Fungicides for Control of Phytophthora Root Rot of Azalea in Landscape Beds

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ABSTRACT

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Ethazol, fosetyl Al, and metalaxyl at rates of 0.025, 0.044, or 0.0014 kg a.i./5.5 m^2 of soil surface were applied to landscape beds of azalea cultivar Hinodegiri that were naturally infested with *Phytophthora cinnamomi*. The fungicides were applied at 30- or 60-day intervals during the growing season for 2 yr. No foliar symptoms developed on plants during the first growing season, and disease incidence based on root isolations of *P. cinnamomi* was low to nil. Dramatic symptom development was observed in some plots during the second growing season where *P. cinnamomi* was not controlled. Fungicide efficacy in decreasing order of protection was metalaxyl, fosetyl Al, and ethazol. In general, no differences in rates of symptom development regardless of fungicide were associated with 30- or 60-day intervals of application. Mortality after two growing seasons was greatest in untreated, infested plots and ethazol-treated plots, lower in fosetyl Al-treated plots, and nil in metalaxyl-treated plots. Inoculum density of *P. cinnamomi* was highest in the root zones of plants in untreated, infested plots and ethazol-treated plots (range 1.0–3.8 propagules per gram [p/g] of soil), intermediate in fosetyl Al-treated plots (range 0.1–2.2 p/g of soil), and lowest in metalaxyl-treated plots (range nil to 0.07 p/g of soil) over a 2 yr period. At the rates tested, only metalaxyl gave satisfactory control of Phytophthora root rot of azalea in landscape beds.

Control of Phytophthora root rot with fungicides is a standard management practice in many commercial nurseries. This practice is based on research with several fungicides including ethazol, fosetyl Al, and metalaxyl (2,4). Once disease-free nursery stock is transplanted in the landscape, however, susceptible crops may become infected with naturally occurring *Phytophthora* spp. and other pathogens.

The purpose of this study was to assess the efficacy of several fungicides for control of Phytophthora root rot of azalea in landscape beds and to monitor population dynamics of *Phytophthora cinnamomi* Rands in soil under three fungicide regimes.

MATERIALS AND METHODS

Landscape beds. Two beds each 3.04 × 32.8 m with a history of Phytophthora root rot caused by *P. cinnamomi* were used at a research nursery in Raleigh, NC. The soil was the B horizon of a poorly drained, Cecil clay soil (pH 5.8). The A horizon was removed several years before establishing the nursery site. Before planting, the beds were rototilled to a depth of 15 cm. Each bed then was divided into 18 plots (1.8 × 3.04 m). Two plots in each bed were selected at random and fumigated with a methyl bromide + chloropicrin mixture (0.68 kg / 5.5 m^2 of soil surface) on 4 October 1982.

Fungicide incorporation and planting. On 5 October 1982, ethazol (Truban 5G) or fosetyl Al (Aliette 10G) was broadcast to individual plots at rates of 0.015 and 0.17 kg a.i./5.5 m^2 of soil surface, respectively, and rototilled. Immediately after incorporation of ethazol and fosetyl Al, with the exception of plots fumigated the previous day, four 2-yr-old azaleas (*Rhododendron obtusum* Planch. 'Hinodegiri') that had grown in 2.6-L containers for one season were transplanted to each plot. After transplanting, metalaxyl (Subdue 2EC) was broadcast as a concentrate (6 ml/3.8 L of water) with a garden sprinkling can at a rate of 0.0014 g a.i./5.5 m^2 of soil surface. Fumigated plots were planted 2 wk later. Overhead irrigation (2.8 cm of water) was applied immediately to enhance downward movement of fungicide and subsequent uptake by plant roots. Naturally infested, untreated plots and fumigated, untreated plots were used as controls.

During the growing season, plants were treated with broadcast applications of ethazol, fosetyl Al, or metalaxyl at rates of 0.025, 0.044, or 0.0014 kg a.i./5.5 m^2 of soil surface, respectively, on 30- or 60-day schedules each year beginning on 3 May 1983 and 16 March 1984. Each growing season, plots on the 30- and 60-day schedules received seven and four applications of fungicide, respectively. Irrigation water (2.8 cm) was added after each application. The experimental design was a randomized complete block with four observations (plants) per replicate and four replicates per treatment.

Each bed was top-dressed with a 3-cm-thick layer of pine bark mulch to conserve soil moisture and suppress weed development. At the beginning of each growing season, beds were top-dressed with preemergence herbicide and with 11 kg of commercial 10-10-10 fertilizer per 99.7 m^2 of soil surface. In 1984, unusually wet conditions necessitated a second application of 10-10-10 fertilizer (4.5 kg/99.7 m^2 of soil surface) on 26 June. Postemergence herbicides were used as needed for weed control during the growing season. Irrigation was applied when needed to ensure at least 2.8 cm of moisture per week during the growing season.

Disease assessment. Plants were observed for foliar symptoms of Phytophthora root rot throughout the two growing seasons. Visual differences in chlorosis, growth, necrosis, and plant death between infested and fumigated plots were used to assess treatment efficacy. Plant size (average plant height plus average plant width divided by two) also was estimated in June and September 1984. A 1.7-cm-diameter soil-sampling tube was used to collect a soil-root core from under the canopy of each plant in a single plot. The samples were placed in plastic bags until the roots were washed free of adhering soil in running tap water. Roots then were blotted and transferred in 1-cm-long clumps (five clumps per plate), each clump containing eight to 15 root pieces, to a modified pimaricin-penicillin-polymixin medium (5). Pimaricin concentration was reduced to 10 mg/L. A plant was considered infected if any of the 10 root clumps (two plates per sample) yielded *P. cinnamomi*.

Population dynamics of *P. cinnamomi*. Inoculum density of *P. cinnamomi* was assessed at six dates beginning 12 July 1983. At each sampling date, a soil-root core was taken to a depth of 15 cm at the drip line of each of four plants per plot with a 2.5-cm-diameter soil-sampling tube. The four samples from each plot were bulked so that four bulked samples (16 cores) per treatment were collected. The samples were placed in plastic bags and held at room temperature until samples were processed 1–2 days later. A 100-g subsample was removed, stirred in 200 ml of tap water for about 6 min, and then processed on a semiautomatic

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elutriator (3). Elutriation time was 6 min with air and water flow rates of 30–40 cm^3/sec and 80 ml/sec, respectively (6). One-fifth of the sample was collected from the sample splitter on a 15-cm-diameter, 38-μm sieve. The residue on the sieve was rinsed into a 100-ml beaker with tap water and allowed to settle for a minimum of 1 hr (supernatant became clear). The supernatant was aspirated to leave a final volume of 30–40 ml. The residue was then mixed with the remaining water and dispensed as uniformily as possible onto 10 plates of a pimaricin-chloramphenicol-hymexazol agar medium (PCH) (6). The plates were incubated at 20 C in the dark for 2–3 days before the developing colonies of *P. cinnamomi* were counted. Additional subsamples of about 10 g each were dried in an oven at 105 C overnight to determine percent soil moisture so that counts could be expressed on the basis of propagules per gram (p/g) of dry soil.

RESULTS AND DISCUSSION

Plants became established during the fall and winter of 1982–1983, and plant survival was 100% in the spring of 1983. No symptoms of Phytophthora root rot developed on the azaleas during the 1983 growing season even though inoculum was present in the soil. Root infection was low (Table 1). Apparently, during the 1983 growing season, the plants had large enough proportions of healthy roots to compensate for low proportions of roots infected with *P. cinnamomi.*

Symptom development. Foliar symptom development was dramatic in 1984. Above-average rainfall in June and July may have contributed to an accentuation of symptoms. Disease progress, based on rate of foliar symptom development, was greatest in ethazol-treated plots and in infested, untreated plots (Fig. 1). By August 1984, disease progress was 30 and 45% in plots treated with fosetyl Al on a 30- or 60-day schedule, respectively. In plots treated with metalaxyl, disease progress was 0 and 13% on a 30- or 60-day schedule, respectively (Fig. 1). Disease progress was similar in plots treated with a given fungicide regardless of application interval. Plants in fumigated plots remained symptom-free until August 1984, when 38% of the plants had symptoms of Phytophthora root rot. Apparently a row spacing of about 1.8 m between plants in different treatments was not completely sufficient to prevent dissemination of inoculum between plots, or roots contacted inoculum in the soil below the fumigated layer after 22 mo.

Root infection. Incidence of root infection was 56 and 69% in ethazol-treated plots for 30- and 60-day application intervals, respectively. Incidence was 56% in infested, untreated plots by June 1984 (Table 1). Fosetyl Al-treated plots had 25–30% plant infection for plants on 30- and 60-day schedules in June, whereas no plants were infected in metalaxyl-treated plots. A comparison of symptom development with root infection in June demonstrated the lag in appearance of foliar symptoms until well after root infection had occurred. Several factors including plant resistance and environmental and edaphic parameters must interact in regulating appearance of symptom development following root infection and should be investigated further.

Plant size and mortality. By June 1984, plants in fosetyl Al-treated plots on a 60-day schedule and in metalaxyl-treated plots on a 30-day schedule, as well as plants in fumigated plots, were significantly larger than plants in ethazol-treated plots and infested, untreated plots (Table 1). These differences in plant size also were found in September 1984.

Mortality in June 1984 was 6 and 13% in infested, untreated plots and ethazol-treated plots, respectively, but increased to 34% in infested, untreated plots and to 31 and 41% in ethazol-treated plots by

Table 1. Infection, plant size, and mortality in azaleas in landscape beds infested with *Phytophthora cinnamomi* and treated with ethazol, fosetyl Al, or metalaxyl on a 30- or 60-day interval

	Infection incidence (%)[a]			Plant size (cm)[b]		Mortality (%)	
Material and interval	**Oct. 1983**	**Jun. 1984**	**Sept. 1984**	**Jun. 1984**	**Sept. 1984**	**Jun. 1984**	**Sept. 1984**
Fosetyl Al							
30-day	0	30	50	33.8	32.8	0	13
60-day	6	25	31	37.6	37.2	0	13
Metalaxyl							
30-day	0	0	13	39.6	44.3	0	0
60-day	0	0	0	36.9	41.6	0	0
Ethazol							
30-day	6	56	81	31.5	22.7	6	31
60-day	0	69	81	28.6	21.3	13	44
Control							
Infested	13	56	88	31.5	24.3	6	34
Fumigated	0	50	56	39.2	36.2	0	13
LSD				5.4	10.3		

[a] Infection incidence is the percent recovery of *P. cinnamomi* from root samples from each plant in each experimental plot averaged over four replicates.
[b] Plant size is the average plant height plus average plant width divided by two for individual plants in each plot averaged over four replicates.

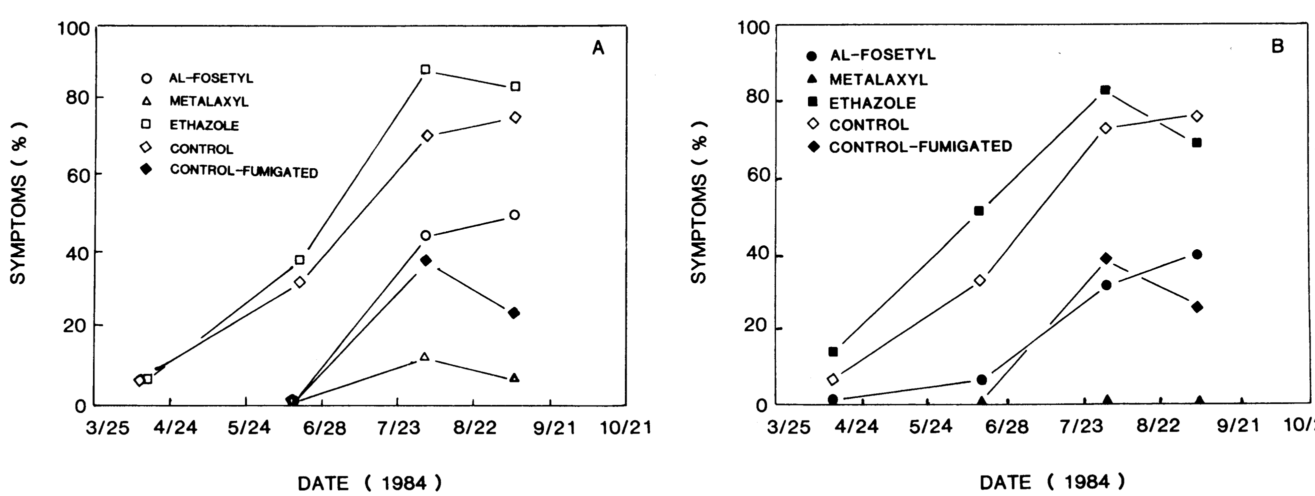

Fig 1. Disease progress curves based on foliar symptom development for Phytophthora root rot of azaleas planted in landscape beds and treated with either fosetyl Al, ethazol, or metalaxyl or left untreated: **(A)** 30-day and **(B)** 60-day application interval.

September (Table 1). No mortality was observed for plants in metalaxyl-treated plots and only 13% mortality was found in fosetyl Al-treated plots by September.

Population dynamics. Inoculum density of *P. cinnamomi* was about 3.7 p/g of dry soil in infested, untreated plots at the first sampling date in July 1983 (Fig. 2). Since similar patterns for inoculum density were found over time in the 30- and 60-day fungicide application intervals, only the 60-day interval data are presented. Average inoculum density in fumigated, untreated plots was 0.8 p/g in July 1983, and with the exception of a sharp decrease in September, remained fairly constant through the 1984 season. The occurrence of *P. cinnamomi* in fumigated plots may have been due to inadequate row spacing as described earlier or lack of adequate ditches along the bed to prevent surface waters from contaminating the plot. In either case, inoculum was detected in only one of four replicates.

In July 1983, inoculum density was 2.1 p/g in ethazol-treated plots and 0.3 p/g in fosetyl Al-treated plots (Fig. 2). *P. cinnamomi* was not detected in soil samples during 1983 for metalaxyl-treated plots on 30-day schedules. In metalaxyl-treated plots on 60-day schedules, inoculum density declined from 0.06 p/g in July to nondectable densities by September 1983.

In May 1984, inoculum densities were similar to those of the previous year. In ethazol-treated plots, inoculum density decreased from 1.8 to 0.1 p/g of soil by August but increased to the previous high density the following month (Fig. 2). The variation observed may be due to sampling differences associated with clumped inoculum. In fosetyl Al-treated plots, inoculum density of *P. cinnamomi* increased between May and August to a value similar to that of the untreated, infested plot. Increase in inoculum density in fosetyl Al-treated plots was correlated with increased recovery of *P. cinnamomi* from roots and with mortality (compare Fig. 2 and Table 1). Inoculum density of *P. cinnamomi* was less than 0.1 p/g of soil in metalaxyl-treated plots throughout the experiment. The persistence of metalaxyl in soils for more than 60 days after application may account for the low incidence of detection in metalaxyl-treated plots (1).

The success of fungicide application for control of Phytophthora root rot in landscape beds is related to several factors including use of disease-free planting stock, fungicide formulation, and soil physical properties that ensure fungicide movement into the root zone after irrigation and subsequent root uptake, persistence of the fungicide in the root-zone profile, and an inherent toxicity of the fungicide toward the pathogen. Under the conditions of this study, only metalaxyl gave satisfactory control of Rhytophthora root rot of azalea.

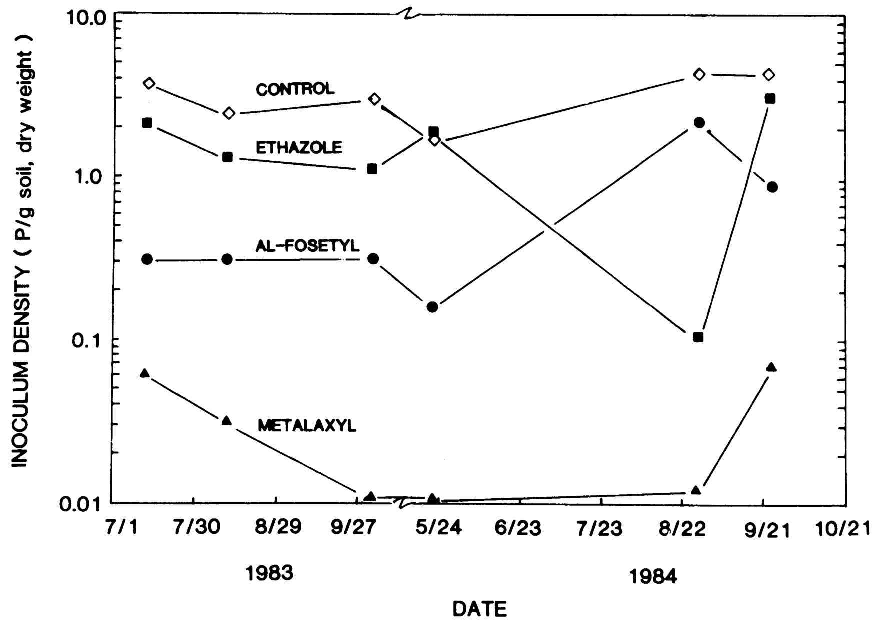

Fig 2. Population dynamics of *Phytophthora cinnamomi* over a 2-yr period in the root zones of azaleas planted in landscape beds and treated at a 60-day interval with either fosetyl Al, ethazol, or metalaxyl or left untreated.

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LITERATURE CITED

1. Bailey, A. M., and Coffey, M. D. 1984. A sensitive bioassay for quantification of metalaxyl in soils. Phytopathology 74:667-669.
2. Benson, D. M. 1979. Efficacy and in vitro activity of two systemic acylalanines and ethazole for control of *Phytophthora cinnamomi* root rot of azalea. Phytopathology 69:174-178.
3. Byrd, D. W., Jr., Barker, K. R., Ferris, H., Nusbaum, C. J., Griffin, W. E., Small, R. H., and Stone, C. A. 1976. Two semiautomatic elutriators for extracting nematodes and certain fungi from soil. J. Nematol. 8:206-212.
4. Coffey, M. D., Ohr, H. D., Campbell, S. D., and Guillemet, F. B. 1984. Chemical control of *Phytophthora cinnamomi* on avocado rootstock. Plant Dis. 68:956-958.
5. Eckert, J. W., and Tsao, P. H. 1962. A selective antibiotic medium for isolation of *Phytophthora* and *Pythium* from plant roots. Phytopathology 52:771-777.
6. Shew, H. D., and Benson, D. M. 1982. Qualitative and quantitative soil assays for *Phytophthora cinnamomi*. Phytopathology 72:1029-1032.