*Proc. Fla. State Hort. Soc. 98:*119-122. 1985.

FOSETYL ALUMINUM FUNGICIDE FOR CONTROLLING PYTHIUM ROOT ROT OF FOLIAGE PLANTS

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Additional index words: Aliette 80WP, *Pythium splendens*, foliar application.

Abstract. **Aliette 80WP (fosetyl aluminum) was tested for efficacy in controlling root rot caused by *Pythium splendens* Braun on a variety of foliage plants. Drench applications of fosetyl aluminum provided a high level of disease control for pothos and spathiphyllum. Foliar and root applications of fosetyl aluminum gave a good growth response of foliage for pothos, spathiphyllum, schefflera, and aglaonema infected with *P. splendens*. Noticeable phytotoxicity developed on any plants treated with either a soil drench or a foliar spray of fosetyl aluminum.**

Root diseases are one of the more serious problems faced by foliage plant producers. Chemical control of root diseases caused by *Phytophthora* and/or *Pythium* spp. has been the preferred method by most growers. Etridiazole (Truban and Terrazole); captan (Captan); fenaminosulf (Lesan); propamocarb (Previcur N and Banol); metalaxyl (Subdue); and, most recently, fosetyl aluminum (Aliette) have been used for control of these fungi on foliage plants and other ornamental crops.

Fosetyl aluminum has been shown effective in controlling diseases caused by several species of *Phytophthora*. Control of *P. cinnamomi* on azalea was achieved with soil applications (1), while control of the same species on avocado was achieved with trunk injections (2). *Phytophthora cinnamomi* and *P. parasitica* were controlled on pineapple using preplant dips or foliar sprays (4). Phytophthora root rot of sour orange, caused by *P. parasitica*, was controlled with foliar sprays of fosetyl aluminum as well (3).

Little work has been reported regarding efficacy of fosetyl aluminum in controlling diseases caused by *Pythium* spp. In one study, several species of *Pythium* causing blight of perennial ryegrass were controlled using foliar sprays (5). In order to provide efficacy and phytotoxicity data for fosetyl aluminum as a foliar or spray application against *Pythium* spp., tests were performed in 1984 and 1985 on foliage plants. *Pythium splendens*, which is found on the majority of foliage plants with root rot disease, was chosen to evaluate phytotoxicity and efficacy concerns on a variety of common foliage plants.

Materials and Methods

All tests were performed using seedlings or cuttings obtained from commercial producers. Plants in greenhouse trials were established in a potting medium consisting of Canadian peat (50%) and pine bark (50%) amended with 4.0 kg dolomite, 4.4 kg Osmocote (19:6:12), and 0.9 kg Micromax (micronutrient source)/m^3 of medium. Prior to amendment, the potting medium was steam-treated for 1.5 hr at approximately 90°C. Plants in field trials were planted in a potting medium consisting of Canadian peat (30%), Florida peat (30%), charred bark (20%), and perlite (20%). Pots were top dressed with Osmocote (19:6:12) at the rate given for greenhouse trials and irrigated with approximately 1 cm water per day. Maximum light level of 300 $\mu mol\ s^{-1}m^{-2}$ was provided, with a range in temperature from 20 to 38°C. Light levels in greenhouse trials ranged from 150 to 200 $\mu mol\ s^{-1}m^{-2}$ natural light and temperatures from 16 to 35°C. Ten or 12 plants per treatment, each in 15-cm plastic pots, were arranged in a randomized complete block pattern on a greenhouse bench. Drench volume was adjusted to approximately 0.5 ml/cm^2 of potting medium surface and foliar sprays were applied to runoff.

Inoculum was prepared from a single isolate of *Pythium splendens* originally obtained from *Epipremnum aureum* (Linden & Andre) Bunt. (pothos). Inoculum was grown on cornmeal agar medium (CMA, Difco) for 3 days in the dark. One plate of inoculum was ground for 15 sec in a Waring blendor with 200 ml of sterilized deionized water. Control plants were treated with a similar slurry made from CMA plates alone. Ten ml of the appropriate slurry were added to the potting medium surface and the surface was watered lightly.

Ratings varied according to plant type and included number of leaves, number of shoots, plant height, vine length, fresh weights of shoots and roots, and a root grade or percent pot with healthy appearing roots, depending upon type of root system. Percent pot with healthy appearing roots and root grades were evaluated by gently removing the pot from the root mass and examining the surface of the potting medium. The root grade was made on the following scale: 1 = healthy appearing, white roots covering potting medium surface, 2 = slight root loss with healthy appearing roots over 75% of the potting medium surface, 3 = loss of 50% of the roots with healthy appearing roots over only 50% of the potting medium surface, 4 = healthy appearing roots over less than 25% of the potting medium surface, and 5 = no healthy appearing roots. The

Florida Experiment Stations Journal Series No. 6879. This project was supported in part by grant funds from IR-4 and Rhone Poulenc, Inc. The authors wish to express thanks to Bill McLees, Jeanne Yuen and Lee Pirkey for technical assistance and to the Florida growers who supplied plant materials for this study. Special thanks to Double F, Inc. for allowing us to perform field trials at their nursery.

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percent of healthy appearing roots data was changed to the arcsin of its square root for statistical analysis.

1984 Greenhouse Trials. The following plants were tested in 1984: *Aglaonema commutatum* Schott. 'Silver Queen', *Brassaia actinophylla* Endl. (schefflera), and pothos. All tests included a noninoculated and an inoculated control as well as chemical treatments. 'Silver Queen' treatments included fosetyl aluminum (Aliette 80WP, Rhone Poulenc, Inc.) foliar sprays of 2.4 and 4.8 g a.i./liter and drenches of 1.9 and 4.8 g a.i./liter, as well as drenches of metalaxyl (Subdue 2E, Ciba Giegy Corporation) (0.2 g a.i./liter), etridiazole (Truban 30WP, Mallinckrodt, Inc.) (0.2 g a.i./liter), propamocarb (Previcur N 66.5%, Nor-Am Agricultural Products, Inc.) (2.1 g a.i./liter, and captan (Capan 50WP, Stauffer Chemicals) (1.2 g a.i./liter). Applications were made 30 May and 30 July with inoculation 9 May and ratings 6 Sept. Schefflera treatments included those mentioned above for fosetyl aluminum and metalaxyl only. Applications were made 28 June and 10 Sept. with inoculation 21 June and ratings 20 or 21 Sept. Pothos treatments included only those for fosetyl aluminum given above. Pothos were treated 9 March and 9 May with inoculation 21 Feb. and ratings 13 June.

1985 Greenhouse Trials. Greenhouse trials in 1985 included the following plants: *Aphelandra squarrosa* Nees. (zebra plant), *Dieffenbachia maculata* (Lodd.) G. Don 'Perfection', *Philodendron scandens* C. Koch & H. Sello. subsp. *oxycardium* (Schott) Bunt. (heart-leaf philodendron), and pothos. Tests on all plants included noninoculated and inoculated controls, fosetyl aluminum sprays (2.4, 4.8, and 7.2 g a.i./liter) and drench (1.9 g a.i./liter) and metalaxyl drench (0.2 g a.i./liter). Treatments were applied to zebra plant 2 and 30 Aug. (all except metalaxyl, which was applied once only), with inoculation 29 July and ratings 24 or 25 Sept. 'Perfection', heart-leaf philodendron, and pothos were treated 4 June and 2 July (except metalaxyl which was applied once only), with inoculations 10 June and 17 July and ratings 30 July.

1985 Field Trials. The following plants were included in a field trial at a commercial nursery in Ft. Myers, Fla.: *Chamaedorea elegans* Mart. (parlor palm), *Cissus rhombifolia* Vahl (grape ivy), *Schefflera arboricola* H. Ayata (dwarf schefflera), *Spathiphyllum* sp. 'Wallisii', and *Syngonium podophyllum* Schott. 'White Butterfly'. Tests on all plants included noninoculated and inoculated controls, fosetyl aluminum sprays (2.4 and 4.8 g a.i./liter) and drench (1.9 g a.i./liter), and metalaxyl drench (0.2 g a.i./liter). Treatments were applied 21 June and 22 July (except metalaxyl, which was applied once only), with inoculations 18 June and 19 July and ratings 24 Aug.

Table 1. Effect of soil fungicide treatment on growth of *Aglaonema commutatum* ('Silver Queen') infected with *Pythium splendens* (1984).

Treatment[z]			Fresh weight (g)	
Chemical	Method	Rate (a.i./liter)	shoots	roots
Noninoculated control	—	—	213.6 a[y]	131.5 a
Inoculated control	—	—	202.7 a	124.6 a
Fosetyl-Al	foliar	2.4 g	208.6 a	127.7 a
Fosetyl-Al	foliar	4.8 g	229.1 ab	141.3 ab
Fosetyl-Al	drench	1.9 g	229.6 ab	135.4 a
Fosetyl-Al	drench	4.8 g	260.4 b	142.0 ab
Metalaxyl	drench	0.2 g	229.2 ab	157.7 b
Etridiazole	drench	0.2 g	228.5 ab	133.2 a
Propamocarb	drench	2.1 g	201.3 a	122.2 a
Captan	drench	1.2 g	219.4 ab	130.1 a

[z]Applications were made to runoff (spray) or as 0.5 ml/cm² (drench) 30 May and 30 July 1984. Plants were inoculated 9 May and ratings were taken 6 Sept. 1984.
[y]Mean separation in columns by Duncan's new multiple range test, 5% level.

Table 2. Effect of soil fungicide treatment on growth of *Brassaia actinophylla* (schefflera) infected with *Pythium splendens* (1984).

Treatment[z]				
Chemical	Method	Rate (a.i./liter)	Fresh weight shoots	Root grade[y]
Noninoculated control	—	—	125.4 ab[x]	1.0 a
Inoculated control	—	—	109.8 a	2.3 bc
Fosetyl-Al	foliar	2.4 g	127.6 ab	1.8 bc
Fosetyl-Al	foliar	4.8 g	110.4 a	2.5 c
Fosetyl-Al	drench	1.9 g	157.6 bc	2.3 bc
Fosetyl-Al	drench	4.8 g	172.9 c	1.8 bc
Metalaxyl	drench	0.2 g	128.9 ab	1.7 b

[z]Applications were made to runoff (spray) or as 0.5 ml/cm² (drench) 28 June and 10 Sept. 1984. Plants were inoculated 21 June and ratings were taken 20 or 21 Sept. 1984.
[y]Roots were graded on the following scale: 1 = healthy appearing, white roots covering potting medium surface, 2 = slight root loss with healthy appearing roots over 75% of the potting medium surface, 3 = loss of 50% of the roots with healthy appearing roots over only 50% of the potting medium, 4 = healthy appearing roots over less than 25% of the potting medium surface, and 5 = no healthy appearing roots.
[x]Mean separation in columns by Duncan's new multiple range test, 5% level.

Results and Discussion

1984 Greenhouse Trials. Mean plant height and number of shoots per plant for 'Silver Queen' were unaffected by treatment (Table 1). In contrast, fresh weights of both shoots and roots were affected by fungicide treatment. Plants treated with the 4.8 g rate of the fosetyl aluminum drench had significantly higher shoot weights than both control treatments. Plants in the remaining treatments had shoot weights equal to those of plants in control treatments (Table 1). Significantly higher mean fresh weight of roots occurred on plants treated with the metalaxyl drench compared to both control treatments. No phytotoxicity resulted from any fungicide application during this trial.

Mean height of schefflera was unaffected by treatment, but fresh weight of shoots was significantly influenced by the fungicide treatment (Table 2). Highest fresh weight of tops occurred when schefflera were treated with either rate of the fosetyl aluminum drench (Table 2). Fresh weights of tops for plants in other treatments were similar to those of control treatments. Root grades were recorded for schefflera due to the difficulty in separating their fibrous roots from the peat in the potting medium. Although root grades of all fungicide treatments were statistically the same as that of the inoculated control, slightly better roots were found on plants treated with metalaxyl or the 4.8 g fosetyl aluminum drench (Table 2).

Neither vine length nor number of chlorotic or necrotic leaves was affected by treatment for pothos (Table 3). Highest fresh weight of roots was found on plants treated with either rate of the fosetyl aluminum drench or spray (Table 3). Highest fresh weight of shoots was found on plants receiving either rate of the fosetyl aluminum drench.

1985 Greenhouse Trials. All ratings for heart-leaf philodendron were unaffected by treatment, including control plants, which did not develop any symptoms of Pythium root rot. No signs of phytotoxicity on any fungicide treated plants developed either. Similar results occurred for 'Perfection', although generally the best growth was found on plants treated with the high rate of the fosetyl aluminum spray.

Mean number of leaves on pothos was unaffected by treatment. Fresh weight of shoots was also unaffected by treatment (Table 4). Mean percentage of healthy appearing roots was significantly reduced by inoculation and was best for plants treated with metalaxyl or the fosetyl aluminum drench (Table 4). The higher rate of fosetyl aluminum applied as a spray also gave significant root rot control compared to the inoculated control (Table 4). Optimal control of pythium root rot of pothos would be obtained using a drench application of fosetyl aluminum or metalaxyl.

Ratings for zebra plant were not statistically affected by treatment. No phytotoxicity symptoms were noted during this trial.

1985 Field Trials. Of the plants included in these trials, only dwarf schefflera and 'Wallisii' responded significantly to inoculation. Although dwarf schefflera inoculated with *P. splendens* developed severe root rot, none of the fungicides provided a significant level of disease control. It is possible that under field conditions and 2 inoculations disease pressure was too high for a comparative evaluation. No phytotoxicity symptoms developed on any of these plants during these trials.

Both fresh weight of shoots and percent healthy appearing roots were significantly affected by fungicide treatment applied to 'Wallisii'. Fresh weight of shoots was significantly greater for plants treated with either rate of the fosetyl aluminum spray compared to those for control treatments (Table 5). Highest percent of healthy appearing roots was found on plants treated with fosetyl aluminum with no control seen on metalaxyl treated plants when compared to the inoculated control. All plants treated with fosetyl aluminum had root systems which had a significantly higher percent healthy appearing roots compared to the noninoculated control as well (Table 5). In contrast, root weights were unaffected by treatment.

These trials demonstrate the efficacy of fosetyl aluminum in controlling pythium root rot of both pothos and spathiphyllum and in production of more foliage growth on 'Silver Queen' and schefflera. In most trials, this compound provided the best growth response when applied as a drench, while in other cases, the fungicide appears to work as well when applied as a foliar spray. Root production of pothos and spathiphyllum was highest for plants receiving drench applications of either metalaxyl and fosetyl aluminum. A significant foliar response occured on 'Silver Queen' and schefflera as well, when fosetyl aluminum was applied as a drench at 4.8 g a.i./liter. This may be due to direct growth stimulation of the host or indirect effects due to inhibition of the pathogen leading to growth of the host. In the remaining trials, either no significant disease pressure occurred or the fungicides tested did not significantly affect disease development or plant growth.

Table 3. Effect of fosetyl aluminum treatments on growth of *Epipremnum aureum* (pothos) infected with *Pythium splendens* (1984).

Treatment[z]			Fresh weight (g)	
Chemical	Method	Rate (a.i./liter)	shoots	roots
Noninoculated control	—	—	128.2 ab[y]	37.8 cd
Inoculated	—	—	115.3 a	25.8 a
Fosetyl-Al	foliar	2.4 g	128.9 ab	32.1 b
Fosetyl-Al	foliar	4.8 g	127.7 ab	34.7 bc
Fosetyl-Al	drench	1.9 g	138.6 b	41.2 d
Fosetyl-Al	drench	4.8 g	134.8 b	42.8 d

[z]Applications were made to runoff (spray) or as 0.5 ml/cm² (drench) 9 March and 9 May 1984. Plants were inoculated 21 Feb. and ratings were taken 13 June 1984.
[y]Mean separation in columns by Duncan's new multiple range test, 5% level.

Table 4. Effect of soil fungicide treatments on growth of *Epipremnum aureum* (pothos) infected with *Pythium splendens* (1985).

Treatment[z]				
Chemical	Method	Rate (a.i./liter)	Fresh weight shoots (g)	Arcsin $\sqrt{\%}$ healthy roots
Noninoculated control	—	—	336.4 a[y]	75.4 cd
Inoculated control	—	—	330.1 a	25.4 a
Fosetyl-Al	spray	2.4 g	329.7 a	36.4 ab
Fosetyl-Al	spray	4.8 g	342.5 a	38.4 b
Fosetyl-Al	spray	7.2 g	338.9 a	65.6 c
Fosetyl-Al	drench	1.9 g	346.6 a	75.8 cd
Metalaxyl	drench	0.2 g	344.5 a	79.3 d

[z]Treatments were applied to runoff (spray) or as 0.5 ml/cm² (drench) 4 June and 2 July 1985 (except metalaxyl). Plants were inoculated 10 June and 17 July and ratings were taken 30 July 1985.
[y]Mean separation in columns by Duncan's new multiple range test, 5% level.

Table 5. Effect of soil fungicide treatment on growth of *Spathiphyllum* 'Wallisii' infected with *Pythium splendens* (1985).

Treatment[z]			Fresh weight (g)		
Chemical	Method	Rate (a.i./liter)	shoots	roots	Arcsin $\sqrt{\%}$ healthy roots
Noninoculated control	—	—	127.0 a[y]	235.9 a	53.5 b
Inoculated control	—	—	144.5 ab	219.9 a	32.5 a
Fosetyl-Al	spray	2.4 g	177.3 c	268.9 a	84.0 c
Fosetyl-Al	spray	4.8 g	191.2 c	261.2 a	85.0 c
Fosetyl-Al	drench	1.9 g	171.9 bc	208.4 a	87.0 c
Metalaxyl	drench	0.2 g	165.4 bc	256.1 a	45.5 ab

[z]Treatments were applied to runoff (spray) or as 0.5 ml/cm² (drench) 21 June and 22 July 1985 (except metalaxyl). Plants were inoculated 18 June and 19 July and ratings were taken 24 August 1985.
[y]Mean separation in columns by Duncan's new multiple range test, 5% level.

The ability to apply a fungicide for control of a root disease as a foliar spray will be an important development for many growers, since costs and ease of application are favored by this method. Use of the high rate of fosetyl aluminum (approximately 8 lb. Aliette 80WP/100 gal) may be questioned due to phytotoxicity and residue considerations. However, at no time during these trials was any phytotoxicity noted nor was residue even at the high rate excessive. Applications of this fungicide resulted in less foliar residue than applications of the majority of fungicides used for control of leaf spot diseases on foliage plants. Under some growing conditions, use of fosetyl aluminum as a foliar spray may be alternated with drench applications of fosetyl aluminum or metalaxyl for controlling losses in plant growth or vigor due to *Pythium splendens* root rot on pothos, spathiphyllum, 'Silver Queen', and schefflera.

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Proc. Fla. State Hort. Soc. 98:122-123. 1985.

EFFECT OF NUTRITIONAL BALANCE ON BRACT AND FOLIAR NECROSES OF POINSETTIA

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Additional index words: Euphorbia pulcherrima, nutrient.

Abstract. **'Gutbier V-14 Glory' poinsettia (*Euphorbia pulcherrima* Wild.) has a tendency to develop necrosis at bract margins. Bract necrosis may be prevented by calcium nutritional sprays. Apparently, the very rapidly developing bracts have a modest calcium requirement (0.1 to 0.2% Ca on a dry weight basis) but the Ca must be steadily available in the transpiration stream at the time of bract development. Bract necrosis was considerably aggravated by increasing levels of $MgCO_3$ substitution for $CaCO_3$ in liming. Calcium deficiency caused necrosis to develop on leaves as well as bracts with the highest level of substitution (100%). These marginal necroses were essentially prevented by spraying twice weekly with 1.2 g $CaCl_2$/liter of deionized water. Competitive cations (NH_4^+, K^+, and Mg^{++}) provided at higher levels in nutritional regimes accentuated the calcium deficiency symptoms.**

Struckmeyer (4) described calcium deficiency syndrome for poinsettia (*Euphorbia pulcherrima*) to include the following: small leaves, necrotic lesions, and a cupping or curling under of margins of upper leaves. The terminal growing point failed to continue growth, resulting in stunted plants. She made no mention of symptoms on bracts or other flower parts.

Wilfret (5) pointed out in a 1981 report on poinsettia cultivar evaluation that 'Gutbier V-14 Glory' was a new cultivar that showed the most promise for central Florida production if the often severe bract necrosis problem could be controlled. Nell and Barrett (1, 3) found that 'Gutbier V-14 Glory' plants had the most bract necrosis when plants were irrigated frequently and fertilized heavily during bract coloration; bract necrosis was much greater in plants receiving 100% ammonium nitrogen in contrast to those receiving half nitrate and half ammonium nitrogen (2). These observations, coupled with the symptomology of the disorder (6, 7), suggested that bract necrosis was a calcium deficiency related disorder. It was, therefore, decided to test the hypothesis that bract necrosis is an expression of a calcium deficiency in the rapidly developing poinsettia bract. It was believed that using soil conditions predisposing plants to calcium deficiency with and without preventive foliar nutritional sprays would essentially establish the role of calcium deficiency in bract necrosis.

Materials and Methods

A steam-sterilized 50:50 mixture of EauGallie fine sand and Florida sedge peat was amended with different liming materials (Table 1) to control calcium availability. Rooted cuttings of 'Gutbier V-14 Glory' were planted one per 18-cm plastic pot on 30 Aug. 1984. Plants were grown without supplemental light or shade and were pinched 13 Sept.

Results and Discussion

Substitution of $MgCO_3$ for $CaCO_3$ in liming the media resulted in inducing calcium deficiency that was only partially corrected by $CaCl_2$ sprays as shown by data (Table 1) on leaf and bract necrosis. The high rate of competitive cations, which decrease uptake of calcium, increased the incidence of bract and leaf necrosis over that of the low rate. Growth of poinsettias was severely hampered by the 2 lowest levels of $CaCO_3$. Characteristic calcium deficiency developed on plants in these treatments. $CaCl_2$ spray

Thanks are expressed to Pat Cox for capable technical assistance and to Paul Ecke, Inc., Encinitas, Calif. for furnishing plants.