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Fosetyl-Al, A Management Tool for Control of *Phytophthora* Root Rot

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Abstract. **The xylem and phloem transport of fosetyl-Al fungicide results in a flexible application regime which includes foliar sprays, trunk injection, trunk paint and chemigation. In eleven trials conducted in Florida and California, one or two injections of a 10% fosetyl-Al solution consistently improved tree vigor. The average in- crease in twig growth in four Florida studies of two-year duration was 57% for one application and 67% after two applications. Yield from a three-year South African study (2 spring fosetyl-Al and metalaxyl applications/year) for untreated, fosetyl-Al 80WP solution (20 mL/meter canopy diameter), fosetyl-Al Injectable (20 mL/meter canopy diameter), and metalaxyl 5G (40 g/m2 soil application) were: 35, 192, 227 and 167 kg/tree respectively. The mean disease rating across seven South African trials with injection treatment rates of 0.3 g fosetyl-Al/m 2 canopy declined on a yearly basis from 5.4 at initiation to 2.2 after one year, 1.5 after the second year, and 0.9 in the third year (0-10 scale, 10 = dead). Two additional South African studies showed a 19% yield increase in the third year with the use of fosetyl-Al (15 mL/m canopy) during which time tree health improved 33% while untreated trees declined 33%. Fosetyl-Al injections in Australia have resulted in a 70% improvement in tree health within 5 to 15 month of initial application. Fosetyl-Al [aluminum tris-(0- ethyl phosphonate)] (sold commercially under the tradename Aliette) has been used throughout the avocado growing regions of the world for 11 years. In the United States, it has been labeled as a sleeve drench and foliar spray for non-bearing avocados since 1986. Registrations exist for control of avocado feeder root rot caused by *Phytophthora cinnamomi* in Australia, Spain, South Africa, Mexico, and Venezuela. California presently has a Section-18 (conditional registration) for injection in bearing trees.**

Fosetyl-Al is a true systemic fungicide exhibiting both upward and downward movement in plants. The xylem and phloem transport of fosetyl- Al have allowed varying application scenarios including foliar sprays, trunk injection, trunk paint, sleeve drench and chemigation for control of avocado feeder root rot caused by *Phytophthora cinnamomi.* Research from the Republic of South Africa, Australia and the United States which demonstrates the efficacy of these fosetyl-Al application techniques will be presented.

Results

South Africa. The fosetyl-Al injection technique was developed (Darvas *et al.,* 1983) in an effort to produce a quicker tree recovery than obtained with fosetyl-Al (formulated as Aliette WP) as a foliar spray to trees with limited canopy due to *Phytophthora* root rot. A calcium-buffered liquid formulation of fosetyl-Al was found to be superior to solutions of fosetyl-Al wettable powder for avocado injections (Wood, 1986). The mean disease ratings across seven trials treated twice per year with injectable fosetyl-Al (0.3 g/m^2 canopy) declined on a yearly basis from 5.4 at initiation in 1983 to 2.2 after one year, 1.5 after the second year, and 0.9 in the third year (0-10 scale, 10=dead).

In November 1989, two avocado studies were concluded in Nelspruit, Eastern Transvaal and Louis Trichardt, Northern Transvaal. Stem injections of fosetyl-Al and the dipotassium salt of phosphorous acid were made based on the canopy diameter. Tree recovery was more significant at Louis Trichardt, with fosetyl-Al (15 mL/m canopy) superior to phosphorous acid at either 15 mL/m or 7.5 mL/m canopy and all fungicide treatments demonstrated significantly improved vigor over the untreated control (Table 1). Evaluations were expressed in disease index (0-10, 10 = dead) or % tree health improvement. It was noted by the field staff conducting the trials that after three years of treatment, a visual distinction can easily be made between fosetyl-Al and phosphorous acid-treated trees. After an initial improvement, phosphorous acid treated trees showed signs of decline. At the Nelspruit location, all fungicide injection treatments provided comparable improvement based on the disease index scale, but third-year yields in fosetyl-Al treated plots were numerically superior to fruit yields for either rate of phosphorous acid treated trees (Anelich, 1990).

Fosetyl-Al is presently registered for use in South Africa as Aliette Ca^R for injection, Aliette WP^R as a foliar spray (375 g/100 L water) and Aliette WP^R as a root drench for nursery trees (375 g/100 L water).

Australia. Rapid response to fosetyl-Al fungicide injection treatment has been demonstrated in a test in Tamborine, Queensland, conducted by the Department of Primary Industries. Fosetyl-Al (15 mL/m tree canopy) provided a 48% improvement over the untreated control within 5 months of the first of two applications. Flush vigor dramatically improved during the same time period with the mean of fosetyl-Al Ca treated plots rated 3.25 (0 = nil, 10= 100% flush at terminals) and untreated control rated 1.58. A second test site in Caboolture, Queensland, provided similar results after three injection applications (15 months). Results with fosetyl-Al (15 mL/m canopy) were

comparable to metalaxyl (50 g/kg at 100 g/m^2 canopy area). The addition of zinc sulfate to fosetyl-Al resulted in an improved response as measured by leaf retention, spring flushing and tree health (Table 2).

Fosetyl-Al has been registered in Australia as Aliette^R for foliar spray since 1981 and for injection as Aliette Ca^R since 1989 (Pelizzo, 1990).

United States. Fosetyl-Al has been evaluated in Florida and California as a foliar spray, sleeve drench, stem injection, and through chemigation. Averaged across five avocado seedling studies, measurements of trunk diameter and tree height indicated that foliar sprays of fosetyl-Al were more effective at controlling *Phytophthora* root rot than a sleeve drench (Table 3). Foliarly-applied fosetyl-Al resulted in seedling growth comparable to metalaxyl drenches. In an earlier study conducted by Dr. M. Coffey, University of California, Riverside, the sleeve drench application of fosetyl-Al was comparable to foliar sprays (Table 4). After three years of applications, drench applications of metalaxyl 5G were statistically inferior to fosetyl-Al treatments as measured by disease index and lower yield.

As occurred in Australia and South Africa, injection applications were evaluated as a means of enhancing fosetyl-Al activity and shortening tree recovery time (Coffey, 1987). Averaged over 11 trials in Florida and California, a single spring injection application of fosetyl-Al injectable formulation was only moderately less effective than two applications per year (spring, fall) as evaluated by disease index after the second year (Table 5). Tree recovery was significant (Tepper, 1988).

To confirm an application method that has been effective in citrus in the U.S., chemigation trials are currently being conducted by Dr. H. Ohr, University of California, Riverside.

In the United States, fosetyl-Al has been registered since 1986 with the Environmental Protection Agency as Aliette^R 80WP as a pre plant drench and foliar spray. on non-bearing avocados (not to be harvested within 12 months.) A Section 18 conditional registration is presently in effect for liquid Aliette Injectable^R (9.5% active fosetyl-Al) in California on bearing trees. Federal approval of Aliette^R 80WP and Aliette^R Injectable is anticipated in 1992.

Summary

Fosetyl-Al fungicide can effectively treat *Phytophthora* root rot of avocado applied as a sleeve drench to seedlings and as a foliar spray or trunk injection on bearing trees. Data indicate successful commercial treatment of infected trees should be stem injections with fosetyl-Al followed by foliar sprays as maintenance treatment after tree vigor has been restored. Preventative treatment of *Phytophthora* root rot should begin at the seedling stage with either sleeve drench or foliar spray treatments of fosetyl-Al.

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Table 1. Results of two avocado fungicide trials in the Republic of South Africa after 3 years of stem injection treatments, November 1989.

Treatment		Louis Trichardt[z]		Nelspruit[z]	
	Rate (mL/canopy)	Disease Index[y]	% Tree Health Improvement	Disease Index	Yield kg/tree
Untreated		8.0	-33.3	6.3	177.4
fosetyl-Al	15.0	4.0	33.3	4.8	211.8
phosphorous acid[x]	15.0	5.3	11.7	5.0	124.0
phosphorous acid[x]	7.5	5.7	5.6	5.5	192.9

[z] evaluations made November 1989 after three years of treatment.
[y] Avocado Feeder Root Rot disease index (0-10 scale, 10 = dead).
[x] dipotassium salt of H_3PO_3.

Table 2. Response of 'Fuerte' avocados to three fungicide injection treatments over a 15 month time period for control of *P. cinnamomi* root rot, Caboolture, Queensland.

Treatment	Leaf Retention[z]	Spring Flush[y]	% Tree Health Improvement	
			12 Mo.	15 Mo.
Untreated	4.8	0.6	6.6	32.4
fosetyl-Al Ca & zinc sulfate	5.0	1.0	35.2	70.5
metalaxyl	4.6	0.4	39.8	63.2

[z] Leaf retention during flowering (0 = nil, 10 = full canopy) after 15 months.
[y] Spring flush of shooting terminals (0 = nil, 10 = 100%) after 15 months.

Table 3. The effects of fosetyl-Al sleeve drench and foliar sprays on *Phythophthora* root rot of non-bearing avocado.[z]

Treatment	Rate (kg ai/ha)	Trunk[y] diameter (cm)	Tree[y] height (cm)
Control		2.1	66.2
fosetyl-Al (F)	2.2	2.7	71.6
fosetyl-Al (F)	4.5	3.1	76.5
fosetyl-Al (D)[x]	0.28	2.2	74.2
fosetyl-Al (D)[x] + fosetyl-Al (F)	0.28 4.5	2.3	78.6
metalaxyl (D)[x]	29.6 mL/ha	3.5	73.0

[z] Tests were conducted in California and Florida during 1985-87. The data is the mean of five tests. (F = foliar application, D = sleeve drench once preplant).

[y] Growth measurements taken 12-15 months after initial treatment.

[x] The drench applications were applied at 5 oz/10 gallons (3000 PPM) as a sleeve drench 48 hours prior to planting (2.5 lb ai/100 gallons). Metalaxyl was applied as a drench at 1.0 fluid oz/tree.

Table 4. The effects of fosetyl-Al foliar sprays on *Phytophthora* root rot of bearing avocado.[z]

Treatment	Rate	Disease Index (0-10)	Yield (kg/tree)
Control	---	3.4 a	1.3 a
fosetyl-Al (F)	3 gm ai/L[y]	0.8 b	17.2 b
fosetyl-Al (D)	8.5 gm ai/m[y]	0.8 b	28.4 b
fosetyl-Al (F) + fosetyl-Al (D)	3 gm ai/L[y] 8.5 gm ai/m[y]	1.2 b	29.2 b
Metalaxyl	2.5 gm ai/m[y]	2.8 a	14.2 b

[z] Tests were conducted in California from 1981-83 by Dr. M. Coffey at the University of California, Riverside.

[y] The application spray schedule, [year (# of applications)]: fosetyl-Al - foliar (2.5 lb ai/100 gal.) Applications 1981 (5), 1982 (3), 1983 (3); fosetyl-Al - drench (1.87 lb ai/1000 sq. ft.) 1981 (4), 1982 (2), 1983 (2); Metalaxyl - drench (0.6 lb ai/1000 sq. ft.) 1982 (2), 1983 (2).