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TIMING OF APPLICATION OF METALAXYL AND FOSETYL-ALUMINUM FOR CONTROL OF PHYTOPHTHORA FOOT ROT

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Abstract. **Timing of application of systemic fungicides for control of *Phytophthora parasitica* Dast. in stem lesions on 1-yr-old Etrog citron (*Citrus medica* L.) trees was evaluated. Preinoculation foliar sprays of fosetyl-aluminum (1500 ppm and 3000 ppm), phosphorous acid (pH 6.8, 2000 ppm), or drench application of metalaxyl (50 ppm) resulted in smaller lesions and lower disease ratings than postinoculation applications. All fungicide treatments reduced lesion size and severity rating below those of the inoculated controls. However, only metalaxyl reduced recovery of the fungus from stem lesions. Fosetyl-aluminum and metalaxyl applications reduced lesion size and severity rating on citrons at 30 days but not at 60 or 100 days after fungicide application.**

Recent studies have indicated that foot rot caused by *Phytophthora parasitica* can be effectively controlled with the proper application of certain fungicides accompanied by good management practices (8). Many types of chemical applications have been tested, such as trunk paints (6), soil drenches (3), and foliar sprays (1). Fosetyl-Al (Aliette 80 WP) and metalaxyl (Ridomil 2E) are two systemic fungicides widely used in Florida to control Phytophthora foot rot. Movement of metalaxyl, when applied as a soil drench, is mostly upwards (2, 6, 7), but downward movement of the fungicide has been suggested (8). Fosetyl-Al moves downward systemically from the foliage to the roots (5). In addition, movement upward from the roots to aboveground parts has been reported (3). Phosphorous acid, the degradation product of fosetyl-Al, has been shown to be highly effective in inhibiting activity of Phytophthora species both *in vitro* and *in vivo* (4). For this reason, phosphorous acid has been included in this investigation. The purpose of this study was to evaluate the effect of timing of application of foliar sprays of fosetyl-Al and phosphorous acid, and soil drenches of metalaxyl for the control of Phytophthora foot rot.

Materials and Methods

Etrog citrons seedlings were grown in the screenhouse in 3-liter pots containing Pro-mix BX (Premier Brands, Inc., New Rochelle, NY 10810). All plants had a stem diameter of 1 to 2 cm and were approximately 1 m high. Plants were selected for uniformity among all treatments.

Mycelial mats of *Phytophthora parasitica* Dast. were grown for inoculum in V-8-$CaCO_3$ broth in 60 mm diameter petri dishes for 48 hr, rinsed twice with sterile distilled water, and incubated at room temperature in a minimal amount of sterile-distilled water for another 48 hr. The petri dishes were then placed at 5°C for 10 min to induce zoospore liberation. Plants were inoculated with a zoospore/mycelial mat suspension of *P. parasitica* by cutting two 2 mm by 35 mm rectangular incisions, one on each side of the stem, and placing a mat under each stem flap. Each stem was wrapped with a strip of wet absorbent cotton. A bottomless styrofoam cup was placed around the stem and filled with moistened peat moss. Noninoculated citrons were cut and wrapped in a similar fashion. After inoculation, the citrons were arranged in a randomized complete block design in the screenhouse and each plant was placed in an aluminum pan in which water was allowed to stand for 48 hr.

Timing of application. Groups of ten plants received one of the following fungicide treatments: fosetyl-aluminum spray, 1500 ppm; fosetyl-aluminum spray, 3000 ppm; phosphorous acid spray (pH 6.8), 2000 ppm; and metalaxyl drench, 50 ppm. Each fungicide treatment was applied to one group of 10 plants 10 days prior to inoculation and 10 and 30 days after inoculation (preinoculation treatment). Another group of 10 plants was treated with each fungicide 10 and 30 days after inoculation (postinoculation treatment). Additional treatments were an inoculated, nontreated control and a noninoculated, nontreated control. Fosetyl-aluminum and phosphorous acid (adjusted to pH 6.8 with 1 N KOH) were applied as foliar sprays to run-off. Metalaxyl was applied as a soil drench using 200 ml per 3-liter pot.

Disease evaluation. Plants were evaluated 57 days postinoculation for disease severity, lesion area, and percent recovery of the fungus. The inoculated stem section of each citron was excised and disease severity was rated on the following scale: 0 = healthy; 1 = bark flap dead, callous present; 2 = lesion necrosis, but some callous present; 3 = lesion with moderate necrosis, no callous; 4 = lesion with severe necrosis, stem girdling. Two assessments were made for each stem and these values were averaged. Lesion length and area was determined by direct measurement of discolored tissue on both inoculation sites for each stem, and an average value obtained for each plant. Data were expressed as percent reduction of lesion area and of disease severity compared to the inoculated, nonsprayed controls.

Reisolations from inoculated sites were made by plating 2 tissue pieces from each lesion margin on PVP medium (9). Recovery of *P. parasitica* was expressed as the percentage of tissue pieces from which *P. parasitica* was reisolated.

Fungicide longevity. Initially, 50 citrons each were treated with fosetyl-Al as a foliar spray at 3000 ppm, metalaxyl as a soil drench at 50 ppm, or left unsprayed. In addition, 10 nonsprayed, noninoculated plants were maintained as a check against natural infection. Groups of 10 plants from each of the above groups were inoculated as described previously at 1, 10, 30, 60, and 100 days posttreatment. Six weeks after inoculation, plants were evaluated for disease severity, lesion area, and fungal recovery as described above.

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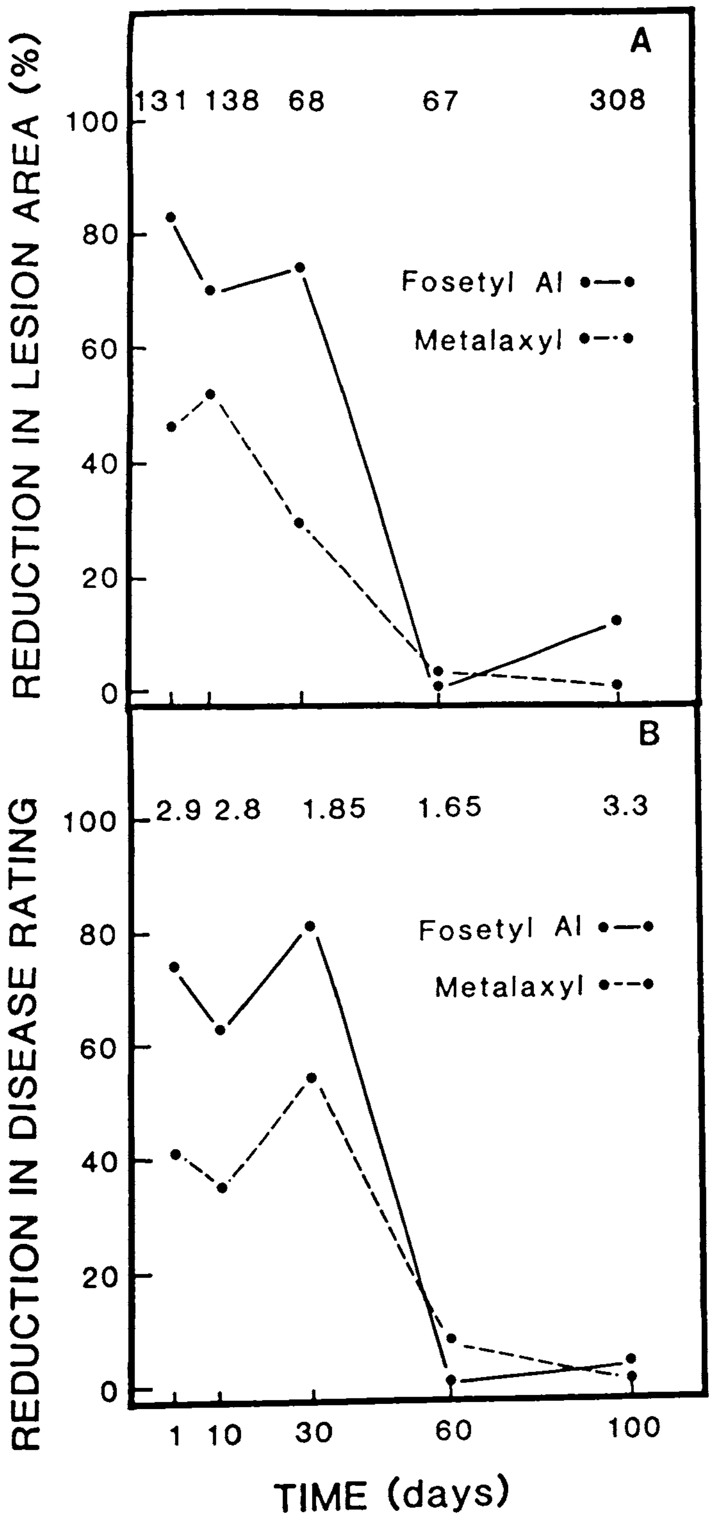

Fig. 1. Longevity of fungicide effectiveness against Phytophthora foot rot development on citron. Data is expressed as the percentage reduction in (A) lesion area (mm^2) and (B) disease severity for fungicide treated plants compared to inoculated controls. Numbers across the top portion of the graphs are the base values for the nonsprayed inoculated plants: lesion area in mm^2 (A) and disease rating on a scale of 0 = healthy to 4 = severe disease (B).

Results and Discussion

Timing of application. All fungicide treatments, whether applied pre- or postinoculation, significantly reduced lesion area and disease severity ratings compared to inoculated nontreated controls (Table 1). Reisolation of *P. parasitica* was not affected by the timing of fungicide application. Metalaxyl treatment resulted in the lowest percent recovery, indicating some fungicidal activity. To determine the effect of fungicide treatment and timing of application on disease severity, results from the treated plants only were analyzed. Preinoculation treatments significantly reduced lesion area ($P \leq 0.01$) and disease severity ($P \leq 0.01$) as compared to postinoculation treatment.

Although infection by *P. parasitica* was reduced by applications of fungicides at both pre- or postinoculation, control was significantly better when fungicides were applied as a preventive measure rather than as a curative measure. None of the fungicides or rates tested were substantially better than the others.

Fungicide longevity. Fosetyl-Al and metalaxyl were effective in reducing lesion area and disease rating on inoculated citrons up to 30 days after fungicide application (Fig. 1 A, B). However, 60 and 100 days after treatment, the fungicides were no longer effective in reducing lesion size and disease severity rating. Other studies indicate detectable levels of metalaxyl and fosetyl-Al were found by bioassay 6 weeks and 8 weeks, respectively, after application (2).

On the basis of this study, disease control by one application of fosetyl-Al or metalaxyl could be expected for at least 30 days after treatment, but not longer than 60 days. Application of fosetyl-Al is recommended at times of leaf flushes, not to exceed 4 times a year. Continuous foot rot protection on small trees could be expected from a spray program which begins with the first leaf flush in early spring, and is followed by 3 subsequent 60-day foliar applications. At the present time, metalaxyl applications are recommended at three 3-month intervals for nonbearing citrus trees. We propose that metalaxyl treatments would be most effective if applied 3 times during the high temperature and rainfall periods from late spring to early fall. This corresponds to the period when *P. parasitica* has the greatest disease potential (unpublished data).

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Table 1. Efficacy of fungicide treatments applied pre- and postinoculation with *Phytophthora parasitica* for control of lesion development on citrus seedlings.

Treatment	Method of application	Rate (ppm)	Lesion area (mm^2)		Disease rating[z]		% isolation[y]	
			Pre	Post	Pre	Post	Pre	Post
Fosetyl-Al	Foliar spray	1500	185 bc[x]	215 cd	1.90 bc	2.10 bc	50	65
Fosetyl-Al	Foliar spray	3000	134 c	239 bc	1.45 c	2.35 bc	55	50
Phosphorus acid	Foliar spray	2000	183 bc	282 b	1.65 bc	2.50 b	50	55
Metalaxyl	Soil drench	50	239 b	229 bcd	1.95 b	2.05 c	15	20
Noninoculated control	—	—	169 c[w]	169 d[w]	0.25 d[w]	0.25 d[w]	0	0
Inoculated control	—	—	437 a	437 a	3.25 a	3.25 a	75	75

[z]On a scale of 0 = no effect to 4 = severe girdling.
[y]Percentage of stem pieces from which *P. parasitica* was reisolated.
[x]Mean separation in columns by Duncan's multiple range test, p = 0.05.
[w]Values indicate the amount of mechanical injury caused by the inoculation procedure.

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PERFORMANCE CHARACTERISTICS OF PTO AIRBLAST SPRAYERS FOR CITRUS

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Abstract. **Power requirements and spray depositions were determined for a number of power-take-off (PTO) airblast sprayers. They ranged in horsepower requirements from 8 to 81 at PTO speeds of 540 and 600 rpm, respectively. Copper was used as a tracer on artificial targets for the spray deposition studies. These tests were conducted on 16 ft high 'Valencia' trees with all sprayers applying the same amount of copper per acre at a ground speed of 1.5 mph, with application rates per acre up to 125 gal per acre. The maximum deposit, averaged over all sprayers, was 5 times the minimum deposit within the tree. Deposition results are presented with respect to target height in the tree and horizontal radial distance from the tree trunk.**

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Airblast sprayers driven by tractor power-take-off (PTO) have been available for applying pesticides to Florida citrus for several decades. However, the grower demand for PTO driven airblast sprayers has recently increased relative to conventional, engine-driven, airblast sprayers due mainly to the size and cost of the machine. Higher powered tractors are more readily available to accommodate PTO sprayers. In many cases, this combination can be bought and operated at a cost equivalent to that of a large engine-driven sprayer. Recent freeze losses in the northern citrus production areas have eliminated many large citrus trees and reduced the need for the large engine-driven airblast sprayers.

Since operating costs of a spraying system are directly related to its power consumption, this factor as well as pest control (uniformity and quantity of deposition) are important considerations in the purchase of a sprayer. The two objectives of the research reported herein were to measure the power requirements and deposition characteristics of a number of PTO driven airblast sprayers.

Materials and Methods

Sprayer Power Requirements

A Ford, Model TW-10, diesel tractor was used to determine the power requirements of the PTO airblast sprayers. A dynamometer (AW Dynamometer, Inc.) test was conducted on the tractor to determine the relationship between fuel consumption rate and power developed at the PTO using PTO speeds of 540 and 600 rpm. From that information horsepower requirements for each sprayer were determined. Tractor power output (hp) was calculated from best fit "least squares" regression equations at 540 and 600 rpm as given below.

$$HP_{540} = -38.4 + 70.6\ (\ln X)$$
$$HP_{600} = -59.3 + 81\ \ (\ln X)$$

Where X = fuel consumption rate in gallons per hour

These equations provided reasonably good fits to the data with coefficients of determination greater than 0.99.