Annual Report of the Northern Nut Growers Association (2011) 101:15-17

Resistance of chestnut trees to infestation by Asian chestnut gall wasp

Sandra Anagnostakis*, Stacy Clark[1], and Henry McNab[2]

*The Connecticut Agricultural Experiment Station, P.O. Box 1106, New Haven, CT 06504, Sandra.Anagnostakis@ct.gov, office phone 203-974-8498, fax 203-974-8502, [1]USDA/Forest Service, Southern Research Station, Upland Hardwood Ecology and Management Research Work Unit, The University of Tennessee Department of Forestry, Wildlife, and Fisheries, 2431 Joe Johnson Dr., Knoxville, TN 37996-4563, and [2]USDA Forest Service, 1577 Brevard Rd., Asheville, NC 28806

Keywords: chestnut trees, *Castanea*, chestnut gall wasp, *Dryocosmus*

Abstract

Asian chestnut gall wasp (*Dryocosmus kuriphilus*) was introduced into Georgia (USA) in 1975 and has been spreading north throughout the range of American chestnut (*Castanea dentata*). This pest is now present throughout most of Tennessee. In 2003, it was found near Cleveland, Ohio and has been spreading south from there. In 1995, hybrid chestnuts with *C. dentata* female parents and two Ozark chinquapin X Chinese chestnut male parents (*C. ozarkensis* X *C. mollissima*) were planted in North Carolina, where this introduced insect is now naturalized. Of the 93 trees planted, 69 survived four years, and 36 were still surviving after 14 years. The surviving trees were evaluated for the presence of Asian chestnut gall wasp galls in 2006 and 2009. After 14 years, the progeny of one male parent had 67% survival and of the other, 16% survival.

Among the survivors, 31 had no wasp galls in 2009 and 4 had 10 or fewer galls. The four female parents (American chestnuts and half-sibs) were assumed to be fully susceptible, so the genes controlling resistance to infestation cannot be cytoplasmic. If resistance is conferred by one or two nuclear genes, resistance can easily be transferred into timber chestnuts and orchard chestnut cultivars.

INTRODUCTION

Asian chestnut gall wasp, *Dryocosmus kuriphilus*, (Payne et al. 1976; Rieske, 2007) has now spread from the state of Georgia, where it was introduced in 1974, to most of the southern growing area of chestnut trees in the United States, and to the vicinity of Cleveland, OH (Rieske, 2007; Stehli, 2003; Stehli, 2006). American and Chinese chestnuts (*Castanea dentata* and *C. mollissima*) all appear to be susceptible to this pest (Payne et al 1976). At present there are few predators to stop gall wasp from moving throughout the range of American chestnut trees (Cooper et al., 2007). Eggs are laid in leaf and flower buds, the developing galls kill the leaves and flowers, and infestations can result in tree death. The pest was found in northern Italy in 2002, and European chestnut (*C. sativa*) and many commercial hybrids were infested with levels serious enough to result in significant tree mortality (Sartor et al., 2009). No pesticides are currently registered for control of this insect. 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 Asian chestnut gall wasp was present.

MATERIALS AND METHODS

The research plot was established at 760 m elevation in the Southern Appalachian Mountains (35°30'N, 82°37'W) about 16 km southwest of Asheville, NC where both chestnut blight disease (caused by *Cryphonectria parasitica*) and Asian chestnut gall (*D. kuriphilus*) were present. 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 (*C. 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 female parents of the hybrids planted were four different American chestnut trees that were half-sibs, and the male parents (called M1 and M2) were two different trees of *C. ozarkensis* X *C. mollissima* (Ozark chinquapin crossed with Chinese chestnut; the Ozark chinquapin and Chinese chestnut parents of these two trees were not the same) (Table 1) and both male parents had good resistance to chestnut blight disease. 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 (bare-root) 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 for the first four years of the study. Most of the seedlings had

grown to sapling size by 1999 and had formed a closed canopy that shaded competing vegetation. The trees were examined in the fall of 2006 (Anagnostakis et al., 2009) and 2009, and the presence of chestnut blight disease cankers on the trunks and galls on terminal branches were recorded.

RESULTS

In 1999, 26 of the 44 hybrids with M1, and 43 of the 49 hybrids with M2 were still alive. By 2006, 17 of 44 and 36 of 49 survived; by 2009, the survival rate fell to 7 of 44 and 29 of 49 respectively for M1 and M2 progeny. In 2009, all but one of the survivors had cankers of chestnut blight disease on their trunks (i.e., one tree had no cankers) and seven had died to the ground and had large sprouts with small blight cankers.

In 2006, 36 of the total 53 survivors had few (one to 10) or no wasp galls. In 2009, 35 of the 36 survivors had few or no wasp galls (Table 2).

DISCUSSION

Asian chestnut gall wasp has been a serious problem in Japan on Japanese chestnut (*C. crenata*) for many years, and efforts have been made to select cultivars with some tolerance to the insect. Kotobuki and his colleagues (1984) made 26 crosses (770 total progeny) of Japanese cultivars of chestnut, and rated them for presence of galls. When rated after 5 or 6 years, 50% or more of the progeny of 11 crosses had "no galls on tree" or "very small number of galls on weak twigs." Cultivar 'Ginrei' conferred resistance to progeny five times when used as a female parent, and twice when used as a pollen parent. Other cultivars used in crosses had fewer resistant progeny. The

authors did not offer any conclusions about genetic control of resistance to gall wasp infestation. However, Kotobuki said that significantly more offspring had resistance if the parents were cultivars with good resistance than if the parents were less resistant. Sartor *et al*. (2009) reported that cultivar 'Bouche de Betizac' (a Japanese X European hybrid) showed good resistance to infestation in their tests. 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 Asian chestnut gall wasp in Japan.

We expected genes from the Chinese chestnut parents to impart partial resistance to chestnut blight disease to some of the hybrids. This would allow some trees to survive long enough to be rated for gall wasp resistance. Chinese chestnut trees have never been reported to have any resistance to gall wasp infestation. Because gall wasp resistance was observed in Allegheny and Chinese chinquapins (*C. pumila* and *C. henryi*) (Anagnostakis, personal observation), we used male parents that were Chinese chestnut crossed with Ozark chinquapin (*C. ozarkensis*), which is a timber tree (unlike *C. pumila*) with more winter hardiness than *C. henryi* and some resistance to chestnut blight disease (Anagnostakis, personal observation). If the Ozark chinquapins had genes for resistance to gall wasp infestation in their cytoplasm, the *C. ozarkensis* X *C. mollissima* trees used as male parents would have carried these genes, but none of our planted hybrids would have any resistance, since American chestnuts (the mother-trees) all appear to be susceptible. If nuclear genes for resistance were dominant, 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 was segregation for susceptibility to gall wasp infestation among our 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 male parents. The 28 of the 36 surviving hybrids with good to moderate chestnut blight disease resistance all had few or no galls.

New crosses will be made and tested in the future. Larger numbers of progeny will help us determine whether resistance to Asian chestnut gall wasp is simply inherited. If so, that resistance can easily be transferred by breeding to timber and orchard chestnut types at risk.

ACKNOWLEDGEMENTS

This work was supported by the USDA Forest Service, and by McIntire-Stennis grant #631 from the USDA. A preliminary report on this work was made at the Workshop on Chestnut Management in Mediterranean Countries in Turkey in 2007. The assistance of Pamela Sletten during all of this work is gratefully acknowledged.

Literature Cited

Anagnostakis SL (1998) Chestnuts in Georgia. Annu. Rept. Northern Nut Growers Assoc. 89:5-14

Anagnostakis SL, Clark S, McNab H (2009) Preliminary report on the segregation of resistance in chestnuts to infestation by oriental chestnut gall wasp. Acta Hort. #815, ISHS, A. Soylu and C. Mert eds., p.33-37

Cooper WR, Rieske LK (2007) Community associates of an exotic gallmaker, Dryocosmus kuriphilus, (Hymenoptera: Cynipidae) in eastern North America. Ann. of the Ent. Soc. Amer. 100:236-244

Kotobuki K, Machida Y, Sato Y, Kajiura I, Kozono T (1984) Genetics of the resistance to the Chestnut Gall Wasp (*Dryocosmus kuriphilus* Yasumatsu), harvest date, mean nut weight, and the characteristics of selected clones of chestnut: results of the fourth chestnut breeding program. (in Japanese) Bull. Fruit Tree Res. Stn. 11:43-53

Payne JA, Green RA, Lester CD (1976) New nut pest: an Oriental Chestnut Gall Wasp in North America. Annu. Rep. Northern Nut Growers Assoc. 67:83-86

Rieske LK (2007) Success of an exotic gallmaker, Dryocosmus kuriphilus, on chestnut in the USA: a historical account. Bull. Euro. and Mediter. Pl. Prot. Org. 37:172-174

Sartor C, Botta R, Mellano MG, Beccaro GL, Bounous G, Marinoni DT, Quacchia A, Alma A (2009) Evaluation of susceptibility to *Dryocosmus kuriphilus* Yasumatsu

(Hymenoptera: Cynipidae) in *Castanea sativa* Miller and in hybrid cultivars. Acta Hort. #815, ISHS, A. Soylu and C. Mert eds., p289-297

Stehli R (2003) Oriental chestnut gall wasp found in N.E. Ohio. The Nutshell 57:1&19

Stehli R (2006) Oriental Chestnut Gall Wasp in Ohio – an update. The Nutshell 60:27

Table 1. Source of the hybrid chestnut trees planted in 1995 in North Carolina in an area where Asian chestnut gall wasp (*Dryocosmus kuriphilus*) and chestnut blight disease (*Cryphonectria parasitica*) were present.

Female parent*	**Male parent 1**	**#trees planted**	**#survivors 2009**
American 1	Ozark chinquapin 1 X Chinese 1	6	1
American 2	Ozark chinquapin 1 X Chinese 1	18	1
American 3	Ozark chinquapin 1 X Chinese 1	20	5
	Male parent 2		
American 4	Ozark chinquapin 2 X Chinese 2	49	29

*The four American trees were half-sibs from a female tree in a woodlot in Rocky Hill, CT; Ozark chinquapins 1 and 2 were from Russelville, Arkansas, planted 1936 in Hamden, CT; Chinese chestnut 1 was a graft of Luther Burbank's 'Miracle', planted about 1949 in Hamden, CT; Chinese chestnut 2 was Plant Introduction #70315 planted 1930 in Hamden, CT.

Table 2. Number of trees with chestnut blight cankers (caused by *Cryphonectria parasitica*) on their trunks and number with Asian chestnut gall wasp (*Dryocosmus kuriphilus*) galls on terminal branches, in 2006 and 2009. Trees had two different male parents (M1 and M2) and the female parents were American chestnuts that were half-sibs. All were planted in North Carolina in 1995.

Male	**Blight cankers on trunks***				**Galls on terminal branches****					
	2006		**2009**		**2006**			**2009**		
	+	**-**	**+**	**-**	**0**	**1-10**	**≥11**	**0**	**1-10**	**≥11**
M1	17	0	7	0	6	7	2	6	1	0
M2	20	16	28	1	5	18	13	25	3	1

*Chestnut blight disease cankers present (+) or absent (-) on trunks; **Wasp gall numbers: 0 – no galls detected on branch terminals, 1 – 10 galls noted on branch terminals, 11 or more galls noted on branch terminals