Studies of the Biology and Control of Brown Heartwood Rot on Lemon Trees in 2000[1]

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Abstract

Brown heartwood rot is commonly found in mature lemon groves in southwestern Arizona. Two basidiomycete fungi, Antrodia sinuosa and Coniophora eremophila, have been isolated from symptomatic trees. Similarities between the two pathogens include the following: each fungus grows optimally at 30 to 35°C, neither organism produces a fleshy fruiting body, they colonize lemon trees primarily through branch fractures and other non-pruning wounds, and both cause a brown wood rot in infected trees. A major difference between the two pathogens is that Antrodia forms spore-producing fruiting bodies on infected wood within lemon groves, whereas fruiting on lemon wood infected by Coniophora has not been observed. The rate of wood decay in lemon branches inoculated with Antrodia is at least three times greater than that caused by Coniophora. Wood decay columns produced by either fungus from late spring to early autumn were at least three times larger than those that developed from late autumn to early spring. When inoculated with either pathogen, the length of wood decay columns on branches 10 mm in diameter was numerically smaller than those on branches 20 and 40 mm in diameter. Wood decay on Lisbon lemon branches inoculated with either Antrodia or Coniophora was significantly greater than that on Marsh grapefruit, Orlando tangelo, and Valencia orange. Treatment of lemon branch inoculation sites with azoxystrobin or propiconazole at 20 g of active ingredient per liter of solution reduced the resultant length of wood decay columns by 61 and 77%, respectively, for Antrodia, and 92 and 85%, respectively, for Coniophora. When selected desert plants were inoculated, Antrodia produced wood decay columns on Palo Verde, salt cedar, greasewood, and mesquite branches that were much shorter than those recorded on Lisbon lemon branches. On the other hand, Coniophora produced longer wood decay columns on salt cedar and mesquite than on Lisbon lemon, whereas wood rot on lemon was greater than that on Palo Verde and greasewood. Current disease management strategies include minimizing branch fractures and other non-pruning wounds, and periodic inspection of trees and removal of infected branches, including physical removal of all wood infected with Antrodia from the grove site.

Introduction

In 1992, a species of *Coniophora* was first reported to be associated with a brown heartwood rot in lemon trees in southwestern Arizona (Matheron, Gilbertson, and Matejka, 1992). The wood decay had been observed in lemon

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plantings in this region for at least 30 years, but the cause was previously unknown. Subsequent research revealed the identity of this basidiomycete to be *Coniophora eremophila*, the only species of *Coniophora* known to occur in the Sonoran desert region of Arizona and Mexico (Lindsey and Gilbertson, 1975). During surveys of mature orchards to determine the incidence of lemon trees infected with *Coniophora*, a second basidiomycete fungus was isolated from symptomatic decayed wood. This fungus subsequently was identified as *Antrodia sinuosa*. *Coniophora eremophila* is primarily a saprobe on dead fallen wood on a number of species of desert trees, shrubs, and cacti. There are no reports of *Antrodia sinuosa* causing decay of heartwood in living hardwoods.

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The objectives of this research project were to study the effect of season (ambient temperature) on the rate of wood decay, examine the rate of wood decay on branches of differing diameters, compare the ability of each pathogen to cause brown heartwood rot on different types of citrus trees, evaluate potential fungicides for disease control, and test the ability of each fungus to cause wood decay in some desert plants growing in southwestern Arizona.

Materials and Methods

All studies involved the actual inoculation of citrus tree branches (or in one test branches of selected desert plants) followed by the measurement of resultant wood decay columns at a given time after inoculation. To prepare inoculum, 8-mm-diameter x 13-mm-long autoclaved wood dowel pieces were placed on mycelium of *Antrodia* or *Coniophora* growing in plastic Petri plates containing potato dextrose agar, then incubated for 1 month in the dark at 28°C. Each test plant was inoculated by placing one dowel segment containing one of the pathogens into a 9-mm-diameter x 26-mm-long hole in the branch. Shorter holes and inoculum dowel segments were used when branches were less than 30 mm in diameter. The dowel segment containing the pathogen was positioned and retained in the bottom of each inoculation hole by driving another dowel piece not containing the pathogen into each wound. This longer dowel piece was cut off flush with the surface of the branch and the wound was sealed with paraffin. Disease development usually was assessed approximately 6 months later (except for the seasonal study when branches were harvested 3 months after inoculation) by removing inoculated branches, splitting them in half, and measuring the length of the resultant decay columns. Inoculated branches ranged from 6 to 8 cm in diameter, except in the lemon branch diameter study. In the fungicide trial, the inoculation hole in each branch was filled with a test fungicide, then the dowel segment containing one of the pathogens was coated with the same compound before placement into the inoculation hole. The second dowel segment used to retain the colonized dowel piece in the inoculation hole also was treated with the same fungicide. Each treatment within a field study was replicated at least seven times and each trial was established in a randomized complete-block design.

Results and Discussion

The highest rate of wood decay for each pathogen occurred from May through October (Table 1), when the mean length of wood decay column for *Antrodia* and *Coniophora* was 188 and 42 mm, respectively, and the mean air temperature was 29°C. In comparison, the mean length of wood decay columns from November through April for the same pathogens was 65 and 11 mm, respectively, with a mean air temperature of 17°C. When inoculated with either pathogen, the length of wood decay columns on branches 10 mm in diameter was numerically smaller than those on branches 20 and 40 mm in diameter (Table 2). Wood decay columns on Lisbon lemon, Marsh grapefruit, Orlando tangelo, and Valencia orange trees inoculated with *Antrodia* averaged 214, 132, 84, and 84 mm in length, respectively, whereas values for the same types of citrus trees inoculated with *Coniophora* averaged 114, 52, 53, and 40 mm, respectively (Table 3). Wood decay caused by both pathogens was significantly greater on lemon compared to other tested types of citrus. Two fungicides, azoxystrobin and propiconazole, were most suppressive to development of wood rot in lemon branches inoculated with

Antrodia or *Coniophora* compared to nontreated branches (Table 4). When inoculated with *Antrodia*, wood decay columns in lemon branches treated with propiconazole or azoxystrobin at 20 g of active ingredient per liter of solution were 36 and 62 mm in length, respectively, compared to a value of 159 mm in nontreated branches. When branches treated with the same fungicides and rates were inoculated with *Coniophora*, wood decay columns averaged 6 and 3 mm in length, respectively, compared to a value of 40 mm in nontreated branches. When inoculated with *Antrodia*, the length of wood decay columns on Palo Verde, salt cedar, greasewood, and mesquite branches ranged from 12 to 60 mm and were all much smaller than the average length of 159 mm recorded on Lisbon lemon branches (Table 5). In comparison, a greater degree of wood decay was observed on salt cedar and mesquite compared to Lisbon lemon when inoculated with *Coniophora*, whereas wood rot on lemon was greater than that recorded on Palo Verde and greasewood.

Brown heartwood rot is a continuing concern for lemon producers in southwestern Arizona and southeastern California. Since *Antrodia* and *Coniophora* primarily colonize lemon trees at branch fracture sites and other non-pruning wounds, minimizing limb breakage and other non-pruning wounds should significantly reduce new infections. Citrus groves should be inspected at least annually and any infected sections of branches should be removed. Since Antrodia can sporulate on infected lemon wood on the tree or on old infected wood pieces on the grove floor, it is important to remove all infected wood from the grove site. No fungicides are currently registered for control of this disease; however, experimental evidence suggests that preventative treatment of wounds with azoxystrobin or propiconazole could reduce the subsequent development of brown heartwood rot.

Literature Cited

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Table 1. Seasonal changes in severity of wood rot.

	Length of wood decay column in mm	
Time period	*Antrodia*	*Coniophora*
February to April	60	17
May to July	201	56
August to October	175	29
November to January	70	5

Table 2. Wood decay on branches of different diameters.

	Length of wood decay column in mm	
Branch diameter in mm	*Antrodia*	*Coniophora*
10	128	10
20	133	16
40	154	17

Table 3. Wood decay on different kinds of citrus.

	Length of wood decay column in mm	
Type of citrus tree	*Antrodia*	*Coniophora*
Lisbon lemon	214	114
Valencia orange	84	40
Marsh grapefruit	132	52
Orlando tangelo	84	53

Table 4. Effect of fungicides on wood rot development.

Fungicide: (20 g active ingredient per liter)	Length of wood decay column in mm	
	Antrodia	*Coniophora*
Propiconazole	36	6
Azoxystrobin	62	3
BAS 500	105	32
Kresoxim-methyl	131	30
Trifloxystrobin	160	12
Nontreated control	159	40

Table 5. Brown wood rot on some desert plants compared to lemon

Type of plant	Length of wood decay column in mm	
	Antrodia	*Coniophora*
Palo Verde	12	15
Salt cedar	15	90
Greasewood	20	1
Mesquite	60	64
Lisbon lemon	159	45