# Field Grafting Improved Chestnut Cultivars to Increase Yield: An Operational Test in an Agroforestry System.

## Final Report for FNC10-833

Project Type: Farmer/Rancher
Funds awarded in 2010: $5,985.00
Projected End Date: 12/31/2013
Region: North Central
State: Missouri
Project Coordinator:

Dr. Stephen Shifley
Shifley's Nut Farm

## Project Information

Summary:

The objective of this grant was to measure the grafting success and potential increase in chestnut yields that can be gained by grafting scion wood selected from improved chestnut cultivars to young Chinese chestnut trees. The chestnut trees are part of an agroforestry operation using alley cropping to produce chestnuts in rows of trees and to produce hay in the 28-foot-wide alleyways between rows of trees. In 2011 and 2012 we successfully completed grafting three selected Chinese chestnut cultivars (Qing, Gideon, and Peach, with an ungrafted control) in a statistically designed field experiment (a replicated complete block design). We also included demonstration areas for two other cultivars: Kohr and Auburn Super. A total of 199 trees were grafted. Despite the fact that the summer of 2012 delivered a severe drought, graft success was slightly more than 90 percent. The grafted trees were not expected to produce nuts in 2012, but the ungrafted control trees were. They had been gradually increasing nut production in the preceding years. However, due to the drought, none of the ungrafted control trees produced marketable chestnuts in 2012. That was typical for other producers who did not water aggressively. We conducted outreach with a one-day grafting workshop in April of 2012 that was attended by four people from Central Missouri.

In May 2012 we got one cutting of mixed grass and legume hay from between the trees, roughly 0.75 tons of hay per acre of mixed trees and forage. The drought precluded further cuttings. Nevertheless the mixed grass and legumes continued to provide effective erosion control and appear to have rebounded sufficiently to produce hay in 2013, weather permitting. In March of 2013 we pruned trees and collected scion wood from the grafted trees for grafting later in 2013. We sent some of the scion wood to a grower in Arkansas who wrote seeking the cultivars we were working with. In subsequent years we will continue to fertilize and prune the grafted and ungrafted (control) trees and measure the mean nut yield per tree for each of the cultivars and the controls. The orchard will continue to be available for field tours by other interested growers or potential growers.

## Introduction:

In 2007 we established an agroforestry operation on 7 acres of our small farm in central Missouri. We planted Chinese chestnut trees for nut production. Between the trees planted at a 28-foot spacing we are growing hay, some of which we use for our horses and some of which we sell. This is an alley cropping system with hay produced in the “alleyways” between rows of trees. It takes 8 years or more for the chestnut trees to grow large enough to produce commercial crops of chestnuts. During that time the mixed grass and legume forage crop protects the soil and provides some income. As the trees become larger, they will increasingly shade the forage crop and reduce hay production. But the loss of forage should more than be offset by the value of the chestnut crop.

Training from the chestnut experts at The Center for Agroforestry at the University of Missouri taught me that grafting chestnut trees with scion wood from chestnut cultivars with proven high productivity is necessary to ensure large crops of high-quality nuts in the future. (Virtually all fruit and nut trees in commercial orchard operations are grafted in this way.) I set up an experimental design to conduct an operational comparison of the success of three different Chinese chestnut cultivars. Experts (current and recently retired) from The Center for Agroforestry at the University of Missouri helped me identify three promising chestnut cultivars for the experiment. I used funds from the SARE grant to hire an expert grafter to graft scion wood from the selected cultivars to chestnut trees that were already established in my agroforestry system.

This report describes the field experiment and the early results in detail. Results are complete for evaluating the survival (success) of the three selected cultivars. This project is set up for long-term monitoring of chestnut yields in future years as the trees grow large enough for commercial-scale nut production.

### Project Objectives:

The objective of this grant was to measure the increase in chestnut yields that can be gained by grafting scion wood selected from improved chestnut cultivars to young Chinese chestnut trees established in an agroforestry operation designed to simultaneously produce chestnuts and forage.

Performance was measure by:
1. Establishment of an experimental design to test outplanting of three improved Chinese chestnut cultivars
2. Grafting trees according to the experimental design
3. Measuring graft success rates
4. Maintaining grafted trees
5. Measuring chestnut yield by cultivar for 5 subsequent years
6. Reporting results of the analysis
7. Providing demonstrations or other outreach activities

# Research

### Materials and methods:

My primary chestnut orchard consists of 17 rows (Figure 1). Rows are variable in length; the longest have room for a maximum of 27 trees. Planting locations are on a 28-foot square spacing within and between rows. That spacing is designed to accommodate farm equipment to harvest hay in the alleyways between rows of

trees. I planted unimproved Chinese chestnuts, mostly of the Qing variety, beginning in 2007. The actual number of live, graftable trees in each row varies depending on row length, tree survival, and tree size; 12 to 14 trees per row are typical.

In the spring of 2011, I set up a complete, randomized block experimental design using an orchard row as a treatment unit. Each row was assigned one of four grafting treatments: (1) graft with Qing scion wood, (2) graft with Gideon scion wood, (3) graft with Peach scion wood, and (4) a control with no graft. Blocks were groups of four adjacent rows that together received a full set of treatments. There are four blocks (16 rows) in the experiment. Treatments were randomly assigned to each row within a block (Table 1).

On April 30, 2011, Dr. Ken Hunt grafted 36 trees with the three cultivars according to the experimental design. The initial scion wood came from cultivars at the Center for Agroforestry at the University of Missouri. For demonstration purposes (not part of the formal experiment) Ken also grafted scion wood from the Auburn Super cultivar on four trees adjacent to the study site.

Ken utilized three-flap (banana) grafts on trees up to about 1/2-inch in diameter at the graft union. For larger trees (1 to 5 inches bole diameter) He used an inlay bark graft with up to three pieces of scion wood grafted per tree (Figure 2). Nearly all of my established chestnut rootstocks are of the Qing variety (unimproved). Table 1 identifies the assignment of treatments and the number of grafted trees in each treatment replicate for the preliminary trial in 2011.

On March 10, 2012, Ken Hunt and I collected scion wood for 2012 grafting from the new growth of shoots that he grafted in 2011. I purchased Peach scion from another chestnut grower in central Missouri.

Over three days in April 2011, Dr. Hunt used the same techniques to graft an additional 140 trees in the experiment. That brought the total number of grafted trees in the experiment to 176 as shown in Table 1. An additional 23 of the Auburn Super, Kohr and Qing cultivars were grafted in an area of the orchard devoted to demonstration (Table 2). Thus, a total of 199 trees were grafted

Maintenance of grafted Chinese chestnut trees included the following:
• I staked each grafted tree with a heavy-duty steel stake (usually 1-inch galvanized electrical conduit).
• As it grew, I secured the shoot of the grafted scion wood to the steel stake at one-foot height increments.
• I caged each grafted tree with welded wire to a height of 5 feet to minimize deer damage.
• Each year I applied a fertilizer (20-10-10) with slow release nitrogen around the drip line of each tree in the early spring (shortly prior to leaf out) and again in mid-June.
• Each year I mowed tree rows twice during the growing season
• Each year I applied glyphosate herbicide (1.5%) around each tree twice (April and July) to achieve a treated diameter on the ground equal to approximately the tree height.
• I watered grafted trees once per week during periods when we did not receive significant rainfall. August and September 2011, and June through August 2012, were exceptionally dry.

- Table 1
- Table 2
- Figure 1

- Figure 2

Research results and discussion:

The grafting was highly successful. Out of 176 grafted trees in the experiment, 163 grafts (93%) were successful (Table 3). This is despite a near record drought in 2012 (26 inches of precipitation, a 9 inch deficit relative to the 30-year normal of 35 inches). When the data were analyzed by block and treatment row according to the experimental design, the mean graft survival rates by cultivar were Gideon 90 percent, Peach 90 percent, and Qing 92 percent. Statistically there were no significant differences among the cultivars in graft success.

The overall graft success rate for the 23 trees in the demonstration area was 83 percent (see Table 4). Graft survival rates by cultivar were Auburn Super 75 percent, Kohr 75 percent, and Qing 91 percent.

The shoot height growth of the scion wood grafted on established rootstocks was impressive. Some grafted shoots grew six feet in 2012; growth of three feet was typical. That is twice the typical height growth for the ungrafted trees. The drought in 2012 required considerable time devoted to watering trees in June through August using a truck-mounted water tank.

We knew that the grafted trees would produce few nuts in the first few years following grafting. The expectation is that nut yield and quality of grafted trees will gradually increase and surpass that of the ungrafted control trees. We will monitor nut yield by cultivar (following the experimental design) for at least the next five years to determine what differences in yield result from different cultivars. In previous years the ungrafted control trees produced crops of chestnuts. Due to the drought the chestnut yield from the control trees was virtually nonexistent in 2012. Few trees produced burs (the seed case that typically holds two or three chestnuts) and those that did contained undersized chestnuts. It is likely that I will need to add an irrigation system to my orchard to deal with future droughts. That option is discussed further in subsequent sections.

In May 2012 we got one cutting of mixed grass and legume hay from between the trees, roughly 0.75 tons of hay per acre of mixed trees and forage. The drought precluded further cuttings in 2012. Nevertheless the mixed grass and legumes continued to provide effective erosion control and appear to have rebounded sufficiently to produce a good hay crop in 2013, weather permitting.

We have established an operational field trial of promising chestnut cultivars in an agroforestry system using alley cropping for hay production between rows of trees. Graft survival and chestnut yields by cultivar will continue to be monitored for yield in coming years.

- Table 3
- Table 4

## Impact of Results/Outcomes

• Grafted 199 trees according to a statistical experimental design
• Measured graft success in 2011 and 2012; total graft success greater than 90 percent.
• Established a working agroforestry demonstration site with 265 trees including 5 grafted chestnut cultivars and forage production in the alleyways between rows of trees.

• Held a grafting demonstration in April 2012 (see Publications/Outreach section)
• Attended the North American Chestnut Farm Workshop (August 2012) where I:
  o Met other chestnut growers from the U.S. and abroad
  o Saw demonstrations of chestnut harvesting systems
  o Saw demonstrations of chestnut processing operations
  o Learned about chestnut marketing, and value-added chestnut products
  o Learned about potential insect, disease, and nut predation problems
  o Learned about current chestnut research
  o Learned about alternative ground cover management strategies to control competing vegetation and increase nut harvest efficiency.
• Learned much about practical chestnut orchard husbandry though working with Dr. Ken Hunt.
• Established an ongoing field experiment to monitor chestnut yields by cultivar over time. This experiment is in a practical agroforestry setting and subject to the variation in tending and cultivation practices typical of a part-time business operation as opposed to a full time research operation.

**Participation Summary**

## Educational & Outreach Activities

### PARTICIPATION SUMMARY:

Education/outreach description:

We held a one-day grafting workshop on April 28, 2012. During the workshop Ken Hunt demonstrated chestnut grafting techniques to four attendees from Boone and Audrain Counties.

The demonstration site will remain available for field tours. We will report results of chestnut yield trials in future years as they become available.

## Project Outcomes

Recommendations:

### Potential Contributions

We have established a demonstration site for five chestnut cultivars and a long-term experiment to monitor yield of three chestnut cultivars specifically recommended for central Missouri. It will continue to serve as demonstration area for a combined forage and chestnut agroforestry system with alley cropping. Over the next five years we will continue to monitor graft survival by cultivar and chestnut yield by cultivar.

### Future Recommendations

I will annually measure chestnut production by cultivar for 2013 to 2017.

It will be important to maintain trees in a productive condition. This will require the following annual practices:
• Keep shoots of the grafted scion wood secured to a heavy-duty stake to a height

of approximately 8 feet
• Keep grafted trees caged with welded wire to a height of 5 feet to minimize deer damage
• Prune trees each winter to develop desirable form
• Prune grafted trees periodically during the growing season to limit the growth of shoots and sprouts that emerge from the original rootstock
• Apply fertilizer with slow release nitrogen beneath the drip line of each tree in April (shortly prior to leaf out) and again in mid-June.
• Apply glyphosate herbicide (1.5%) twice (April and July) around each tree to achieve a treated diameter on the ground equal to approximately the tree height
• Mow other vegetation within tree rows as necessary to control weeds
• Water grafted trees as necessary during periods when rainfall is insufficient.
• Whitewash tree trunks as necessary to prevent sunscald
• Once or twice per summer cut hay in alleyways between rows of trees for forage production and to control undesirable weeds.

I will need to make a decision about running permanent irrigation lines to the trees. My current method of watering trees with a truck-mounted water tank is extraordinarily time consuming. That method can keep trees alive during periods of drought, but it will be insufficient to ensure adequate nut set and sufficient nut size--especially as the trees get larger in size.

I will continue to look for opportunities to sell scion wood from growth on grafted trees that is pruned each winter to control tree form.

I will continue to look for opportunities to host field visits to my agroforestry system using alley copping.

I will continue to maintain relationships with scientists and technicians at The Center for Agroforestry at the University of Missouri. They have been key to increasing my understanding of agroforestry systems in general and growing chestnuts in particular.
I will look to them for guidance in my next steps of developing efficient procedures for chestnut harvesting, processing, and marketing.

I will continue to talk with others about the benefits and difficulties of operating an agroforestry system with chestnuts as a component. Agroforestry can be demanding because it requires multiple skill sets: (1) growing and maintaining trees, (2) growing one or multiple agronomic crops, and sometimes (3) marketing nontraditional crops such as chestnuts. Agroforestry seems well suited to small acreages or areas unsuitable for row crops due to topography or location. It seems swell suited to owners/managers who have broad interests, are innovative, enjoy solving problems, and are motivated to be closely involved in the day-to-day farm operations. It seems well suited to owners who have sufficient resources to commit to a multi-year startup investment of funds, labor, and energy.

This site is maintained by SARE Outreach for the SARE program and is based upon work supported by the National Institute of Food and Agriculture, U.S. Department of Agriculture, under award No. 2019-38640-29881. SARE Outreach operates under cooperative agreements with the University of Maryland to develop and disseminate information about sustainable agriculture. USDA is an equal opportunity provider and employer.

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