

Nematicidal Effects of Oxamyl Applied to Leaves of Banana Seedlings

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Abstract: Foliar applications of oxamyl prevented nematodes from invading roots of diploid bananas. One spray with 1,250 µg/ml was more effective than 1, 2, or 3 sprays with 625 µg/ml applied at 5-day intervals. After 3 sprays with 1,250 µg/ml, invasion may be prevented for up to 4 weeks and possibly longer. Washing roots after oxamyl treatments prevented nematicidal control. When applied to nematode-infected plants, three sprays of oxamyl decreased nematode populations in the roots. **Key Words:** Vydate®, *Musa acuminata malaccensis*, *Radopholus similis*, *Helicotylenchus multicinctus*, *Rotylenchulus reniformis*, chemical control.

Foliar applications of oxamyl appear to control nematodes after translocation of the chemical or its derivatives to infection sites within the root system. Oxamyl probably prevents nematode invasion of roots (1, 5, 8, 10) and/or suppresses population establishment within roots (1, 2, 3, 4, 7). Taylor and Alphey (10) suggested that a nematicide is exuded from roots of oxamyl-sprayed plants. More recently, Potter and Marks (6) concluded that such an exudate persists in the rhizosphere for up to 21 days. Rich and Bird (8) found that oxamyl or a derivative was translocated to the roots of cotton and tomato within 24-48 h.

Better nematode control may be obtained when treatments are applied before or at the time of inoculation with nematodes (2). Multiple applications of the chemical are sometimes more effective than single applications of a more concentrated solution (3, 4, 8).

This investigation was designed to determine the effectiveness of one to three foliar applications of oxamyl in preventing nematode invasion of diploid bananas. In addition, the location and persistence of the nematicidal action of oxamyl against *Radopholus similis* (Cobb) Thorne, *Helicotylenchus multicinctus* (Cobb) Golden, and *Rotylenchulus reniformis* Linford and Oliveira were investigated.

MATERIALS AND METHODS

Banana plants of a seed-producing diploid clone, 'Pahang' *Musa acuminata*

malaccensis (Ridley) Simmonds (9) were germinated in oven-sterilized soil (70-80 C for 7 h) and later transplanted to plastic pots 12- or 18-cm deep with 1.5 or 3.5 kg of oven-sterilized soil, respectively. Ten-week-old seedlings between 10-20 cm in length were sprayed with aqueous solutions of oxamyl (908 gm oxamyl (a.i.)/3,785 ml formulation) containing a sticker-wetting agent Triton B 1956 at 0.25 ml/liter on upper and lower leaf surfaces until run-off. Applications were made with a compression sprayer. Control plants were sprayed with water and wetting agent only. To prevent contamination during treatment, cotton wool was placed on the soil surface, and the pots were placed horizontally on the edge of a greenhouse bench. In tests with multiple applications, the sprays were applied at 5-day intervals.

Seedlings were inoculated with suspensions of nematodes obtained by comminuting banana roots collected from commercial fields or by repotting plants in naturally infested soils. For inoculations and treatment evaluations, the method of extracting nematodes was to chop roots into 1- to 2-cm lengths and comminute 25-gm subsamples for 10 sec at high speed and 10 sec at low speed in a kitchen blender. The debris was washed for 2 min with a fine spray over a series of 297-, 149-, 74- and 44-µm sieves. Nematodes which collected on the two finer sieves were saved for counting and/or inoculation. Tests were concluded 5-6 weeks after inoculation. Pots were soaked in water for 5 min before soil was washed from the root systems.

In the first experiment, foliar applications of 625 and 1,250 µg (a.i.)/ml oxamyl were applied 1, 2, or 3 times before inoculation with mixtures of *R. similis* (Rs), *H.*

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multicinctus (Hm), and *R. reniformis* (Rr). Two days after the final oxamyl applications, one half of the plants were removed from the original pots, washed, and repotted in 18-cm deep pots which contained 3.2 liters of naturally infested soil. The infestations of nematodes/100 cm³ of soil for the 1 to 3 applications (respectively) were 15 Rs, 150 Hm, 375 Rr; 5 Rs, 250 Mm, 1,250 Rr; and 10 Rs, 240 Hm, 2,490 Rr. The remaining plants were retained in their original 12-cm deep pots. For the respective 1, 2, or 3 oxamyl applications, these plants were inoculated with either 800 Rs, 648 Hm, 520 Rr; 2,000 Rs, 2,000 Hm, 600 Rr; or 600 Rs, 1,000 Hm, 900 Rr. Each treatment was replicated four times.

In a second experiment, seedlings were sprayed 3 times at 5-day intervals with either water or aqueous solutions of oxamyl (1,250 µg/ml). One, 2 and 4 weeks after the third application, plants were (i) removed from the pots and replanted with the minimum possible disturbance in 18-cm deep pots which contained heat sterilized loamy soil or (ii) soaked in water for 5 min before the root systems were washed free of soil and similarly repotted. The plants were then inoculated with suspensions of *R. similis*, *H. multicinctus*, and *R. reniformis*. The numbers of species/pot for the 1-, 2-, and 4-week treatments (respectively) were

400 Rs, 1,300 Hm, 100 Rr; 1,500 Rs, 1,300 Hm, 100 Rr; 7,100 Rs, 3,900 Hm, and 50 Rr. Each treatment had five replications.

The third experiment was similar to the second except that suspensions of *R. similis*, *H. multicinctus*, and *R. reniformis* were applied to 12-cm deep pots 1, 2, 4, 8, and 12 weeks after the last of three foliar treatments. The quantities of each species applied for the respective time treatments were 10,000 Rs, 150 Hm, 140 Rr; 8,000 Rs, 2,500 Hm, 520 Rr; 7,200 Rs, 1,100 Hm, 300 Rr; 3,200 Rs, 1,000 Hm, 500 Rr; and 3,300 Rs, 3,000 Hm, 100 Rr. Each treatment was replicated 6 times.

In the fourth experiment, uniformly infected seedlings were obtained by planting in an infested soil and subsequently by inoculating with equal volumes of suspensions of *R. similis*, *H. multicinctus*, and *R. reniformis* on 5 occasions over a 5-week period. Three weeks later, plants were divided randomly into two groups. The nematode population in the root systems of four representative plants from each group was assessed. One group was sprayed with oxamyl 1,250 µg/ml 3 times at 5-day intervals, and the other group was sprayed with water. Nematode populations were assessed from the roots of 5 plants of each treatment 1 and 3 weeks after the third foliar treatment.

TABLE 1. Control of *Radopholus similis* (Rs), *Helicotylenchus multicinctus* (Hm) and *Rotylenchulus reniformis* (Rr) on banana seedlings with oxamyl.

Treatments oxamyl (µg/ml)	Nematodes/gm root							
	Seedlings transplanted into infested soil after washing roots.				Seedlings undisturbed, inoculated with nematode suspension.			
	Rs	Hm	Rr	Total	Rs	Hm	Rr	Total
One Spray								
1,250	14	171	20	205	2**	0	0	2*
625	8	156	16	180	23*	1	0	24*
0	1	148	5	154	208	0	0	208
Two sprays								
1,250	5	88	2	95	0*	0	0	0*
625	6	13	5	149	13*	6	0	19*
0	4	123	6	143	77	9	0	86
Three sprays								
1,250	6	38	7	50*	0*	0	0	0*
625	8	24	21	53*	5*	3	0	8*
0	61	51	24	136	30	4	0	34

Asterisk () indicates column means within spray groupings differ from water-sprayed controls ($P=0.05$).

RESULTS

Successful inoculations were made with suspensions of *R. similis* (Rs) and *H. multicinctus* (Hm), and the numbers recovered gave no indication of interspecific competition. The only successful method of inoculation of *R. reniformis* (Rr) was with naturally infested soil (Table 1).

In the first experiment, washing roots at transplanting removed a nematocidal effect and only after 3 applications of oxamyl at 625 or 1,250 µg/ml were the combined totals of Rs, Hm and Rr significantly less than those of the control (Table 1). When plants were not transplanted, the highest dosage of oxamyl gave total control of Rs and Hm when it was applied 2 or 3 times and almost complete control when it was applied once. One, two, or three sprays with oxamyl at 625 µg/ml were less effective (Table 1).

The removal of nematocidal activity by washing roots was confirmed in the second experiment (Table 2). When washing, transplanting, and inoculation occurred 1, 2, and 4 weeks after the third application of oxamyl, the combined totals of Rs and Hm subsequently recovered were less in the oxamyl-sprayed unwashed roots than in those of the other treatments ($P = 0.05$) with the exception of week 2 when total numbers were also less in the water-sprayed roots washed treatment. In the 1- and 4-week treatments, numbers of *H. multicinctus* were also less in the oxamyl-sprayed unwashed roots but *R. similis* numbers were only significantly less in the 1-week series.

In the third experiment, some nematocidal activity persisted for 2 weeks after spraying although the total numbers of Rs and Hm indicated that some activity might persist for up to 8 weeks, but these differences were not significant (Table 3).

TABLE 3. Root infection with *Radopholus similis* and *Helicotylenchus multicinctus* as affected by the time of inoculation after foliar oxamyl treatments.

Nematode species	Nematodes/root system/time of inoculations after spray									
	1 week		2 weeks		4 weeks		8 weeks		12 weeks	
	oxamyl	control	oxamyl	control	oxamyl	control	oxamyl	control	oxamyl	control
<i>R. similis</i>	524**	2,640	2,318	5,094	106	286	534	930	818	412
<i>H. multicinctus</i>	0	26	23*	210	1,130	1,386	150	190	310	521
Total	524*	2,666	2,341*	5,304	1,236	1,672	693	1,120	1,128	933

Asterisk () indicates means within time groupings differ from respective controls ($P=0.05$).

TABLE 2. Effects of root washing on invasion by *Radopholus similis* (Rs) and *Helicotylenchus multicinctus* (Hm) of oxamyl-sprayed or water-sprayed bananas.

Treatments	Nematodes/gm root*		
	Rs	Hm	Total
One week from oxamyl treatment to transplanting and inoculation			
Water-sprayed, roots washed	14 ^a	11 ^a	25 ^a
Water-sprayed, roots not washed	27 ^a	20 ^a	47 ^a
Oxamyl-sprayed, roots washed	14 ^a	5 ^a	19 ^a
Oxamyl-sprayed, roots not washed	1 ^b	1 ^b	2 ^b
Two weeks from oxamyl treatment to transplanting and inoculation			
Water-sprayed, roots washed	110	60	170 ^b
Water sprayed, roots not washed	271	99	370 ^a
Oxamyl-sprayed, roots washed	147	78	225 ^a
Oxamyl-sprayed, roots not washed	112	22	134 ^b
Four weeks from oxamyl treatment to transplanting and inoculation			
Water-sprayed, roots washed	209	145 ^a	354 ^a
Water-sprayed, roots not washed	242	143 ^a	385 ^a
Oxamyl-sprayed, roots washed	269	147 ^a	416 ^a
Oxamyl-sprayed, roots not washed	163	78 ^b	242 ^b

*Means in columns of similar time groups followed by the same letter do not differ ($P=0.05$) according to Duncan's multiple range test.

In the fourth experiment, applications of oxamyl suppressed the infections of root systems by the three nematode species. From pretreatment totals (mean of 8) of 895 Rs, 3,425 Hm, and 475 Rr/root system, the numbers in roots of treated plants decreased to 440 Rs, 1,460 Hm, 20 Rs and 320 Rs, 1,800 Hm, 140 Rs after 1 and 3 weeks, respectively. In nontreated plants, the respective nematode numbers after 1 and 3 weeks were 900 Rs, 3,240 Hm, 160 Rs and 1,680, Rs, 3,760 Hm, 320 Rr. The differences in numbers of Rs and Hm between treatments at each sampling were significant ($P=0.05$). Infection by Rr was suppressed in all oxamyl treatments.

DISCUSSION

Foliar spraying with oxamyl is effective in controlling populations of *R. similis* and *H. multicinctus* within banana roots and in preventing root-invasion.

The removal of nematicidal activity by washing roots 2 days after spraying leaves suggests a rapid translocation to the root system; it is not clear if the nematicide is within the roots and is leached by washing or if it is on the root surface or even in the adjacent soil. Taylor and Alphey (10) postulated the production of a nematicidal root exudate which could persist in soil even after the removal of the treated plant; however, the presence of such a compound in the soil could not be demonstrated by Potter and Marks (6) who considered that the exudate remained on the root-surface or in the rhizosphere soil.

Nematicidal persistence in undisturbed plants may last for 14 to 28 days and possibly longer. The accumulation of a

nematicidal agent in the roots, or at or near the root surface, however, appears to happen during the first 7 days after spraying since nematicidal concentrations apparently failed to develop after root-washing except when washing was done 2 days after the third spraying with oxamyl at 1,250 $\mu\text{g}/\text{ml}$.

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