Restoration of Chestnuts as a Timber Crop in Connecticut

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Abstract

American chestnut trees were an important source of timber in Connecticut until chestnut blight disease reduced them to understory shrubs. Breeding begun in 1930 has now produced trees with enough resistance to initiate field trials in the forest. Biological control by hypovirulence viruses is being used in the plots in an effort to keep native trees alive. If native trees cross with the planted trees with resistance, future generations should have increased resistance to chestnut blight disease and the genetic diversity of the population will be increased.

INTRODUCTION

Connecticut (CT) was heavily forested in 1600, but by the early 1800s, agricultural use of the land resulted in forest cover of approximately twenty percent of the state. Since much of the land is no longer farmed, trees have been allowed to grow, and the state now has about sixty percent tree cover. In 1910, when chestnut blight disease started killing CT chestnut trees, half of the standing timber was American chestnut (*Castanea dentata*) and there were about 130 million mature American chestnut trees in the state (Anagnostakis calculations from CT state records). The trees grew straight to heights of eighty feet, and after clear-cutting, they easily out-competed other hardwoods to dominate the forests.

In 1930, Arthur Graves made his first crosses of American and Japanese chestnut (*C. crenata*) and planted them on his family's land in Hamden, CT. He then began a long collaboration with geneticist Donald Jones at The Connecticut Agricultural Experiment Station (CAES). Graves gave the state of CT land in Hamden, CT with plantings of chestnut species and hybrids, to insure the continuation of Connecticut's chestnut breeding program. The CAES collection includes all of the species and most of the possible hybrids of chestnut, making it an extremely valuable resource for the breeding program. Graves' students, Hans Nienstaedt and Richard Jaynes, made many of the hybrids that are still part of the current breeding program.

The breeding plan was based initially on crossing blight-resistant Asian trees with susceptible American trees, and evaluating the hybrids for resistance to chestnut blight disease. When it became clear that at least two genes were responsible for this resistance, CAES began a backcross breeding program based on the plan of Charles Burnham (Burnham, 1988).

In order to control pollination, female flowers are bagged in late June to protect them from pollen from other trees; bags are removed and selected pollen is applied to the flowers in July and the bags put back in place. Trees of two forms are being chosen: trees for timber which are tall and straight, with little energy put into forming nuts; and, trees for nut production which are short and spreading, with maximum energy put into forming large, good-tasting nuts. Both tree forms must have resistance to chestnut blight disease and be well-adapted to the climate of the northeastern USA. Selections also are being made of trees with resistance to ink disease, caused by the root pathogen *Phytophthora cinnamomi*, even though this organism rarely over-winters in northern climates. Asian chestnut gall wasp (*Dryocosmus kuriphilus*) is now present in our orchards and selections for resistance to this pest also are underway (Payne et al., 1976). Jerry Payne (USDA, Byron, GA, retired) has observed that American and Chinese chinquapins (*Castanea*

pumila, *C. ozarkensis*, and *C. henryi*) resist infestation, and some cultivars of Japanese chestnut (*C. crenata*) are reported to have some resistance.

After importing hypovirulent (virus-containing) strains of *C. parasitica* from France in 1972, we demonstrated that we could mitigate blight disease on American chestnuts with hypovirulent strains of the fungus (Anagnostakis and Jaynes, 1973). Orchards of *C. dentata* from northern seed sources were then planted as a breeding resource. Chestnut blight cankers on the trees were inoculated with hypovirulent strains of the fungus, resulting in ten-to-fifteen percent of the trees surviving and fruiting (Anagnostakis, 1990).

The crosses that produced blight-resistant trees for timber have, by necessity, used a rather narrow genetic base, even though different trees were used as parents in each generation. Since the native populations of American chestnuts in Connecticut continue to sprout, by using hypovirulent strains of the pathogen for biological control, we are able to keep many of them alive and flowering until the competition from other tree species sprouting in the plots becomes severe. CAES now plants resistant trees from the breeding program in forest clear cuts with native chestnut trees and treats cankers on native chestnut trees with hypovirulent strains of the pathogen to keep some alive long enough to flower. If these cross with the planted trees, future generations of chestnuts will have trees with blight resistance, ink disease resistance, gall wasp resistance, and all of the native genetic diversity.

MATERIALS AND METHODS

To date, CAES has crossed Japanese or Chinese (*C. mollissima*) chestnuts with good resistance to chestnut blight disease with American chestnuts, crossed the hybrids again to American for two or three successive generations, (second or third back-crosses, BC_2 and BC_3, respectively) and selected the offspring for resistance to blight. Plantings of backcross seedlings were made in five Connecticut towns: Prospect in 2000; Burlington in 2002; Farmington in 2006; Hampton in 2007; and Vernon in 2009. One planting was made on Long Island, in Manhasset, New York in 2009. There is deer fencing around only the Vernon plot, but the other Connecticut plantings are heavily impacted by deer browse. There are no deer in the area where trees were planted in Manhasset, New York.

Chestnut blight cankers on native chestnuts were sampled after the timber harvests, *Cryphonectria parasitica* was isolated from the samples, and hypovirulence viruses transmitted to the cultures by pairing strains in the laboratory (Anagnostakis and Day, 1979). Mixtures of virus-infected strains were made to match the virulent strains in each plot, and these were used to treat cankers in the each plot for a minimum of four years.

A control plot of 209 BC_2 and BC_3 trees was planted in an open former tobacco field in Windsor, CT in 2000. A plot with 780 BC_2 x BC_3 and BC_3 x BC_3 trees was planted in Griswold, CT in 2000 with 660 trees inside a deer fence, 80 in tree tubes (Plantra® Jump Start® tubes), and 40 with no protection. No biocontrol was used in these plots, so that resistance to chestnut blight could be assessed more easily.

RESULTS

In 2012, five of the forest plots were examined and numbers of survivors noted (Table 1). The two remaining sites will be checked in the winter of 2012/2013. Planted trees in the 2000 and 2002 sites were flowering and fruiting in 2012, and native-American chestnuts were surviving in all of the plots.

In 2012, the Windsor control plot had 14 survivors of the original 209 trees planted, and the average dbh was 15.3 cm. The Griswold control plot had 455 survivors of 780 planted with an average dbh of 1.6 cm (Table 2).

DISCUSSION

Crosses of our native-American chestnut trees with the introduced hybrids will result in first generation offspring that are intermediate for resistance to chestnut blight

disease, but in subsequent generations, trees with full resistance to the pathogen can be produced. Studies are now underway to find the best methods to plant chestnuts in forested areas, and using the results of Clark et al. (2014) and Pinchot et al. (2014) we hope to increase survival and have chestnut trees available again as a timber source in Connecticut.

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Tables

Table 1. Survival and average dbh of timber hybrid chestnut trees planted in forest clear-cuts in Connecticut and New York. Measurements were made in the summer of 2012.

Town	Year planted	Planted	Type	Survival	Avg. dbh (cm)
Prospect 1	2000	40	BC_2 and BC_3	7 (18%)	13
Prospect 2	2000	61	BC_2 and BC_3	20 (33%)	6.8
Burlington	2002	20	BC_2 and BC_3	17 (85%)	3.2
Vernon	2009	155	$BC_2 \times BC_3$	110 (71%)	1.5
Manhasset	2009	100	$BC_2 \times BC_3$	84 (84%)	3.9

Table 2. Survival and average dbh of timber hybrid chestnut trees planted in open fields in Connecticut as controls. Measurements were made in the summer of 2012.

Town	Year planted	Planted	Type	Survival	Avg. dbh (cm)
Windsor	2000	209	BC_2 and BC_3	14 (7%)	15.3
Griswold	2009	360	$BC_2 \times BC_3$ fenced	231 (64%)	1.4
Griswold	2009	40	$BC_2 \times BC_3$ tubes	32 (80%)	1.7
Griswold	2009	20	$BC_2 \times BC_3$ open	10 (50%)	1.6
Griswold	2009	300	$BC_3 \times BC_3$ fenced	147 (49%)	1.3
Griswold	2009	40	$BC_3 \times BC_3$ tubes	25 (63%)	3.1
Griswold	2009	20	$BC_3 \times BC_3$ open	10 (50%)	2.9