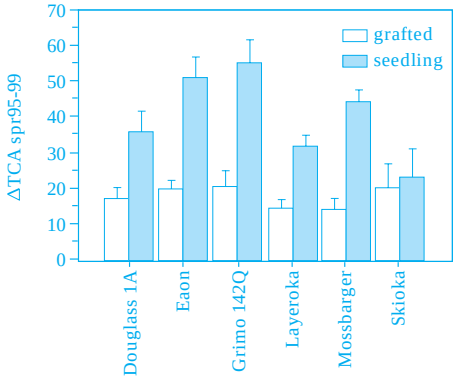

Figure 1. Cumulative increase in trunk cross-sectional area (cm^2) of six chestnut varieties as grafted or seedling trees, during five years of growth after planting in 1995. Values are means of five replications ± SE of means.

Results

Cumulative tree growth and mortality. During five years of observations, tree growth was not significantly different among the grafted cultivars, but among the seedling lineages, trees of 'Douglas1A,' 'Layeroka' and 'Skioka' were smaller than the others (Figure 1). Average trunk cross-sectional area was about twice as great for seedling trees compared with their grafted parents, and this trend was consistent for all lineages except 'Skioka.' There were also major differences in cumulative tree mortality among the cultivars and their seedlings (Figure 2). The lowest mortality rates after five years were for seedlings of 'Eaton' and 'Grimo 142Q' (both 4%), while the most tree losses occurred for grafted 'Skioka' (71%) and its seedlings (40%). For 'Douglas 1A,' 'Eaton,' 'Grimo 142Q,' Mossbarger,' and 'Skioka,' the mortality rates were two to three times greater for grafted cultivars compared with their seedling progeny.

Nut yields and quality. The grafted trees all produced some nuts in the second and third years after planting (1996-97), while seedling lineages produced only a few nuts in those early years. From the fourth year onward, both grafted and seedling trees have produced a marketable crop of nuts annually. Surprisingly, seedlings of 'Grimo 142Q' produced more nuts per tree than their grafted parent cultivar. In general, the cultivars that were more productive as grafted trees—such as 'Mossbarger,'

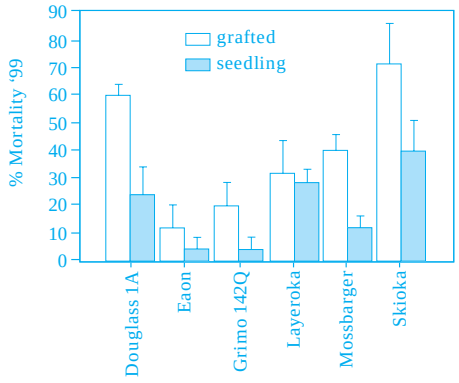

Figure 2. Cumulative mortality (percent) of grafted and seedling chestnut trees of six varieties, after five years growth. Values are means of five replications ± SE of mean.

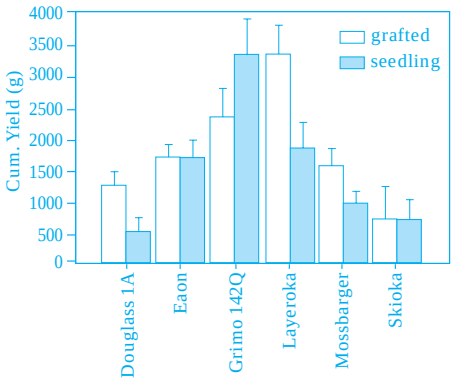

Figure 3. Cumulative yields (average grams of nuts per tree, dried to 15% moisture content) of six grafted and seedling chestnut varieties during the first five years of growth. Values are means of five replications ± SE or mean.

Figure 4. As chestnuts ripen, they expand rapidly and burst open the protective burr that surrounds them during summer as they develop. Each burr usually contains three nuts, but only one or two of them develop to maturity. These chestnuts are ready to harvest.

'Layeroka,' Grimo 142Q' and 'Eaton'—were also relatively productive as seedling trees. Heritability of the early yielding trait in these cultivars appeared to be quite high. Considering the cumulative yields of grafted and seedling trees for each cultivar, dry-weight nut production was greatest for seedlings of 'Grimo 142Q' and grafted trees of 'Layeroka' (Figure 3). Yields were equivalent for seedlings vs. grafted trees of 'Eaton' and 'Skioka,' and relatively low but greater for grafted trees of 'Douglas 1A' and 'Mossbarger.' Yield efficiency (nut yields per unit of trunk cross-sectional area) was several times greater for all of the grafted cultivars compared with their more vigorous seedlings (data not shown), even though total yields per tree were actually less for some grafted cultivars (Figure 3). Average size and dry weight per nut were slightly greater (4 vs. 6 g dry weight per nut) on grafted vs. seedling trees in the early bearing years. However, by the fourth and fifth years average nut weights were statistically similar for grafted and seedling trees, ranging from 8 to 12 g dry weight per nut. Nut size was somewhat greater on the lower yielding cultivars (e.g. 'Douglas 1A') and reduced on the heavier yielding trees. The values recorded for nut yields were for nuts dried to about 15% moisture content, to correct for differences in fresh weight values caused by rainfall during harvest time. Fresh weight values for nuts were about four times greater than dry weights, so the values in Figure 3 can be multiplied by a factor or four to estimate marketable fresh weight nut production per tree.

Discussion

Grafted cultivars generally did not provide more uniformity or consistency of yield and nut quality than their seedlings for the variables that we measured. Considering the higher costs and greater mortality of grafted trees during establishment years, there appears to be little financial reward that would justify the greater costs and risks of planting grafted chestnuts—if growers can obtain seedling trees of varieties such as 'Eaton,' 'Layeroka' or 'Grimo 142Q' that performed reliably as seedling trees. Some of the differences within these chestnut lineages were surprising. For example, 'Skioka' was the worst performing variety, while its daughter 'Layeroka' was among the most productive. We were also surprised at the yield precocity of all these cultivars and seedling trees, most of which produced nuts in the second or third year after planting.

For grafted trees, planting density could probably be increased by closer spacing than our 3 by 8 meter grid for the trees in this experiment. Most of the grafted trees have barely filled their allotted space in the tree rows at the time of this report, ten years after they were planted. A problem with higher planting densities for grafted chestnuts would be that rootstock sprouts almost always replaced grafted trees that died, and those seedlings would soon overshadow the surrounding grafted trees. For seedling orchards, a planting distance of 6 by 10 meters would be appropriate, as these trees became too crowded at the 3 by 8 meter spacing in this experiment.

Responses to pruning and training systems also differed for grafted vs. seedling trees. The less vigorous grafted trees responded quite well to open-center training, developing multiple scaffolds with relatively wide branch angles and adequate light maintained in the tree center. In contrast, open-center pruning and training of the more vigorous seedling trees produced an overly dense and shaded central area, while seedling trees developed a reasonably good pyramid form that benefited from apical dominance after five years of central-leader pruning and branch spreading.

A few general comments about chestnuts may be useful in concluding this report. With respect to marketing, the demand for chestnuts is mostly among immigrants from Asia and Europe, who live in major metropolitan areas of the US. Growers should develop a marketing plan to reach these customers before investing in a chestnut orchard. We were able to sell all of the chestnuts from our experiment for $3 per pound at a Cornell Horticulture Department's retail produce market that serves a diverse consumer base, but many of our local customers needed instruction in how to prepare chestnuts for cooking.

As our planting matured, a resident population of the chestnut-oak curculio weevil developed. This pest is native in oak acorns and fed on the American chestnut before it was decimated by blight. The chestnut weevil has a long snout and ovipositor that enable it to puncture the thick spiny integument or "burr" that protects developing chestnuts. It deposits eggs in the interior nutmeat, where they hatch in August and partially consume the nutmeat before over-wintering as inactive larvae. It is difficult to detect curculio egg-laying damage in harvested chestnuts, and some of our customers were not pleased when they spent a considerable time peeling and preparing chestnuts, only to discover

weevils inside some of them! Several well-timed insecticide sprays during July and early August may be required to control this pest in established chestnut orchards. Other than occasional European red mite flare-ups and gypsy moth infestations during some years, there were no serious insect or disease problems with our planting during this experiment.

Perhaps the greatest challenge in growing chestnuts is harvesting your nuts before the squirrels, woodchucks, raccoons, foxes, coyotes, deer, feral hogs, or bears get them! Squirrels are the most difficult wildlife pest to control, as they climb trees and sever the stems of almost mature chestnut burrs, returning later to extract the nuts when the fallen burrs have opened on the ground. The other pests can be managed if you harvest nuts every few days over the one to two week period between late September and mid October when most chestnut varieties reach harvestable maturity in NY. Chestnuts increase rapidly in size and change color from creamy white to light brown as harvest time approaches, carbohydrates convert to soluble solids and the nuts absorb water and fill out (Figure 4). During this maturation phase the nuts burst open their protective spiny covering, and within a week or so the mature nuts will drop to the ground. There is a brief window of opportunity at this time, when a picker with sturdy gloves can pull off or shake down the opening chestnut burrs and extract the one to three nuts that each contains. Once those nuts pop out of the open burrs and fall on the ground, they are difficult to find. They may also become soiled, water soaked and more prone to mold in storage, and are soon devoured by appreciative local wildlife.

Researchers in Michigan have tested pre-harvest Ethephon treatments and cherry-tree shakers as mechanical methods for harvesting chestnuts, with encouraging results. For tart cherry growers with the necessary equipment, growing chestnuts could be an option for niche markets. Otherwise, harvest labor could be a prohibitive part of production costs—especially if northeastern growers are competing with chestnut growers in China to serve the relatively limited US market for this crop.

For long-term storage, chestnuts can be disinfested with a dilute Clorox solution, and stored in airtight containers under refrigeration. Alternatively, they can be dried down to about 15% moisture content in a dehydrator or spread out in trays on a greenhouse bench. Dried chestnuts can be stored for months in airtight bags under refrigeration, but they must be boiled and rehydrated before they can be consumed or used in most recipes.

There are many economic and horticultural challenges to growing chestnuts in the US, Growers interested in a niche market fruit crop with a long history in our region, a high market value, and many delicious uses ranging from traditional turkey stuffing, to bread, cookies or elaborate French pastries, or just those nostalgic "chestnuts roasting on an open fire," might consider chestnuts. There are some good chestnut varieties available from commercial nurseries. They establish quickly and produce well in a good orchard site, grown either as grafted trees or seedlings of several varieties.

Further Reading

The Northern Nutgrowers Association meets annually in the region and publishes an informative newsletter and proceedings of their meetings. Dr. Sandra Anagrostakis **(Sandra.Anagnostakis @po.state.ct.us)** is a chestnut expert and breeder at the Connecticut Agricultural Experiment Station, and has many useful scientific and general-interest publications about chestnuts available by request. Greg Miller is a chestnut breeder and owner of the Empire Chestnut Company and nursery in Carrollton, OH. His webpage **(www.empirechestnut.com)** has excellent information and other links to relevant sites and sources for chestnut growers. The standard textbook for chestnuts and other nut trees (the Handbook of North American Nut Trees, published by R. Jaynes in 1969) is out of print but still available in many libraries. Several dozen commercial nurseries sell grafted or seedling chestnut trees, and a quick Google search will yield their contact information and catalogs.

Summary

In this project we investigated some practical questions about edible chestnut production in New York. Specifically, we wanted to know which chestnut varieties or lineages would perform best under NY growing conditions, and whether it was more economical to grow inexpensive seedling trees or more expensive grafted trees of known chestnut cultivars. We began the experiment in 1995, planting six clonal (grafted) cultivars, and six groups of seedling trees grown from nuts of each grafted cultivar. We compared a number of different traits among the six varieties and their seedlings, including: 1) tree age at first bearing, 2) nut production and quality, 3) cold hardiness and tree survival, 4) pest problems, and 5) tree vigor and form. The grafted trees began fruiting in the second year and produced more nuts per unit of trunk cross-sectional area (higher yield efficiencies). They suffered greater mortality during the first five years, however, up to 70% losses for one cultivar ('Skioka'), compared with less than 10% mortality rates for most of the seedling lineages. Cumulative yields per tree were best for 'Eaton,' seedlings of 'Grimo 142Q,' and grafted trees of 'Layeroka.' Nut size and quality were similar for grafted cultivars and their seedling progeny, and the seedlings came into production a year later than their grafted parent trees. Chestnut curculio weevil was the main pest problem, although wildlife such as squirrels, woodchucks and deer could also be a problem unless the nuts are harvested before they fall to the ground. Grafted trees responded well to open-center pruning and training, while the seedling trees were easier to manage as central leader trees. Grafted trees were about 40% smaller than their seedling progeny after 10 years. We concluded that growers could successfully produce chestnuts in upstate NY regions with lake-moderated climates. Inexpensive and hardy seedlings of chestnut cultivars such as 'Grimo 142Q,' 'Eaton,' 'Layeroka,' or 'Mossbarger' may be more economical than, and equally productive as grafted trees under our growing conditions. Harvesting chestnuts is very labor intensive, and marketing them will require careful development of a niche customer base in major metropolitan areas of the Northeast.

Ian Merwin is a research and teaching professor in the Department of Horticulture in Ithaca, NY. Miranda Kahn was a graduate student and Rachel Byard a technician in the Department of Horticulture.