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Injectable formulations of phosetyl-Al developed for root rot control in avocado trees in South Africa

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SYNOPSIS
Phosetyl-Al, applied as a stem injection, controls Phytophthora root rot of avocado trees very effectively. A 10 per cent aqueous solution of this fungicide has been successfully developed for application by this method. In seven field trials in South Africa, an average of 60 per cent improvement in tree condition was achieved after one season of treatment. This increased to 72 and 83 per cent after two and three seasons respectively. Production was improved by up to 350 per cent over untreated trees after two seasons. The optimum dosage rate was 0,3 g ail m^2 of the tree's drip diameter. Two other formulations containing zinc improved the zinc status of trees. Similar results have been obtained in citrus.

INTRODUCTION

A wettable powder formulation containing 80 per cent phosetyl-Al was registered in 1979 as a foliar spray for controlling Phytophthora root rot in avocados in South Africa. This method of application, however, met with limited success. The general condition of avocado trees at that time was very poor. Many trees had dropped leaves and could not absorb sufficient chemical for it to be effective. There were also practical problems with the application of foliar sprays. Many orchards are in hilly country and the steep slopes made spraying by tractor difficult. In older orchards trees were planted very close together, which also made spraying difficult.

Because of these problems, a number of research workers began investigating alternative methods of applying phosetyl-Al and other chemicals. These investigations led to reports by Darvas, Toerien & Milne (1983) on stem injections and on stem application by means of sponge bands and painting (Snyman, 1982; Snyman & Kotzé, 1983; Darvas, 1983). Because of a shortage of zinc in the avocado areas of South Africa, Darvas (1984) injected a mixture of phosetyl-Al and zinc sulphate which improved the zinc status and general vigour of avocado trees. The early injection work with phosetyl-Al was done using a solution made up from the 80 per cent wettable powder formulation. This report deals with field trials that were aimed at the development of a suitable formulation made specifically for use as a stem injection.

MATERIALS AND METHODS

Comparison of sponge bands and stem injection

A block of *Phytophthora*-infected Edranol trees on seedling rootstocks was rated for severity of root rot symptoms on a scale where 0 = healthy and 10 = dead. Trees of similar size and a disease rating of six or seven were treated as follows:

(a) Untreated control.
(b) Phosetyl-Al 80 per cent WP (Aliette®) applied in a sponge band at 0,8 g ai/cm stem circumference as described by Snyman & Kotzé (1984).
(c) Stem injection of a solution of phosetyl-Al (approx seven per cent ai) made up by mixing Aliette 80 per cent WP with water and centrifuging. Application rate approximately 0,28g ai/m^2 of canopy areas as described by Darvas, Toerien & Milne (1983).

The treatments were applied twice per season in 1982/83 and 1983/84 to two single tree replicates. The trees were rated for disease severity in August 1983 and March 1984.

Comparison of phosetyl-Al formulations for injection

Two field trials were conducted in the Tzaneen and Kiepersol areas respectively. The solution made from Aliette WP and an experimental formulation containing 10 per cent phosetyl-Al (EXP 2008) were compared for efficacy, safety to the crop and suitability for tree injection. EXP 2008 was developed by Rhone-Poulenc Agrochimie in Lyon, France. The following treatments were applied:

(1) Untreated control.
(2) Injection of EXP 2008 at 10 ml prod/m of canopy diameter.
(3) Injection of EXP 2008 at 15 ml prod/m of canopy diameter.
(4) Injection of EXP 2008 at 20 ml prod/m of canopy diameter.
(5) Injection of Aliette 80 per cent WP approximately seven per cent solution at 20 ml/m of canopy diameter.

Treatments were applied twice per season in 1983/84, 1984/85 and 1985/86 to four and six single tree replicates respectively in two trials. The trees were rated for disease severity in the winter of 1984, 1985 and 1986.

Confirmation of efficacy of EXP 2008 in different cultivars under different conditions

Seven field trials were conducted in different avocado production areas in the most important cultivars, Fuerte, Hass and Edranol. EXP 2008 was applied at dosage rates ranging from 10 to 20 ml/m of canopy diameter. In these tests the optimum dosage rate was determined. The mean percentage improvement achieved by this dosage rate was calculated for all the trials. Wherever possible, yields were determined for each treatment.

Comparison of phosetyl-Al formulations with and without zinc

An attempt was made to mix zinc sulphate with EXP 2008, but this mixture could not be injected because of chemical incompatibility. Zinc nitrate was then used in the place of zinc sulphate. A formulation containing both phosetyl-Al and zinc nitrate was also tested. Different methods of applying zinc nitrate were compared in two trials in 1985/86. The following treatments were applied:

(1) Untreated control.
(2) Zinc nitrate foliar spray at 150g/ 100l water.
(3) EXP 2008 + 10 per cent zinc nitrate injected at 15 ml/m of canopy diameter.
(4) EXP 2008D (a formulation containing phosetyl-Al and zinc nitrate) injected at 15 ml/m of canopy diameter.

The treatments were applied twice during summer to 10 single tree replicates. Leaves were sampled in February 1986 and analysed for zinc content.

A formulation containing phosetyl-Al and zinc acetate (EXP 2008C) was tested in 1986 on Fuerte trees. The treatments were:

(a) Untreated control.
(b) EXP 2008 injected alone at 15 ml/m of canopy diameter.
(c) EXP 2008C injected at 15 ml/m of canopy diameter.

The treatments were applied twice during summer to four single tree replicates. Leaves were sampled in February 1987 and analysed for zinc content.

RESULTS

Sponge bands vs stem injections; the application of sponge bands was found to be a very laborious process. Making up the phosetyl-Al solution, was also time consuming and resulted in a very variable concentration of active ingredient when analysed. Time taken up for the injections varied between 12 and 48 hours. The injection method resulted in better tree recovery than the sponge band method (see Table 1).

Phosetyl-Al formulations

The solution made from Aliette WP was always more slowly taken up by the tree than EXP 2008.

EXP 2008 was completely taken up in a few minutes (maximum two hours), while the WP solution sometimes took several days for the syringes to empty. Results of the two trials are given in Tables 2 and 3. From these it can be seen that EXP 2008 brought about a quicker and better recovery than Aliette WP when applied as an injection.

Efficacy in different cultivars

The optimum dosage rate was found to be 0,3g ai/m^2 of canopy area. The average disease ratings for trees treated with the optimum dosage rate are given in Table 4.

Phosetyl-Al plus zinc

The zinc status of trees was enhanced by the injection of zinc nitrate together with EXP 2008. It was also enhanced by injecting phosetyl-Al formulations containing zinc nitrate or zinc acetate (see Tables 5 and 6).

Zinc content was also improved by the injection of EXP 2008C, a formulation containing phosetyl-Al and zinc acetate (see Table 6).

DISCUSSION

The use of phosetyl-AI as a trunk injection has previously been shown to be very effective in controlling avocado root rot (Darvas *et al*, 1983). It was confirmed by these results, which also demonstrated the superiority of EXP 2008 over Aliette WP when used for tree injection. When the WP is used to prepare a solution for injection, the ai dissolves very slowly, resulting in variation in concentration. When injected, this solution can take a number of days to be absorbed by the tree. EXP 2008, which was more rapidly taken up and which produced a faster, better response from the trees, is therefore a much more suitable form of phosetyl-Al for application by injection.

The general zinc deficiency in avocado areas necessitates the application of zinc on a regular basis. The formulations tested here show promise as they could possibly be used for the simultaneous treatment of root rot and zinc deficiency. Further work needs to be done in this regard.

Trials similar to the ones described here, have been conducted on root rot infected citrus trees, with similar results. Significant increases in yield and fruit size have been achieved in the first year after phosetyl-Al injections were applied (Wood, Bennett, Blanken & Grech, 1987). EXP 2008 (Aliette Ca) is now approved for use on both avocado and citrus trees in South Africa.

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TABLE 1 Effect of two methods of applying phosetyl-Al on tree condition of diseased Edranol trees.

	Mean disease rating of trees		
Treatment	1982 (before treatment)	1983	1984
1 Untreated	6,5	6,8	6.3
2 Phosetyl-Al sponge band	6.5	6,0	5,0
3 Phosetyl-Al injection	6,5	5,5	1,5

TABLE 2 Effect of phosetyl-Al injections on tree condition and yield of Fuerte trees in the Tzaneen area.

	Mean disease rating of trees				Yield (kg/tree)
Treatment	1983 (before treatment)	1984	1985	1986	1986
1 Untreated	6,0	6,0	6 3	7 2	44
2 EXP 2008 10 ml/m	6,0	5,0	30	1 8	316
3 EXP 2008 15 ml/m	6,0	4,3	25	08	330
4 EXP 2008 20 ml/m	6,0	5.2	1 7	1 0	356
5 Aliette WP sol'n20 ml/m	6,0	6,2	32	1 0	318

TABLE 3 Effect of phosetyl-Al injections on tree condition of Hass trees in the Hazyview area.

Treatment	Mean disease rating of trees				Yield (No of fruit per tree) 1985
	1983 (before treatment)	1984	1985	1986	
1 Untreated	5,0	4,5	3,8	6,0	101
2 EXP 2008 10 ml/m	5,0	2,0	2,3	2,3	297
3 EXP 2008 15 ml/m	5,0	0,5	0,5	0,7	455
4 EXP 2008 20 ml/m	5,0	1,0	0,8	1,0	392
5 Aliette WP sol'n 20 ml/m	5,0	2,0	0,5	2,8	261

TABLE 4 Disease ratings of trees treated at the optimum dosage rate.

Cultivar	Mean disease ratings			
	1983 (before treatment)	1984	1985	1986
Fuerte	4,3	1,20	1,00	0,90
Fuerte	5,2	1,80	1,10	0,60
Fuerte	6,0	4.30	2,50	0,80
Hass	5,0	0,50	0,50	0,70
Hass	6,0	3,00	2,80	0,30
Hass	6,0	2,00	1,60	2,00
Edranol	5,3	2,50	1,20	1,00
Mean Rating	5,4	2,18	1,53	0,90
Per cent improvement		60%	72%	83%

TABLE 5 Different methods of applying zinc nitrate and their effect on the zinc content of avocado leaves (mean of two trials)

Treatment	Mean zinc content in leaves (mg/kg)
1 Untreated	24,5
2 Zinc nitrate spray	29,0
3 EXP 2008 + zinc nitrate injection	30,0
4 EXP 2008D injection	36.0

TABLE 6 Injection of phosetyl-Al, with and without zinc acetate and its influence on the zinc status of avocado trees

Treatment	Mean zinc content in leaves (mg/kg)
1 Untreated	24
2 EXP 2008 injection	41
3 EXP 2008C injection	59