Efficacy of Sprays of Fosetyl-Al and Drenches of Metalaxyl for the Control of Phytophthora Root and Crown Rot of Cherry

ANNA BIELENIN and A. L. JONES, Department of Botany and Plant Pathology and the Pesticide Research Center, Michigan State University, East Lansing 48824-1312, and the Institute of Pomology and Floriculture, 96-100 Skierniewice, Poland

ABSTRACT

Bielenin, A., and Jones, A. L. 1988. Efficacy of sprays of fosetyl-Al and drenches of metalaxyl for the control of Phytophthora root and crown rot of cherry. Plant Disease 72: 477-480.

A single foliar spray of 4.8 g a.i./L fosetyl-Al prevented the development of cankers on the scion and the Mahaleb rootstock of 1-yr-old Montmorency sour cherry trees wound-inoculated with *Phytophthora cactorum*. Sprayed trees were protected against infection for at least 7 mo. Necrosis on trees sprayed with fosetyl-Al 1 wk after inoculation was about a third the size of necrosis on control trees. Fosetyl-Al applied as a foliar spray three times on a 2-wk interval did not adequately control root rot on Mahaleb seedlings inoculated with *P. megasperma*, *P. cryptogea*, and *P. cambivora* isolated from cherry. Foliar sprays of fosetyl-Al and soil drenches of metalaxyl both reduced *P. cactorum* on seedlings growing in artificially infested potting medium. Metalaxyl applied as a soil drench (5 and 10 mg a.i. per seedling) was more effective then fosetyl-Al applied as a foliar spray in preventing mortality and root rot of Mahaleb seedlings growing in a potting medium artificially infested with *P. megasperma*, *P. cryptogea*, or *P. cambivora*.

Phytophthora root and crown rot is a serious problem in poorly drained soils in sour cherry (*Prunus cerasus* L.) orchards in Michigan (1) and New York (14) and in sweet cherry (*P. avium* L.) orchards in California (10,15). *Phytophthora megasperma* Drechsler, *P. cambivora* (Petri) Buisman, *P. drechsleri* Tucker, *P. syringae* (Kleb.) Kleb., *P. cactorum* (Lebert & Cohn) Sohroet., *P. cryptogea* Pethyb. and Laff., and an unidentified *Phytophthora* sp. have been reported as pathogens of cherry trees (1,10,14,15). It is not uncommon to find two or more of these species in a single orchard. Selection of well-drained planting sites and the use of Mazzard rootstock, less susceptible to *Phytophthora* spp. than the more commonly used Mahaleb rootstock (15), are methods of preventing this disease. These cultural practices cannot always be implemented after an infested orchard is identified. Alternative control procedures need to be developed for use in established orchards.

Fosetyl-Al is a systemic fungicide with good activity against several soilborne diseases caused by *Phytophthora* spp. (3). On tree species, fosetyl-Al has been tested for the control of *P. cactorum* on apple (11), *P. cinnamomi* Rands on avocado (2,4) and walnut (9), *P. citrophthora* (Smith & Smith) Leonian on walnut (9) and citrus (7), *P. parasitica* Dastur on citrus (5,7,12,13), and *P. citricola* Sawada on walnut (9). To our knowledge, results of tests with fosetyl-Al for the control of Phytophthora root and crown rot of cherry have not been published.

The purpose of this study was to evaluate the efficacy of spray applications of fosetyl-Al and drench treatments of metalaxyl for preventing cankers and root rot on cherry inoculated with *P. cactorum*, *P. megasperma*, *P. cryptogea*, and *P. cambivora* isolated from cherry.

MATERIALS AND METHODS

Wound inoculation test. One-year-old Montmorency sour cherry trees grafted on *Prunus mahaleb* L. seedlings (Mahaleb) were planted in 11.4-L plastic pots containing Pro-Mix potting medium (Premier Brands, Inc., New Rochelle, NY) and maintained on a bench in the greenhouse. Isolate M354 of *P. cactorum* from cherry was used to inoculate all trees. Four-mm-diameter disks taken from 7- to 10-day-old colonies on V-8 juice agar were placed into holes cut with a cork borer in the scion and rootstock of each tree to the depth of the cambium. The Mahaleb rootstock was inoculated about 2 mm and the scion about 25 cm above the soil line. Following inoculation, the inoculation sites were wrapped with Parafilm (American Can Co., Greenwich, CT). Fosetyl-Al (Aliette 80 WP, Rhone-Poulenc, Inc., Monmouth Junction, NJ), at 4.8 g of active ingredient per liter, was applied as a foliar spray 1 wk after inoculation or 0–10 wk before inoculation. Treatments were replicated five times. The bark above and below the site of inoculation was removed before measuring the length and width of the necrotic area in the wood (Fig. 1). Results were taken 14 days after inoculation, or 21 days after inoculation when the spray was applied 1 wk after inoculation.

Soil inoculation tests. In experiment 1, 2-mo-old Mahaleb seedlings growing in Pro-Mix potting medium were sprayed three times with 4.8 g a.i./L fosetyl-Al. Mahaleb cherry was selected for these studies because it is the main rootstock used for sour cherry in Michigan. Applications were made 0, 2, and 4 wk before inoculation and were repeated on a 2-wk interval until a total of three applications were applied. Seedlings were inoculated with isolates C-21, M103, and M184 of *P. cryptogea*; M28, M246, M308, M322, and M375 of *P. megasperma*; and M117, M130, and M354 of *P. cactorum* as described by Mircetich and Matheron (10). Each isolate was grown for 6 wk at 21 C in 1-L flasks containing 500 ml of sterile vermiculite thoroughly moistened with V-8 juice broth (10). The inoculum was rinsed with sterile water and placed at the rate of 30 ml per each 1-L pot, 10 ml into each of three holes near each seedling. Pots were flooded biweekly over a 2-mo

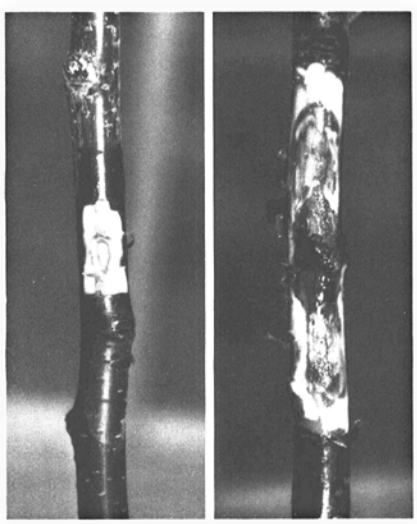

Fig. 1. Trunk of 1-yr-old Montmorency sour cherry 2 wk after inoculation with *Phytophthora cactorum*; tree sprayed with 4.8 g a.i./L fosetyl-Al 7 wk before inoculation (left) and unsprayed control (right). Bark was removed to expose the necrotic tissue.

Michigan Agricultural Experiment Station Journal Article 12445.

Accepted for publication 22 October 1987 (submitted for electronic processing).

Table 1. Size of cankers on Montmorency sour cherry trees sprayed with fosetyl-Al at 4.8 g a.i./L before or after inoculation with *Phytophthora cactorum* into wounds on the scion and trunk

	Canker length × width (cm^2)[y]			
	Montmorency scion		Mahaleb rootstock	
Timing of spray	Fosetyl-Al	Control	Fosetyl-Al	Control
After inoculation				
1 wk	20.7	75.6	5.9	11.0
Day of inoculation	0.1	43.8	1.0	8.5
Before inoculation				
1 wk	0.0	38.8	1.3	12.4
2 wk	0.3	34.2	0.2	8.9
3 wk	0.0	38.1	0.0	7.7
4 wk	0.0	12.8	0.1	6.2
5 wk	0.0	21.5	0.2	6.2
6 wk	0.0	13.6	0.3	5.8
7 wk	0.0	19.2	0.0	2.7
8 wk	0.0	4.2	0.1	4.1
9 wk	0.0	9.2	0.0	6.8
10 wk	0.9	13.7	0.0	5.3
7 mo[z]	0.1	16.2	...	...

[y]Lesions measured 14 days after inoculation, or 21 days after inoculation when the spray was applied 1 wk after inoculation. Each value is the mean of five replications.
[z]Trees overwintered for about 3.5 mo in a cooler and reinoculated after resuming growth.

Table 2. Effect of sprays of 4.8 g a.i./L fosetyl-Al on the growth and root rot development of 2-mo-old Mahaleb cherry seedlings (inoculated with *Phytophthora* spp.) grown in artificially infested potting medium for 3 mo and flooded for 48 hr at 2-wk intervals for 2 mo

Inoculum	Timing of spray	Shoot growth[x] (mm)	Dry root weight[x] (g)	Root rot rating[y]
P. cryptogea				
	4 and 2 wk before and on day of inoculation	142.4 c	0.9 cd	3.6 b
	2 wk before, on day of, 2 wk after inoculation	183.1 c	1.1 cd	3.7 b
	On day of and 2 and 4 wk after inoculation	271.7 b	1.4 c	2.7 c
	Control (flooded and inoculated)	192.3 c	0.5 d	4.7 a
	Control (flooded, not inoculated)	279.9 b	3.7 b	1.1 d
	Control (not flooded, inoculated)	432.3 a	7.3 a	1.0 d
P. megasperma				
	4 and 2 wk before and on day of inoculation	203.9 b	1.9 c	2.6 a
	2 wk before, on day of, 2 wk after inoculation	207.0 b	1.4 c	2.7 a
	On day of and 2 and 4 wk after inoculation	204.4 b	2.0 c	2.3 a
	Control (flooded and inoculated)	217 3 b	1.6 c	3.3 a
	Control (flooded, not inoculated)	279.9 b	3.7 b	1.1 b
	Control (not flooded, inoculated)	432.3 a	7.3 a	1.0 b
P. cactorum				
	4 and 2 wk before and on day of inoculation	259.6 b	3.7 b	1.3 a
	2 wk before, on day of, and 2 wk after inoculation	307.3 b	4.0 b	1.1 a
	On day of and 2 and 4 wk after inoculation	227.0 b	3.4 b	1.1 a
	Control (flooded and inoculated)[z]	304.7 b	2.7 b	1.4 a
	Control (flooded, not inoculated)	279.9 b	3.7 b	1.1 a
	Control (not flooded, inoculated)	432.3 a	7.3 a	1.0 a

[x]Values are the average of seven replicates and represent the increase in shoot length during the experiment. Within each species, numbers with the same letter do not differ from each other ($P = 0.05$) according to Duncan's multiple range test.
[y]Root systems were rated on a scale of 1–5 (1 = no necrosis and 5 = severe necrosis) 3 mo after planting in infested soil.
[z]Cankers were observed on five of seven seedlings. Mean length of the cankers was 42.4 mm.

period by immersing in water for 48 hr at each flooding.

After 3 mo, the seedlings were removed from the pots and the roots were washed with water to remove the potting medium. The degree of root rot was assessed on a scale of 1–5, where 1 = healthy and 5 = severe necrosis (lateral and tap roots necrotic). After drying at room temperature, the roots were weighed. Growth was assessed by measuring the height of all plants at the beginning and at the end of the experiment, then subtracting to determine the increase in shoot length over the 3-mo period.

In experiment 2, spray applications of fosetyl-Al were compared with soil drench applications of metalaxyl (Ridomil 2E, Ciba-Geigy Corp., Greensboro, NC) on 2.5-mo-old Mahaleb seedlings. The seedlings were sprayed to runoff with 4.8 g a.i./L of fosetyl-Al at 0; 0 and 60; and 0, 30, and 60 days after inoculation. Metalaxyl was applied in 100 ml of water at 5 and 10 mg a.i. per 1-L pot at inoculation, and at 5 mg a. i. per pot at 0, 30, and 60 days after inoculation. Seedlings inoculated with *P. cryptogea* received an additional treatment of 5 mg a.i. of metalaxyl at inoculation plus sprays of fosetyl-Al at 0, 30, and 60 days after inoculation. The following isolates were used: M212, M117, M130, and M354 of *P. cactorum*; M103 and M104 of *P. cryptogea*; M246, M308, M332, M407, and M408 of *P. megasperma*; and C-45 and M72 of *P. cambivora*. All isolates were from cherry, except C-45, which was from soil associated with necrotic cherry roots. Inoculum production and preparation, inoculation procedures, flooding of pots, and data collection were as described for experiment 1, except no root rot ratings were made.

RESULTS

Wound inoculation test. Unsprayed trees had large cankers and extensive gum formation 2 wk after inoculation with *P. cactorum* (Fig. 1, Table 1). Fosetyl-Al applied as a spray 1 wk after inoculation reduced the development of cankers on the scion and rootstock by 72.6 and 46.6%, respectively. Sprays applied 0–10 wk before inoculation protected the scion and rootstock from infection. Callus tissue formed around the site of inoculation on sprayed but not on unsprayed trees (Fig. 1). When trees sprayed with fosetyl-Al the previous year were reinoculated 7 mo later, no necrotic lesions developed on the scion.

Soil inoculation tests. In experiment 1, Mahaleb seedlings flooded but not inoculated with *Phytophthora* had significantly less growth and lower dry root weights than inoculated but not flooded seedlings (Table 2). Both treatments were free of root rot.

Root rot on flooded Mahaleb seedlings inoculated with isolates of *P. cryptogea*

and *P. megasperma* was severe (Table 2). Mahaleb seedlings inoculated with *P. cryptogea* and sprayed three times with fosetyl-Al starting at inoculation had less root rot and greater shoot growth and dry root weights then control seedlings. Seedlings sprayed three times starting 4 or 2 wk before inoculation had significantly less root rot, but shoot growth and dry root weights did not differ from the flooded and inoculated control. Seedlings sprayed three times with fosetyl-Al and inoculated with *P. megasperma* did not differ significantly ($P = 0.05$) from the inoculated controls in shoot growth, dry root weight, and root rot. No root rot was observed on any of the seedlings inoculated with *P. cactorum*. However, cankers were observed on five seedlings in the inoculated controls.

At the end of the 3-mo experiment, wound inoculations were made on the stems of five seedlings per treatment with isolate M354 of *P. cactorum*. The length of necrosis was measured after 5 days. All five unsprayed seedlings, but none of the 15 seedlings sprayed with fosetyl-Al, developed necrotic lesions. The average length of lesions on unsprayed seedlings was 32.2 mm.

In experiment 2, seedlings that were flooded every 2 wk grew slower and had lower dry root weights then seedlings that did not receive the flooding treatment (Table 3). Seedlings treated with fosetyl-Al, metalaxyl, or both fungicides did not differ in shoot growth, but there were detectable differences between treatments in the dry weight of the roots. Leaves on seedlings drenched three times on a 1-mo interval with 5 mg a.i. metalaxyl developed chlorotic margins.

Metalaxyl was more effective than fosetyl-Al for preventing cankers caused by *P. cactorum*, and for preventing the death of seedlings from root rot caused by *P. cryptogea* and *P. cambivora* (Table 3). Dry weights of roots of seedlings drenched with metalaxyl and inoculated with *P. cryptogea* or *P. cambivora* were higher than for roots of the flooded control or for roots of seedlings sprayed with fosetyl-Al. Dry root weights of seedlings inoculated with *P. megasperma* and treated with metalaxyl or with two to three applications of fosetyl-Al were significantly higher than root weights in the flooded control. On seedlings inoculated with *P. cryptogea*, a metalaxyl drench plus three sprays of fosetyl-Al did not prevent seedling mortality or improve root growth over that in the flooded control.

DISCUSSION

As reported for apple (11), sprays with fosetyl-Al are highly effective in preventing cankers caused by *P. cactorum*. Our results indicate that foliar sprays of fosetyl-Al should help to reduce losses of cherry trees in orchards and nurseries where *P. cactorum* is the problem. Sprays would be less helpful in orchards and nurseries where *P. megasperma* and *P. cryptogea* are the problem, since in cherry orchards these latter species are frequently isolated, whereas *P. cactorum* is rarely isolated (1,10,14,15).

Fosetyl-Al was active against *P. cactorum* on cherry trees in our trial for at least 7 mo and on apple in the trials of Orlikowski et al (11) for at least 15 mo, compared with at least 1 mo in trials on 1-yr-old Etrog citron (*Citrus medica* L.) trees inoculated with *P. parasitica* (12). This difference in longevity of activity may reflect a higher sensitivity of *P. cactorum* than *P. parasitica* to fosetyl-Al or a toxic breakdown product present in the stems of treated trees. Fosetyl-Al

Table 3. Effect of fungicide treatment on the growth and survival of 2.5-mo-old Mahaleb cherry seedlings (inoculated with *Phytophthora* spp.) grown in artificially infested potting medium for 3 mo and flooded for 48 hr on a 2-wk interval for 2 mo

Treatment[u]	Timing[v] (days)	Shoot growth[w,x] (mm)	Dry root weight[x] (g)	Mahaleb seedlings	
				Killed[y] (no.)	With cankers (no.)
P. cactorum					
Fosetyl-Al	0	469.7 b	4.9 bc	0	4 (18.3)[z]
	0, 60	448.6 b	5.0 b	0	0
	0, 30, 60	423.3 bc	4.3 bc	0	3 (20.3)
Metalaxyl (10 mg)	0	469.6 b	5.0 b	0	0
(5 mg)	0	424.0 bc	5.0 b	0	0
(5 mg)	0, 30, 60	417.3 bc	2.9 d	0	0
Control (flooded)		338.0 c	3.6 cd	0	7 (31.3)
Control (not flooded)		567.6 a	8.6 a	0	5 (25.4)
P. cryptogea					
Fosetyl-Al	0	300.6 bc	1.1 de	3	5 (26.0)
	0, 60	365.6 bc	1.9 cd	4	3 (27.7)
	0, 30, 60	353.3 bc	1.3 de	3	5 (28.2)
Metalaxyl (10 mg)	0	380.1 b	3.4 b	0	0
(5 mg)	0	352.4 bc	3.4 b	0	0
(5 mg)	0, 30, 60	376.1 b	2.8 bc	0	0
Fosetyl-Al + metalaxyl		328.4 bc	0.9 de	5	5 (34.0)
Control (flooded)		271.0 c	0.3 e	7	...
Control (not flooded)		552.0 a	9.3 a	0	1 (25.0)
P. megasperma					
Fosetyl-Al	0	343.1 b	0.6 c	4	4 (52.5)
	0, 60	372.1 b	3.2 b	1	0
	0, 30, 60	373.3 b	3.3 b	0	1 (30.0)
Metalaxyl (10 mg)	0	351.4 b	4.0 b	0	0
(5 mg)	0	392.0 b	4.1 b	0	0
(5 mg)	0, 30, 60	353.0 b	2.9 b	0	0
Control (flooded)		317.3 b	1.1 c	3	3 (43.3)
Control (not flooded)		511.4 a	9.1 a	0	0
P. cambivora					
Fosetyl-Al	0	325.7 cd	0.9 c	2	5 (42.6)
	0, 60	292.0 d	0.5 c	5	5 (50.0)
	0, 30, 60	350.4 bc	0.6 c	6	6 (57.5)
Metalaxyl (10 mg)	0	376.0 bc	3.7 b	0	0
(5 mg)	0	382.3 b	3.9 b	0	0
(5 mg)	0, 30, 60	374.1 bc	2.8 b	0	0
Control (flooded)		292.1 d	0.3 c	7	6 (103.3)
Control (not flooded)		485.1 a	5.7 a	0	6 (85.0)
Not inoculated					
Fosetyl-Al	0	357.7 b	4.8 bc	0	0
	0, 60	401.7 b	3.8 c	0	0
	0, 30, 60	414.4 b	4.6 bc	0	0
Metalaxyl (10 mg)	0	381.4 b	5.6 b	0	0
(5 mg)	0	390.4 b	4.8 bc	0	0
(5 mg)	0, 30, 60	379.4 b	4.4 bc	0	0
Fosetyl-Al + metalaxyl		423.4 b	4.0 bc	0	0
Control (flooded)		353.1 b	4.4 bc	0	0
Control (not flooded)		536.1 a	10.6 a	0	0

[u] Fosetyl-Al was applied as a foliar spray at the rate of 4.8 g a.i./L; metalaxyl was applied as a soil drench in 100 ml of water at the rate of 5 or 10 mg a.i. per pot.
[v] Treatments were applied on the day of inoculation and, if indicated, 30 and 60 days later.
[w] Shoot growth is the increase in shoot length during the experiment.
[x] Values are the average of seven replicates. Within each species, numbers with the same letter do not differ from each other ($P = 0.05$) according to Duncan's multiple range test.
[y] Number of seedlings out of seven.
[z] Number of parentheses is mean length of cankers in millimeters.

generally shows a narrower spectrum of biological activity than metalaxyl (3).

Wound inoculation with *P. cactorum* was a useful assay for testing for the presence of fosetyl-Al in stems of treated trees. In our experiments with Mahaleb seedlings, we were concerned, based on poor control from a single foliar spray to Mahaleb seedlings in preliminary experiments, that uptake or translocation of the fungicide might not be as good in seedlings as in 1-yr-old grafted trees. Thus, we sprayed seedlings more frequently than grafted trees. However, wound inoculations made 10 days before the experiment ended indicated that fosetyl-Al or a toxic breakdown product was present in the stems of sprayed seedlings. This indicated that the low activity of fosetyl-Al against *P. cryptogea*, *P. megasperma*, and *P. cambivora* was not the result of poor uptake of the fungicide by the leaves.

The development of seven cankers on Mahaleb seedlings sprayed with fosetyl-Al in experiment 2 was inconsistent with the high level of control of *P. cactorum* in experiment 1 and in the wound inoculation test. Estimates of *P. cactorum*, as measured by dilution and plating soil samples from each pot on a selective medium (8), indicated 100–150 colony-forming units (cfu) per gram dry weight of soil were applied to the potting medium and 50–100 cfu were present after the initial 48-hr flooding. Although these estimates of *P. cactorum* were slightly higher than estimates for soils in a problem orchard in England (8), multiple sprays of fosetyl-Al should have been adequate for control. When an isolate from one of the cankers (isolate A) was compared with isolate M354 on Mahaleb seedlings sprayed with fosetyl-Al, isolate M354 failed to infect the seedlings, whereas isolate A caused small cankers (5.3 mm of necrosis after 10 days at 17 C). Cankers on unsprayed seedlings were 40.3 and 41.7 mm long for isolate M354 and isolate A, respectively. The detection of isolate A suggests that the four isolates used in experiment 2 may not have been equally sensitive to fosetyl-Al.

Soil drenches with metalaxyl reduced root and crown rot of Mahaleb cherry in potting medium artificially infested with *P. cactorum*, *P. cryptogea*, *P. megasperma*, and *P. cambivora* from cherry. Control was most dramatic in tests involving *P. cambivora* and *P. cryptogea*. As several species of *Phytophthora* occur together on cherries, there would be an advantage in the broad spectrum activity of metalaxyl against Phycomycetes. Combinations of soil drenches of metalaxyl and of sprays of fosetyl-Al need further evaluation because they did not increase the level of control over fosetyl-Al or metalaxyl alone.

Field studies are needed to define the rates of metalaxyl required to control the species of *Phytophthora* likely to cause Phytophthora root and crown rot of cherry (1,10,14,15). Because *P. cactorum* attacks the crown of the tree, drench treatments directed at the soil around the crown have been highly effective (6,11). However, *P. megasperma* and *P. cryptogea* attack the roots before moving into the crown. Because the large volume of soil occupied by roots may prevent metalaxyl from reaching the roots in adequate amounts, higher rates of metalaxyl applied over a wider area may be required to control infections on roots by *P. megasperma* and *P. cryptogea* than to control infections in the crown by *P. cactorum*.

ACKNOWLEDGMENTS

This research was supported in part by USDA Agreement 85-CRSR-2-2551 and by Rhône-Poulenc, Inc., Monmouth Junction, NJ. We gratefully acknowledge Fellowship Arrangements by the Brethren Service Exchange program through the kindness of H. L. Gibble and S. W. Zagaja.

LITERATURE CITED

1. Bielenin, A., and Jones, A. L. 1988. Prevalence and pathogenicity of *Phytophthora* spp. from sour cherry trees in Michigan. Plant Dis. 72:473-476.
2. Coffey, M. D., Ohr, H. D., Campbell, S. D., and Guillemet, F. B. 1984. Chemical control of *Phytophthora cinnamomi* on avocado rootstocks. Plant Dis. 68:956-958.
3. Cohen, Y., and Coffey, M. D. 1986. Systemic fungicides and the control of oomycetes. Annu. Rev. Phytopathol. 24:311-338.
4. Darvas, J. M., Toerien, J. C., and Milne, D. L. 1984. Control of avocado root rot by trunk injection with phosethyl-Al. Plant Dis. 68:691-693.
5. Davis, R. M. 1982. Control of Phytophthora root and foot rot of citrus with systemic fungicides metalaxyl and phosethyl aluminum. Plant Dis. 66:218-220.
6. Ellis, M. A., Grove, G. G., and Ferree, D. C. 1982. Effects of metalaxyl on *Phytophthora cactorum* and collar rot of apple. Phytopathology 72:1431-1434.
7. Farih, A., Menge, J. A., Tsao, P. H., and Ohr, H. D. 1981. Metalaxyl and efosite aluminum for control of Phytophthora gummosis and root rot on citrus. Plant Dis. 65:654-657.
8. Harris, D. C., and Bielenin, A. 1986. Evaluation of selective media and bait methods for estimating *Phytophthora cactorum* in apple orchard soils. Plant Pathol. 35:565-574.
9. Matheron, M. E., and Mircetich, S. M. 1985. Control of Phytophthora root and crown rot and trunk canker in walnut with metalaxyl and fosetyl Al. Plant Dis. 69:1042-1043.
10. Mircetich, S. M., and Matheron, M. E. 1976. Phytophthora root and crown rot of cherry trees. Phytopathology 66:549-558.
11. Orlikowski, L. B., Leoni-Ebeling, M., and Schmidle, A. 1986. Efficacy of metalaxyl and phosethyl-aluminium in the control of *Phytophthora cactorum* on apple trees. Z. Pflanzenkr. Pflanzenschutz 93:202-209.
12. Sandler, H. A., Timmer, L. W., and Graham, J. H. 1986. Timing of application of metalaxyl and fosetyl-aluminum for control of Phytophthora foot rot. Proc. Fla. State Hortic. Soc. 99:57-59.
13. Timmer, L. W., and Castle, W. S. 1985. Effectiveness of metalaxyl and fosetyl Al against *Phytophthora parasitica* on sweet orange. Plant Dis. 69:741-743.
14. Wilcox, W. F., Jeffers, S. N., Hayes, J. E. K., and Aldwinckle, H. S. 1985. *Phytophthora* species causing root and crown rot of cherry trees in New York. (Abstr.) Phytopathology 75:1347.
15. Wilcox, W. F., and Mircetich, S. M. 1985. Pathogenicity and relative virulence of seven *Phytophthora* spp. on Mahaleb and Mazzard cherry. Phytopathology 75:221-226.