PHYTOPHTHORA ROOT AND CROWN ROT OF FRANKLINIA TREES[1]

Abstract. A root and crown rot leading to wilt of *Franklinia alatamaha* has become an increasingly important disease in nursery production of this plant. The pathogenicity of *Phytophthora* sp. isolated from diseased roots and crown cankers was shown in inoculated, rooted cuttings and 1 to 3 year-old, container-grown plants. The disease has not been observed in well-established field plantings of this tree. The fungus was identified as *Phytophthora cinnamomi* on the basis of morphology and mating type. Truban or Banrot drenches effectively controlled the disease in container stock.

Crown and root disorders of container-grown *Franklinia alatamaha* Marsh. (= *Gordonia alatamaha* Sarg.) have become serious problems in the commercial production of this ornamental species. The cause of this disease has traditionally been ascribed to poor rooting ability, a weak root system or winter kill.

The most prevalent manifestation of the disorder is a root rot. Symptoms of wilting in infected plants occur following an initial flush of growth in the spring or during sunny, hot, summer days. A progressive yellowing, beginning with the lower leaves, soon follows the initial wilting of the tip leaves. At times defoliation may also occur beginning with the lower leaves. A plant may die in a number of days, weeks or months or may linger through the summer, whereupon it becomes quite susceptible to winter injury (e.g., dieback) and winter kill. An examination of an affected root system will show numerous rotted and decaying roots while healthier ones exhibit any number of small brown lesions (Fig. 1). Crown canker is a less prevalent form of this disease. In this case the tree appears to be healthy until the canker nearly girdles the trunk, thus causing identical symptoms of wilt as that of the root rot phase. Cankers and root rot may occur simultaneously on the same plant. The disease has not been observed in well-established field-grown Franklinia trees.

The symptoms and cause of this disease have not been reported. Since *Phytophthora* was repeatedly isolated from crown cankers and root lesions of wilted trees, thus study was undertaken to establish the identity of the pathogen, to determine whether it was the primary cause of wilt and to determine a method of disease control. A preliminary report has been published (4).

Fig. 1. Healthy vs. infected root systems of two-year-old Franklinia.

Materials and Methods

Initial isolations of *Phytophthora* spp. were carried out on potato dextrose agar (PDA). Two-cm root segments (healthy roots exhibiting only a few lesions) and wood from advancing cankered areas were surface sterilized in 5.25% sodium hypochlorite for 0.5 to 1.5 min, placed on PDA and incubated at room temperature. Repeated isolations and reisolation from inoculated plants were subsequently carried out on a selective medium for pythiaceous fungi (5).

Studies of optimum, minimum and maximum growth temperatures were conducted on V-8 juice agar (V-8A) from 4-36C at 4-degree intervals. Plates were inoculated with 1-cm diameter mycelial plugs from margins of actively growing colonies and incubated in the dark. The amount of linear growth was measured at 2-day intervals on four plates per temperature setting.

Mycelial characteristics were determined from

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young, vigorously growing portions of colonies on malt agar (MA) and from older mycelium grown on PDA, corn meal agar (CMA) or V-8A media (6).

Induction of sporangial production was attempted by different methods, e.g., by placing mycelial plugs and baited fruit flies in distilled water, nonsterile pond water (pond: distilled, 1:2) (6), Petri's mineral solution (6), and by Hwang's method (2). Induction of sexual reproductive organs was carried out on V-8A containing 200 ml V-8 juice with 3 g $CaCO_3$ cleared by filtering through a cake of celite 545 (Fisher Scientific Co.), 200 ml; 0.1 g B-sitosterol dissolved in 20 ml of hot 95% ethanol; 20g agar and 800 ml distilled water. The isolates were also paired with each other and with two different sets of known A^1 and A^2 compatibility types of *P. cinnamomi* and incubated at room temperature in the daylight. The *Phytophthora* isolates were then identified from keys and descriptions by Waterhouse (6,7) and Novotelnova (3).

To establish the pathogenicity of the *Phytophthora* isolate, rooted Franklinia cuttings were inoculated. The fungus was grown in 250-ml flasks, containing 50 ml of V-8 broth, (100 ml V-8 juice, 3 g $CaCO_3$ and 1 liter distilled water) for 6 weeks. Forty mycelial mats drained free of medium were homogenized for 20 sec at low speed, and the volume was brought up to 1 liter with distilled water. Nineteen healthy, rooted cuttings grown in 10-cm pots were inoculated by gently scraping away the top layer of soil around the crown, applying 40 ml of the inoculum (approximately one mycelial mat per pot), replacing the soil and watering. An uninocualted check of 19 cuttings was treated in a similar manner with distilled water substituted for inoculum. Reisolation of the organism from wilted cuttings in this and subsequent inoculation experiments was accomplished and described previously.

The comparative ability of a *Phytophthora* isolate from Franklinia and a virulent *P. cinnamomi* isolate from rhododendron to cause typical wilt of rooted Franklinia cuttings was also investigated. Inoculum was grown and applied as described above. Five rooted cuttings were used per isolate and per uninoculated check.

Crowns of 3-year old-Franklinia trees were inoculated by making a 1-cm longitudinal incision through the bark with a sterile scalpel and inserting an agar-mycelium block of the *Phytophthora* isolate into the wounds. The wounds were then covered with cotton and moistened with distilled water to prevent premature dehydration of the inoculum plugs. Check plants were wounded in the same manner with a small ball of moistened cotton substituted for inoculum. Crown inoculation without wounding the bark was attempted by placing an agar mycelium block directly on the bark surface and covering it with moistened cotton. Five trees were used per isolate and check.

Two experimental fungicide treatment series to control Franklinia wilt were conducted in 1975-1976 before the causal organism was definitely determined. The fungicides used and their respective rates/liter were: 5-ethoxy-3-trichloromethyl-1,2,4-thiadiazole (Truban 25EC), 0.7 ml; 5-ethoxy-trichloromethyl-1,2,4-thiodiazole, 15% and dimethyl 4, 4-0-phenylenebid (3-thioallophanate), 25% (Banrot 40WP), 1.0 g; 2-chloro-6-methoxy-4-(trichloromethyl) pyridine (Nurelle, Dow Chemical Co., Moorestown, N.J.), and methyl 1-(&butylcarbamoyl)-2-benzimidazolecarbamate (Benlate 50W), 1.2 g. Fifty 3-year-old Franklinia trees, growing in 7.6-liter containers, received the first series of treatments on 5 May, 23 July and 5 September 1975. The treated trees were selected from a group of trees with a wilt history and arranged randomly. There were 10 plants per treatment. Each fungicide solution was applied at 1 liter/container and watered in after treatment. A nontreated water check was also included.

A second group of 50 trees from a relatively disease-free block was treated on the same dates, but also inoculated on August 8, 1975 with a *Phytophthora* isolate from Franklinia. The fungus inoculum was grown on V-8 broth for 6 wk, then 50 mycelial mats were homogenized in a blender and the volume was brought to 2.5 liter with distilled water. Inoculum was applied at the rate of 50 ml/7.6-liter container and watered in. Disease ratings were taken monthly until the end of the growing season and again in June of the following year. Winter damage was also noted in each treatment.

Results

Identification of the Pathogen. The isolates of *Phytophthora* recovered from Franklinia were identified as *P. cinnamomi* Rands. No other fungi were consistently isolated from the Franklinia trees.

Colonies on V-8A and PDA (24C) exhibited profuse white aerial mycelium and grew in a rosette pattern. Optimum growth occurred at 24-27C., minimum growth at approximately 7C and no growth at 35C. The isolates also produced numerous hyphal swellings (chlamydospores) and sporangia typical of *P. cinnamomi* when grown on the selected media (1). Fungal sex organs were produced only when isolates were paried with known A[1] compatability types of *P. cinnamomi.*

Inoculation and Treatment. All 19 rooted cuttings inoculated with a *P. cinnamomi* isolate from Franklinia wilted and died after 4 weeks, while only one plant of the uninoculated 19 died during the same period. Repeated reisolations from wilted plants yielded *P. cinnamomi.* Inoculations comparing the virulence of the *Phytophthora* isolated from Franklinia with *P. cinnamomi* from rhododendron resulted in typical wilt and root symptoms in all inoculated plants. Only one uninoculated plant died. Disease progression gave some evidence that the Franklinia isolate was more virulent than the rhododendron isolate in Franklinia.

The Franklinia *Phytophthora* isolates also produced crown cankers of various lengths when inserted under the bark. Application of inoculum plugs to the bark surface without wounding or wounding without inoculum did not cause canker development.

The results of fungicide treatments of uninoculated and inoculated trees (Table 1 and 2, respectively) show that Truban, Banrot and the experimental compound, Nurelle, greatly decreased disease incidence. Resistance to winter damage was also noted with these treatments. The wilt symptoms appeared somewhat enhanced in the Benlate treatments.

Discussion

Franklinia root rot and crown canker has become increasingly important in propagating beds and in container-grown trees in nurseries but as yet has not been observed in well-established field-grown plantings. The disease problem has been reorganized by growers in the past, but the cause has not been previously reported. *Phytophthora* was consistently isolated from diseased plants and, when inoculated into healthy plants, produced typical disease symptoms.

Table 1. Disease incidence (wilt) in fungicide treated, uninoculated 3-year old Franklinia trees.

Treatment[a] (Formulation/liter)	Dead plants (No.) fall 1975	spring 1976	total	Dieback[b] (No.)
Truban 25 EC (0.7 ml)	1[c]	0	1	0
Nurelle (2.7 ml)	1[c]	0	1	0
Banrot 40W (1.0g)	0	1	1	0
Benlate 50W (1.2 g)	5	1	6	4
Check (H_2O)	6	1	7	3

[a]Ten trees per treatment. Fungicides applied at 1 liter fungicide solution per 7.6 liter container.

[b]No. trees showing dieback attributed to winter damage.

[c]Trees showed some winter damage at treatment time.

Table 2. Disease incidence (wilt) in fungicide treated, three-year old Franklinia trees inoculated with *P. cinnamomi.*

Treatment[a] (Formulation/liter)	Dead plants (No.) fall 1975	spring 1976	total	Dieback[b] 1976
Truban 25 EC (0.7 ml)	0	0	0	0
Nurelle (2.7 ml)	0	1	1	0
Banrot 40W (1.0g)	0	1	1	1
Benlate 50W (1.2 g)	6	0	6	4
Check (H_2O)	4	1	5	5

[a]Ten trees per treatment. Fungicides applied at 1 liter fungicide solution per 7.6 liter container.

[b]No. trees showing dieback attributed to winter damage.

The root rot phase of the disease is more common than the canker phase. In general the disease is most prevalent on plants grown in heavy or poorly drained soil, which favors the root rot phase. Also rooted cuttings appear much more susceptible to the root rot phase than 3-yar-old

container-grown trees. Evidence that Franklinia crowns were susceptible to this fungus by wound inoculations, but resistant without wounds, would indicate that the crown canker phase of the disease would not likely occur in nature unless trees were mechanically damaged.

Evidence from these tests and general observations of other Franklinia plantings would indicate a relation between wilt and susceptibility to winter damage. Usually, trees showing wilt late in the summer but living through the winter were more subject to dieback attributed to winter damage. Conversely trees that exhibited winter damage were more susceptible to wilt. Apparently physiologically weakened plants are more susceptible.

The general morphology of the *Phytophthora* isolates from Franklinia when grown under the test conditions reported, was similar to known isolates of *P. cinnamomi.* Although few cultural or pathogenic differences were noted among the Franklinia isolates, some strain differences may occur between these isolates and *P. cinnamomi* from other plants. Since an isolate of *P. cinnamomi* from rhododendron was also pathogenic to Franklinia, there was no host specificity indicated, although some differences in virulence between the isolates from the two sources was indicated.

Disease control was achieved with Truban, Banrot and Nurelle (an experimental compound now withdrawn from testing). Benlate was included originally in the experiment because of the nature of the root damage and in the event organisms other than pythiaceous fungi were involved in the root rot phase. Benlate was ineffective and appeared to enhance the disease when compared with the untreated check.

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ABSTRACT

SHURTLEFF, M.C. 1979. **Trees for a city environment.** Grounds Maintenance 14(5): 66, 68, 71, 102, 104.

A city environment demands hardy trees. The ideal choices are disease-resistant, and cope well with soil compaction and variations in soil moisture. They must also withstand air pollution, extremes in weather and injuries from cars and lawn mowers. When selecting a tree, think of the space available and the size of the tree at maturity. A low-growing tree may eventually interfere with vehicular traffic. One with a compact root system will interfere less with sidewalks, sewers and utility lines. Other things to consider include soil drainage and water table level, pH, and exposure to wind and sun. An extensive list of suitable trees, begun in the April issue of Grounds Maintenance, continues in this issue with hackberry to mulberry. The final section, covering oak to Zelkova, will be presented in a future issue.