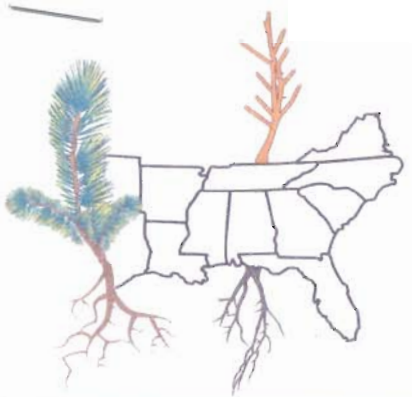

Auburn University
Southern Forest Nursery
Management Cooperative

RESEARCH REPORT 10-01

MANAGEMENT OF PHYTOPHTHORA ROOT ROT OF CHESTNUT (*CASTENEA SPP*) IN FOREST NURSERIES

by
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INTRODUCTION

Prior to the 1900s, approximately 25% of the eastern hardwood forests were comprised of American chestnut (*Castanea dentata*), which dominated the dry, rocky ridges of the Appalachian region, and extended down the slopes to the valley floor. One of the attributes that made chestnut so dominant in the forest was its ability to grow rapidly on a wide range of soil types and under a range of climatic conditions. In the early 1900s, an introduced pathogen, *Cryphonectria (Endothia) parasitica*, (Murr.) Bigelow, virtually eliminated the American chestnut. However, abundant small sprouts persist today throughout its range, which die before or soon after the tree reaches the canopy. Currently, the blight resistance of the Chinese chestnut is being backcrossed into American chestnut in a breeding program being conducted by The American Chestnut Foundation. The program is showing progress and trees suitable for testing on large areas are expected to be available by 2010 (Hebard, 2005).

Even before the introduction and subsequent spread of *Cryphonectria (Endothia) parasitica* into the forests of North America, American chestnut was already receding within its natural range from the effects of *Phytophthora cinnamomi,* the causal agent of Phytophthora root rot, also known as ink disease. Crandell et al (1945) reported that considerable mortality of American chestnut was occurring in the lower elevations of the southern Piedmont in soils that were high in clay content. *C. dentata* is particularly sensitive to Phytophthora root rot, which tends to favor cool, poorly drained soils. The fungus infects the fine feeder roots of the susceptible host, colonizing both the root and root collar. Root tissue of *Castanea* spp. infected by *P. cinnamomi* becomes brown to black in color, while root lesions produce an inky-blue exudate that stains the rhizosphere (Zentmyer 1980).

The restoration of backcross chestnut trees into eastern forests still has a few obstacles to overcome, including silvicultural practices, competition control, and in some locations, mortality

from Phytophthora root rot. For example, American chestnut seedlings have contracted Phytophthora root rot in forest nurseries, which was subsequently carried into the field by outplanting, resulting in close to 100% mortality of transplanted seedlings on some sites (Rhoades et al, 2003).

Survival of backcross chestnut seedlings used for reforestation and aforestation could be increased by outplanting seedlings free of Phytophthora root rot when lifted from the nursery. Furthermore, *Phytophthora*-free seedlings will diminish introduction of this pathogen into new sites. With plans to begin wide-scale reforestation in 2010, a primary concern of The American Chestnut Foundation (TACF) and associated cooperators is producing disease-free seedlings in the nursery and identifying low and/or high hazard outplanting sites. Our current understanding is that disease in the field appears to be related to soil factors and cumulative low temperature degree days (Duniway, J.M. 1983). In contrast, the presence of *P. cinnamomi* in soils does not appear to be critical to disease development, as the fungus is ubiquitous in forest settings, even in areas where the disease does not develop (Duniway, J.M. 1983).

Since American chestnut seedlings can contract Phytophthora root rot in forest nurseries, the goal of the project is to develop recommendations for managing Phytophthora root disease both in forest nurseries and field plantings. This would be accomplished by developing control measures in the nursery and determining site conditions conducive to Phytophthora root rot on outplanted seedlings. The objective of the first year of this project is to begin developing recommendations for managing Phytophthora root rot in forest nurseries using currently available compounds for the control of *Phytophthora spp* in other cropping systems. The effects of these compounds on chestnut growth and production will play an important part in restoring disease-free American chestnut seedlings to the forests and are essential to determining the effect of site conditions on the severity of this disease.

MATERIALS AND METHODS

American (B3F2) and Chinese chestnut (multiple sources) seed from TACF were sown in a heavy, poorly-drained soil in its second season post fumigation with methyl bromide at the East Tennessee Nursery in Cleveland TN. Individual plot size was 4’ x 3’ replicated 4 times in a randomized block design that was sown in January 2009. Each 4' x 3' plot received 28 chestnut seed per linear foot (84 seed per plot) which were sown 7 seed per each of the four drills sown per nursery bed. The treatment plots for both chestnut species sown used 290' bed feet within the nursery. After sowing, seed were covered with a hardwood mulch and left until germination in late March. On March 12, April 13, May 16, June 14, July 12 and August 12, 2009, the seed beds and/or seedlings were treated with compounds reported to be effective in controlling *Phytophthora spp.* in either soil or plant systems (Table 1). The compounds listed in Table 1 were applied using the label rates and methods (soil drench, soil spray, foliar spray) recommended by each manufacture. Prior to the monthly applications, the plots were hand-weeded to remove competition, especially morning glory (*Ipomoea spp*). During the growing season, seedlings were maintained under the standard operating procedures that the nursery uses for pest control, fertility and soil moisture. On November 18, 2009, seedling characteristics were measured within each of the treatments. A 1' x 4' counting frame was placed across, and in the center of each 3' x 4' treatment plot. The number of seedlings within the counting frame were

tallied for each drill and each seedling measured for height (cm) and root collar diameter (RCD). The sowing rate in January 2009 for chestnut was 28 seeds per linear foot (7 seed per drill) so each plot received 84 seed. Differences between the number sown in January 2009 and seedlings counted in November is considered germination percent, or seed efficiency. Seedlings derived from treatment plots within the nursery were kept intact to be included as part of the outplanting experiments

RESULTS

Prior to germination and the appearance of the first leaves in late March 2009, all plots received one treatment of their respective compounds. During the May application period, it was apparent that Presido®, (applied in March and April) was phytotoxic to American Chestnut as seedlings were stunted, wilted and in two of the plots, completely dead (Figure 1). The effects of the treatment were also seen in the adjacent plots as the compound had moved off the treated area and into the adjoining beds. This affect remained throughout the growing season and resulted in Presido® having significantly fewer seedlings (No./sq ft), shorter seedlings (hgt), smaller seedlings (RCD), lower germination (%) and the greatest amount of stunting/burning than all other treatments (Table 2). The affect of Presido® was specie specific as there was none of these affects on the Chinese chestnut (Table 3).

Of the other compounds used, the seed germination ranged from 86% - 70% for Terrazole® and Alliette®, respectively (Table 1). While the large variation precluded any "statistical significance" among the treatments for germination (seed efficiency), with American chestnut seed at a premium, one cannot afford to lose 30 out of every 100 seeds sown (Alliette®) every year. Seedling size among the compounds tested ranged from 92 - 74 cm for the Control and Terrazole®, respectively. None of the seedling variables measured were different from one another or the control, so except for the Presido®, all produced seedlings acceptable for outplanting and survival. While Presido® was the most phytotoxic to American chestnut, two other compounds, Acrobat 50 WP® and Ridomil Gold®, also caused some burning to foliage when compared to the other compounds and control (Table 2). The affect of these compounds was mild compared to the Presido®, however, the stunting lasted all season as seedlings treated with Ridomil Gold® had the smallest RCDs and heights of any treatments used (Table 2). Care must be taken if Ridiomil Gold® were to be used operationally on American chestnut in the future. It was also observed that both the American and Chinese seedlings were the tallest of all the hardwoods species grown at the nursery and may even be too big to effectively outplant (ease of planting, survival, etc) into forest settings. Thus, maybe some "stunting" would be beneficial to keep trees more compact for planting in the field.

One of the aspects of these studies was to control *Phytophthora cinnamomi* and the disease it causes on *Castanea*. For that reason, an area with a previous history of Phytophthora root rot on Chinkapin with heavy, poorly drained soils was chosen for these studies. Chinkapin (*Castanea pumila*) is highly susceptible to *Phytophthora cinnamomi* that results in the rapid and sudden death of infected seedlings (Figure 2). Water samples taken prior to germination indicated that *Phytophthora spp* was present in the irrigation system and a portion of the area (Block 1 and Block 2) remained waterlogged most of the season (Figure 3). Despite our attempts at encouraging disease, there was no evidence of Phytophthora root disease within any of the plots

during the growing season. Thus, it is unknown if the treatments "controlled" the soilborne pathogen, if the pathogen was simply not present or conditions were not conducive for disease development. One method to ensure disease would have been to "challenge" or "inoculate" the beds with the soilborne fungus, which simply, is something that cannot be undertaken in an operational nursery.

Of the two chestnut species sown, Chinese chestnut seedlings generally were the tallest (hgt), biggest (RCD) and had the greatest germination (seed efficiency) over that of American chestnut seedlings (Table 3). Like that on the American chestnut, Ridomil Gold® and Acrobat 50 WP® caused some stunting on Chinese chestnut seedlings with Ridomil Gold® significantly reducing seedling height over many of the treatments used (Table 3). However, like that in American chestnut, a 87 cm (3 ft) seeding may be difficult to outplant in large scale replanting operations and actually, if used to control *Phytophthora spp*, could be used to keep seedling height growth controlled (Figure 4). An alternative would be top clipping, which is generally not conducted with hardwood seedlings at this nursery, but is routinely practiced on seedlings in other nurseries.

MANAGEMENT IMPLICATIONS

These studies have identified a number of compounds that have proven efficacy against *Phytophthora cinnamomi* and could possible control Phytophthora root rot (ink disease) in forest tree nurseries on chestnut. However, a number of the compounds used are phytotoxic to *Castanea* (Ridomil Gold® and Acrobat 50 WP®) that reduced seedling height and diameter over other treated seedlings. Given the relative ease in producing seedlings over 4 ft in height, the use of these compounds to control soilborne fungi and height growth may be useful. One compound tested, Presido®, was highly phytotoxic to American chestnut and should not be used in future trials for the control of *Phytophthora spp*. Of the 8 different compounds tested, Terrazole® resulted in the tallest seedlings, largest RCD, greatest germination percent (seed efficiency) and did not stunt or burn the foliage. This would be the compound of choice to include in future studies that included growing American chestnut and controlling Phytophthora root rot.

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ACKNOWLEDGEMENTS

The authors wish to thank the American Chestnut Foundation for funding this project and the staff and employees of the East Tennessee Nursery in Cleveland, TN for their help in maintaining the research plots.

Table 1. Compounds used to treat *Castanea spp* for the control of *Phytophthora spp* at the East Tennessee Nursery, 2009

Treatment	Active Ingredient	Rate	Application Method
Terrazole® 35%	etridiazole	0.2668 g in 4 L water per 12 sq ft	Soil Drench
Acrobat 50 WP®	dimethomorph	8.22 g in 2 L water @ 84 L / acre	Soil Spray
PlantShield® HC	biologicals	4 g in 20 g clay carrier per 12 sq ft	Soil Sprinkle
Heritage®	azoxystrobin	0.756 g in 4 L water per12 sq ft	Soil Drench
Control	-	4 L water per 12 sq ft	Soil Drench
Agri-Fos®	potassium phosphate	20 ml in 4 L water per 12 sq ft	Soil Drench / Foliar Spray
Ridomil® Gold SL	mefenoxam	42 ml in 2 L water @ 84 L / acre	Soil Spray
Alliette® WDG	aluminum tris	1.45 g in 4 L water	Foliar Spray
Presido®	fluopicolide	1.2 ml in 4 L water per 12 sq ft	Soil Drench

Table 2. American chestnut seedling characteristics treated with fungicides for the control *Phytophthora spp* at the East Tennessee Nursery, 2009.

Treatment	No. / Linear foot	No. / Sq ft	Height (cm)	RCD (mm)	Total No. Per 3' Plot	Germ (%)	Stunt/Burn Incidence (0-3)
Terrazole® 35%	23.3 a	5.8 a	74.8 ab	8.3 a	70.0 a	86.4 a	0.00 c
Acrobat 50 WP®	23.2 a	5.8 a	86.7 a	9.2 a	69.7 a	83.1 a	0.50 bc
PlantShield® HC	22.2 a	5.5 a	91.6 a	9.6 a	66.7 a	82.4 a	0.00 c
Heritage®	21.0 a	5.2 a	91.6 a	9.8 a	63.0 a	77.8 a	0.25 c
Control	20.0 a	5.0 a	92.4 a	10.3 a	60.0 a	74.1 a	0.00 c
Agri-Fos®	19.5 ab	4.8 ab	81.2 ab	9.1 a	58.5 ab	72.2 ab	0.00 c
Ridomil® Gold SL	19.2 ab	4.8 ab	75.9 ab	8.5 a	57 8 ab	71.3 ab	1.00 ab
Alliette® WDG	19.0 ab	4.7 ab	82.5 a	9.6 a	57.0 ab	70.4 ab	0.25 c
Presido®	9.7 b	2.4 b	39.8 b	4.5 b	29.2 b	36.1 b	1.50 a

Means within a column with different letters are significant at *alpha* = 0.05.

Table 3. Chinese chestnut seedling characteristics treated with fungicides for the control *Phytophthora spp* at the East Tennessee Nursery, 2009.

Treatment	No. / Linear foot	No. / Sq ft	Height (cm)	RCD (mm)	Total No. Per 3' Plot	Germ (%)	Stunt/Burn Incidence (0-3)
Terrazole® 35%	25.0	6.3	122.9 a	11.1 a	72.7	89.8	0.00 b
Acrobat 50 WP®	24.5	6.1	101.5 bcd	9.7 cd	63.0	77.7	1.00 a
PlantShield® HC	24.2	6.0	98.5 cd	9.5 cd	69.0	85.1	0.00 b
Heritage®	23.2	5.8	114.8 ab	10.6 ab	75.0	92.5	0.00 b
Control	23.0	5.7	113.6 abc	10.5 abc	66.0	81.5	0.00 b
Agri-Fos®	23.0	5.7	109.1 abc	10.2 abc	73.5	90.7	0.00 b
Ridomil® Gold SL	23.0	5.7	87.3 d	8.7 d	69.0	85.1	1.00 a
Alliette® WDG	22.0	5.5	113.8 abc	10.5 abc	69.7	86.1	0.00 b
Presido®	21.0	5.2	105.2 bc	9.9 bc	69.0	85.1	0.00 b

Means within a column with different letters are significant at *alpha* = 0.05.

Figure 1. Stunting and mortality of American chestnut seedlings treated with Presidio® (red pin flags L to R) and affects of Presido® on adjacent plots (orange R and white L pin flags).

Figure 2. Phytophthora root rot on Chinkapin (*Castanea pumila*) during the growing season.

Figure 3. Waterlogged soils and seedling beds sown to *Castanea spp* resulted in no ink disease from *Phytophthora cinnamomi* during the growing season.

Figure 4. Measuring Chinese chestnut seedlings at the end of the growing season. Producing tall *Castanea spp* in bareroot nurseries will not be a problem, keeping them small enough to outplant may be an issue.