Preliminary Report on the Segregation of Resistance in Chestnuts to Infestation by Oriental Chestnut Gall Wasp

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Abstract

In 1995, hybrid chestnuts were planted in North Carolina, (southern U.S.A.), where the introduced insect Oriental Chestnut Gall Wasp (*Dryocosmus kuriphilus*) is present. Of the 93 trees planted, 53 survived 12 years and were evaluated for the presence of Oriental Chestnut Gall Wasp infestation. Among the survivors, 11 had no wasp galls and 25 had few galls. Because the female parents were all susceptible, the genes controlling resistance to infestation cannot be cytoplasmic. Numbers of trees with little or no infestation suggest that genetic control may be a single, dominant nuclear gene. If this is true, resistance can easily be transferred into timber chestnuts and orchard chestnut cultivars.

INTRODUCTION

Oriental Chestnut Gall Wasp, *Dryocosmus kuriphilus*, (Payne et al., 1976) has now spread from the state of Georgia in the southern United States, where it was introduced in 1974, to most of the southern growing area of chestnut trees in the United States, and to Cleveland, OH in north-central U.S. (Fig. 1) (Stehli, 2003, 2006). There is apparently nothing to stop it moving north, throughout the native range of American chestnut trees. Eggs are laid in leaf and flower buds, and the resulting galls kill the leaves and flowers and sometimes result in death of the trees. No pesticides are registered for control of this insect. Allegheny (American) chinquapin, *Castanea pumila*, and Chinese chinquapin, *C. Henryi*, seem to be resistant to infestation (Anagnostakis, 1998), and all other species of *Castanea* are susceptible to infestation. Breeding experiments were therefore begun to study the genetic control of this resistance, and to produce *Castanea* that can survive in the presence of the insect for both forest and orchard plantings. In 1995, hybrid chestnuts were planted in the state of North Carolina, in cooperation with the U.S. Forest Service, to test the trees for resistance to infestation in an area where Oriental Chestnut Gall Wasp was present.

MATERIALS AND METHODS

The study was installed at 760 m elevation in the Southern Appalachian Mountains (35°30'N, 82°37'W) about 16 km southwest of Asheville, NC (Fig. 1). The study site was located along an edge of a large (>4 ha) forest opening that had been cleared of vegetation in 1994. The trees surrounding the study site were primarily scarlet oak (*Quercus coccinea*) and white oak (*Q. alba*) with an understory of red maple (*Acer rubrum*) and sourwood (*Oxydendrum arboreum*); scattered root sprouts of American chestnut (*Castanea dentata*) were also present. The study site was 0.05 ha, consisting of five rows spaced 3.05 m apart, and trees were spaced 1.5 m apart within each row.

The hybrids planted all had American chestnut trees as the female parent, and either *C. ozarkensis* X *C. mollissima* (Ozark chinquapin crossed with Chinese chestnut) or *C. pumila* X *C. crenata* (Allegheny chinquapin crossed with Japanese chestnut) as a male parent. The hybrids were from hand-pollinated crosses made in 1993 in Connecticut (seed planted in April 1994). A total of 93 seedlings were dug in April 1995 and delivered to the planting site in early May 1995. We used a completely randomized experimental design consisting of single-tree plots and no perimeter buffer row. Competing vegetation

in the acidic (pH<5.5) silty to sandy loam sediment material consisted mostly of blackberry (*Rubus* spp.) canes, which were cut at ground level during the late winter of each year. Most of the seedlings had grown to sapling size by 1999 and had formed a closed canopy that shaded competing vegetation. The seedlings were measured in November 2006, after 12 growing seasons, and examined for Chestnut Blight Disease cankers on the trunks and evidence of wasp infestation.

RESULTS

About half of the trees (53/93) survived to 2006, and 36 of those had few or no wasp galls. The average trunk diameter at 1.4 m was 9 cm and the average height was 9 m. Among the survivors, 64% had little or no observable Chestnut Blight Disease, and 62% of those had few or no galls. Those with *C. pumila* X *C. crenata* as a male parent had the most survivors in 2006 (36 of 49 planted). Of those, 25 had little or no blight and14 of the 25 had few or no galls. Survivors with *C. ozarkensis* X *C. mollissima* as a male parent were 17 out of 44 planted. Nine of these 17 survivors had little or no blight, and seven of those nine had few or no galls.

DISCUSSION

Oriental Chestnut Gall Wasp has been a serious problem in Japan for many years, and efforts have been made to select cultivars with some tolerance to the insect. Kotobuki and his colleagues (Kotobuki et al., 1984) made 26 crosses (770 total progeny) of Japanese cultivars of chestnut, and rated them for presence of galls. By combining their "no galls on tree" and "very small number of galls on weak twigs" categories as "resistant", 50% or more of the progeny of 11 crosses were resistant when rated after 5 or 6 years. Cultivar 'Ginrei' was in this group five times when used as a female parent and twice when used as a pollen parent. Others were less frequently represented. No conclusions were made in this paper about genetic control, but Kotobuki said "In the family from highly resistant parents to chestnut gall wasp such as 'Ginrei' and 'Ishizuchi', seedlings with higher resistance than 'Tanzawa' or 'Tsukuba' are obtained with significantly higher ratio." None of these cultivars are available in our collection, and no current information is available about how well the resistance has held up in the presence of Oriental Chestnut Gall Wasp in Japan.

We expected genes from the Asian chestnut parents to impart partial resistance to Chestnut Blight Disease to a fraction of the hybrids. This would allow some trees to survive to become large enough to be rated for wasp resistance. The stress of cankers on the trees might also make them more attractive to the wasp, although there were gall-free trees among those with many cankers. To eliminate this possible bias, only the trees with good to moderate blight resistance were considered in our scoring for lack of galls. Resistance to Oriental Chestnut Gall Wasp could be inherited from the Allegheny chinquapin parent, and we used the closely related Ozark chinquapin parent on the assumption that it, too, would have resistance. If the genes for resistance were in the cytoplasm, none of these hybrids would have any resistance, since American chestnuts (the mother-trees) are susceptible. If nuclear genes for resistance were dominant, progeny of the first cross of [resistant X susceptible] would all be resistant. The hybrids that we used are a cross of [susceptible] X [resistant X susceptible], and the resistance phenotypes should be segregating among the progeny. We would expect half of the progeny to be resistant if resistance was controlled by a single dominant gene, one out of four if two dominant genes, or one out of eight if there were three dominant genes.

Since there is segregation for wasp infestation among the surviving hybrids, the genes for resistance to infestation cannot be cytoplasmic. The numbers of survivors are too small to determine the exact number of resistance genes in the Ozark chinquapin and Allegheny chinquapin parents. However, seven of the nine Ozark descendants with good to moderate Chestnut Blight Disease resistance had few or no galls, and 14 of the 25 Allegheny descendants with good to moderate Chestnut Blight Disease resistance had few

or no galls. These numbers are close enough to "half" that we can hypothesize that a single dominant gene controls the resistance to Oriental Chestnut Gall Wasp.

New crosses were made in 2006 using *Castanea Henryi*, the Chinese chinquapin, and *C. ozarkensis*, the Ozark chinquapin. Larger numbers of progeny will help us determine whether resistance to Oriental Chestnut Gall Wasp is simply inherited. If so, that resistance can easily be transferred by breeding to timber and orchard chestnut types at risk.

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Figures

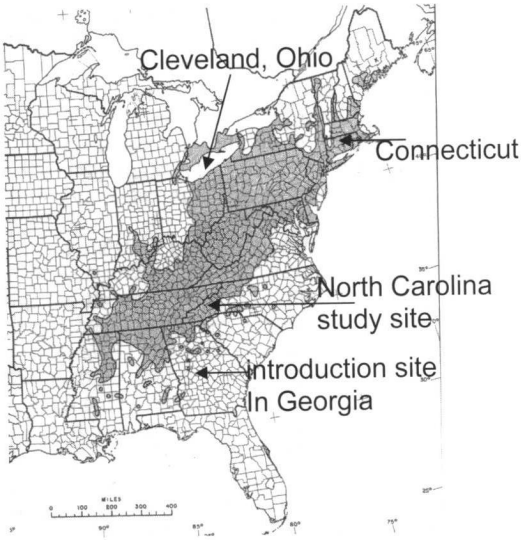

Fig. 1. Native range of American chestnut trees (*Castanea dentata* (Marsh.) Borkh.) in the eastern United States. Trees were bred in Connecticut, and planted in a study site in North Carolina. Gal wasp was first introduced into Peach County, Georgia, and is now found in Cleveland, Ohio. Map from J.R. Saucier, 1973, USDA Forest Service Fact Sheet 230.