Pesticides and Weeds Influence *Phytophthora cinnamomi* Presence and Growth in Container-grown Azaleas

Kathie Kalmowitz¹, Ted Whitwell², Eldon Zehr², and Joe Toler³
Clemson University, Clemson, SC 29634

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Root rot caused by *Phytophthora cinnamomi* Rands is a limiting factor in nursery production of woody ornamentals in the southeastern United States (Benson and Cochran, 1980). Metalaxyl fungicide is routinely used to control this disease (Benson, 1987). Weeds can harbor fungi, such as *Phytophthora* sp., and may increase the incidence of infection. The use of preemergence herbicides, such as oxadiazon, is common in most nurseries for improved weed control. However, we found no reports examining the influence of simultaneous pesticide applications on target and nontarget pests. The occurrence of *Phytophthora cinnamomi* was investigated in the presence of herbicides, fungicide, and weeds in container-grown azalea [*Rhododendron calendulaceum* (Michx.) Torr.]. Laboratory experiments also measured in vitro growth of *P. cinnamomi* with several pesticide levels.

Field studies were conducted at Clemson Univ. Botanical Gardens in June 1985. 'Delaware Valley White' azalea liners were assayed for *P. cinnamomi* by root platings and determined to be disease-free before start of the experiment. Uniform-sized liners were potted into 2.8-liter containers in a commercial medium containing 3 parts pine bark : 1 part peat (v/v) (Fafard, Anderson, S.C.). Containers were double potted and then placed 30 cm apart to avoid contamination between treatments. Plants received 30 mm water daily and were grown in 50% of full sun.

Three isolates of *P. cinnamomi* from naturally infected azaleas were used in both field and in vitro experiments. Standard laboratory procedures were followed for maintaining pure viable cultures. The isolates were cultured for 22 to 27 days on sterile 5% cornmeal in river sand, and all isolates were mixed together before application in the field. Inoculum was assayed for viability on selective

agar (PPAH) (Erwin et al., 1983) before inoculation.

Field treatments were arranged in a randomized complete-block design with four replications and two plants per plot. Treatments were applied in the following sequence: Granular 5% metalaxyl was surface-applied at 6.0 kg a.i./ha with reapplication at 8 weeks. Warm-season weeds, goosegrass (*Elusine indica* L. Gaertn), Pennsylvania smartweed (*Polygonum pennsylvanicum* L.), and prostrate spurge (*Euphorbia humistrata* Eagelm. ex gray) were seeded (25 seeds) in each container and harvested after 8 weeks. Cool-season weeds [wild mustard (*Sinapis arvensis* L.) and perennial ryegrass (*Lolium perenne* L.)] were seeded (25 seeds) after the summer weeds were harvested. Oxadiazon (2% granular) at 2.2 and 22.0 kg a.i./ha and oxyfluorfen + pendimethalin (2% + 1% granular combination) at 3.3 and 33.0 kg a.i./ha were surface-applied 2 days after fungicide application. The high (10×) herbicide rate was used to induce stress on azalea and possibly enhance *P. cinnamomi* infection. Herbicide treatments were applied before weed emergence and again at 8 weeks, after cool-season weeds were seeded. Twenty-five grams of a 5% cornmeal-sand *P. cinnamomi* inoculum was surface-applied to each pot 11 days following the fungicide treatment.

In laboratory studies, the three *P. cinnamomi* isolates were tested separately on corn meal agar (CMA) for growth response to six pesticides at four concentrations (0.1, 1.0, 10, and 100 µg a.i./ml). Technical-grade metolachlor, oxadiazon, oxyfluorfen, pendimethalin (herbicides), and metalaxyl (fungicide) were dissolved in 10 ml of absolute ethanol and filtered-sterilized, then added to sterile CMA. The pesticide solvent, ethanol, was also evaluated at the four levels for ef-

fect on *Phytophthora*. Cultures were incubated in darkness at 25C and radial growth was measured after 5 days. Treatments were arranged in a randomized complete-block design with four replications. Growth inhibition was compared to the ethanol standards.

The presence of weeds in the container consistently resulted in a higher percentage for recovery of *P. cinnamomi*. The pathogen was isolated from azalea roots of all weedy treatments, including 37% (three of eight) of the noninoculated, weedy controls. No other noninoculated pots were positive. When no fungicide was applied, *P. cinnamomi* was recovered from all weedy inoculated treatments and from 87% (seven of eight) of inoculated weed-free containers. When metalaxyl was used, the pathogen was recovered in two of eight weedy pots but in only one of eight weed-free containers. Weed control affected *P. cinnamomi* isolation from roots regardless of the fungicide treatment. A higher frequency of the fungus was associated with the lower herbicide rate where weeds were present compared with the high herbicide rate where weeds were not present. Metalaxyl fungicide suppressed the activity of *P. cinnamomi* regardless of herbicide treatment. Fungicide efficacy did not appear to be affected by the herbicides.

In laboratory studies, metalaxyl effectively restricted mycelial growth at all concentrations, with activity against the fungus increasing 10-fold as the rate increased from 0.1 to 1.0 µg·ml⁻¹ after 5 days (Table 1). Metolachlor inhibited mycelial growth at 10.0 and 100 µg·ml⁻¹ by 85% and 33% of the standards, respectively. Oxadiazon increased mycelial growth at 0.1, 10.0, and 100.0 µg·ml⁻¹. Oxyfluorfen and pendimethalin amendments did not affect fungal growth (data not presented). These results indicate that it is essential to control weeds in container production of azalea where *Phytophthora* root rot can be a major disease problem.

Literature Cited

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¹Former Graduate Research Assistant, Dept. of Horticulture.

²Professor, Dept. of Plant Pathology.

³Assistant Professor, Dept. of Experimental Statistics.

Table 1. Growth of *Phytophthora cinnamomi* after 5 days on corn meal agar medium containing ethanol and the pesticides metalaxyl, metolachlor, and oxadiazon.

Pesticide concn (µg·ml ⁻¹)	Pesticides (%) ^a			
	Ethanol	Metalaxyl	Metolachlor	Oxadiazon
0.1	100 (6.86) ^b	94*	105	108*
1.0	100 (6.94)	9*	96	101
10.0	100 (6.62)	0*	85*	111*
100	100 (5.42)	0*	33*	121*

^aPercent radial growth compared to the corresponding concentration of the ethanol standard. Asterisk (*) indicates differences from the ethanol standard by LSD at $P = 0.05$.

^bMean radial growth (cm) of ethanol standard.