Effects of Oxamyl on the Citrus Nematode, Tylenchulus semipenetrans, and on Infection of Sweet Orange

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Abstract: Foliar sprays of 4 μg/ml oxamyl on sweet orange trees in a greenhouse slightly depressed the number of *Tylenchulus semipenetrans* larvae obtained from roots and soil, but similar treatments were not effective in two orchards. Soil drench treatments decreased the number of citrus nematode larvae obtained from roots or soil of citrus plants grown in a greenhouse and in orchards. Exposure to 5-10μg/ml of oxamyl in water was lethal to only a few second-stage larvae treated 10 days, and many second-stage larvae in 20 μg/ml oxamyl recovered motility when transferred to fresh water. Aqueous solutions of 50 and 100 μg/ml of oxamyl were toxic to citrus nematode larvae. Additional observations indicate that oxamyl interfered with hatch of citrus nematode larvae and was nematistatic and/or protected sweet orange roots from infection. Oxamyl degraded at different rates in two soils. The number of citrus nematode larvae that infected and developed on sweet orange roots was increased by an undetermined product of the degradation of oxamyl in soil, water, and possibly within plants. This product apparently was translocated in roots. *Key Words:* Oxamyl, nematistatic, larval-hatch, degradation, citrus nematode.

Oxamyl (S-methyl(dimethylcarbamoyl)-N-[(methyl-carbamoxyl)oxy]thioformimidate), applied as a foliar spray, root dip, or soil drench, or incorporated in soil, has depressed population densities of different nematodes on a number of plants (3, 8, 9, 12, 13, 14, 15, 16). Oxamyl interferes with larval hatch from eggs (6) and exhibits nematistatic properties to protect cotton, potato, and tomato roots from infection by nematodes (3, 5, 9, 13). Data by Birchfield (3) indicated that oxamyl solution (4.5 kg/ha) increased hatch of *Rotylenchulus reniformis* Linford and Oliveira by 320%. Overman (12) reported that one foliar spray of oxamyl on leather-leaf fern stimulated reproduction, but sprays 2-3 weeks apart reduced the population of *Pratylenchus* sp.; whereas Myers (10) reported 0.1 μg/ml of oxamyl in the aqueous diet of *Aphelenchoides rutgersi* Hooper and Meyers was stimulatory, 1 μg/ml had no apparent effect, and 10 μg/ml retarded reproduction. Radewald (14) obtained control of *Tylenchulus semipenetrans* Cobb on 3-year-old Valencia orange trees with multiple foliar sprays of oxamyl. Timmer (16) reported that foliar applications of oxamyl on grapefruit trees gave partial, but variable control of citrus nematodes. Investigations of the effects of oxamyl treatments on populations of *T. semipenetrans* on citrus trees and of the nematicidal and nematistatic properties of oxamyl on the citrus nematode and on infection of sweet orange roots are reported herein.

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MATERIALS AND METHODS

Foliar sprays on citrus trees: Seedlings of sweet orange, (*Citrus sinensis* L.), (16 months old, 35-45 cm high) that were infected with *T. semipenetrans* and grown in a sandy-loam soil in 3-liter metal pots were sprayed to the run-off stage with 1 and 4 μg/ml oxamyl (90W). Both surfaces of leaves were wet. Vinyl film, covered with absorbent cotton, was fitted snugly around the trunks of the trees to shield the soil from spray. After drying, tops of the seedlings were enclosed in polyethylene bags for 5 days to maintain a film of water on the leaves. Groups of four trees kept in a greenhouse at 21-31 C received 0, 1, 2, or 3 sprays at monthly intervals. A muslin cover shaded the bagged trees from direct sunlight. Numbers of larvae from 2 g of fresh roots and from 50 cm^3 of soil were determined 4 months after treatment.

Field sprays also were evaluated. Fourteen-year-old navel orange trees with 'Cleopatra mandarin' (*C. reticulata* Blanco) rootstock were sprayed with 4 μg/ml oxamyl in water on 2 October 1970. Between 32-36 g of oxamyl a.i./tree (907 g/3.8 liters, Vydate® formulation) were applied by a three-nozzle spray boom at 2.8 kg/cm^2 to single-tree plots. This treatment was replicated five times. The spray completely wet all aerial parts, including numerous young shoots and leaves at different stages of maturity. Frequent dews and mist, but no rain, occurred during October 1970. Soil and root samples were taken from 0-30 and 30-60 cm depths near the drip-line on the south side of the trees 1 month after treatment. Larvae obtained from 2 g of nonwashed feeder roots or 50 cm^3 of soil during 48 h on Baermann funnels were counted. Feeder roots also were soaked in water for 30 min; gently washed to remove soil, larvae, males, and oxamyl; and blotted dry. Duplicate 2-g samples of oxamyl-treated and nontreated roots were placed on funnels in a mist chamber, and larvae that hatched during 0-4 and 4-8 days were counted.

Seven-year-old navel orange trees on 'Troyer citrange' (*C. sinensis* X *Poncirus trifoliata*) rootstock were sprayed on 5 October 1970. Treatments were similar to those applied to the 14-year-old trees, except approximately 16 g a.i. of oxamyl/tree were used. Each plot contained two trees, and the treatments were replicated five times. Soil and root samples for nematode assays were taken from the 0-30 cm and 30-60 cm depths of soil 3.5 months after treatment.

Soil treatments: Efficacy of oxamyl drenches for control of the citrus nematode were tested on infected 'Homosassa' sweet orange seedlings (38-45 cm high) growing in a sandy-loam soil (74.1% sand, 11.4% silt, and 14.5% clay) in painted 3-liter metal pots. Oxamyl (90W) to produce 0-320 μg/g a.i. (dry soil basis) was applied in 500 ml of water/pot. All of the soil was wet. Each treatment was applied to four pots. After 6 weeks in a greenhouse at 21-26 C, larvae obtained from 2 g of fresh roots and from 50 cm^3 of soil on Baermann funnels for 48 h were counted.

Oxamyl also was injected (at the rate of 18 kg/ha a.i.) 5-8 cm deep in the bottoms of two shallow furrows on two opposite sides of 8-year-old navel orange trees with Troyer citrange rootstock on 6 October 1970 and on 19 April and 9 June 1971. The furrows were 30 cm wide, 90 cm apart, and the innermost furrows were approximately 120 cm from the tree trunk. The sandy-loam soil contained 65% sand, 23% silt, and 12% clay. Water was applied in furrows during the 48 h after the oxamyl to wet the soil to a 120-cm depth. Each plot contained two trees 6 m apart, and there were four replications. The number of citrus nematode larvae in the 0-30 cm and 30-60 cm depths of soil beneath the furrows and at the center of the ridge between the furrows was determined 6-14 weeks after each treatment. Four, 2.5-cm diam soil cores were bulked for each plot, and larvae obtained by the Baermann funnel method were counted.

Oxamyl (at the rate of 35.8 kg/ha, a.i.) was sprayed on the soil surface over an area 3.9 x 6.6 m along the north side of 14-year-old navel-orange trees with Cleopatra mandarin rootstock. The long sides of the treated areas were adjacent to the foliage canopy of four, single-tree plots. The oxamyl was mixed into the top 5 cm of soil with a rototiller, and approximately 6 or 12 cm of water were applied by sprinklers during 24 or 48 h, respectively, on 3-4 October 1970. Five weeks later, soil and root samples were taken from depths of 0-30 cm and 30-60 cm in treated and nontreated areas. Numbers of larvae from duplicate samples of 50 cm^3 of soil or 2 g of feeder roots were determined. Feeder roots also were washed to remove larvae, males, oxamyl, and soil; blotted dry; 2 g samples placed on Baermann funnels in a mist chamber at 28 C; and larvae collected during 1-4 and 4-8 days were counted.

Effects of oxamyl on development of citrus nematode on sweet orange: Sufficient oxamyl (90W in 25 liters of water) to produce approximately 5 μg a.i./ml in the soil water in the upper 45 cm of soil at one centibar was applied on 25 May 1971 in a metal basin 57 cm diam and 25 cm high. The basin was placed 7 cm deep into the soil and 37 cm from the trunk of a 3-year-old Homosassa sweet orange seedling growing in sandy-loam soil A (86% sand, 6% silt, 8% clay, 1.2% organic matter, pH 7.0). A similar drench was applied to another tree in sandy-loam soil B (88% sand, 3.5% silt, 8.5% clay, 3.7% organic matter, pH 7.9). Each control basin (on the opposite side of the trees from the oxamyl basins) received 25 liters of water. Twelve plastic rims 11 cm diam and 7 cm high were partially pressed into the soil within each of the large basins. The surface 5 cm of soil within each plastic rim were removed, and approximately 56,000 citrus nematodes (L2) in 200 ml of water were added to the soil in six rims at 9 days and to the other six rims at 21 days after oxamyl or water. The trees were irrigated at 7-10 day intervals. Roots in the top 8 cm of soil within the small rims were collected 6 weeks after inoculation, and numbers of adult female nematodes/cm of root were determined as previously described (1).

Oxamyl (90W) at concentrations of 0, 5, or 10 μg/g (dry soil basis) was mixed into sandy-loam soil C (65% sand, 26.2% silt and 8.8% clay). Sweet-orange seedlings were planted in eight 473 cm^3, plastic pots with soil of each oxamyl concentration. Eight days after planting, approximately 60,000 L2 were poured over the surface of the soil in each of four pots of each treatment. At this time, four seedlings in each concentration of oxamyl were washed free of soil, replanted into nontreated soil, and then inoculated with 60,000 L2/pot that had been held either in 0, 5, or 10 μg/ml oxamyl solution for 8 days. Before inoculation, the oxamyl-treated larvae were placed upon coarse-textured filter paper and washed free of oxamyl. Oxamyl-treated and nontreated larvae then were placed upon a paper towel filter, and larvae that passed through the filter were used for inoculum. The inoculated seedlings were maintained in a 26 C water bath in a greenhouse for 7 weeks, and then the numbers of adult females on their roots were determined.

Effects of concentration of oxamyl and soil type on citrus nematode larvae: The toxicity of 0-20 μg/g of oxamyl 90W (dry soil basis) to L2 in sandy-loam soil C was determined. Six ml of different concentrations of oxamyl and approximately 60,000 L2 were added to 600 g (dry basis) of soil in a polyethylene bag and mixed. The bags of soil were sealed in a 1.9-liter wide-mouth jar. The soil moisture was 12.8%, and the maximum calculated concentrations of oxamyl in the soil water were 0, 39, 79, and 156 μg/ml. Treatments were replicated four times. After 5 and 10 days, two 50 cm^3 lots of soil from each bag were placed on Baermann funnels for 48 h to assay for L2.

Approximately 2.6 x 10^5 newly hatched citrus nematodes L2 were placed in 100 ml of 0, 5, 10, 20, 50, or 100 μg/ml of oxamyl (90W) in 500-ml flasks. The flasks (at 24 C) were shaken frequently, and the percentages of live larvae were determined after 10 days.

Changes of nematicidal properties of oxamyl in sandy-loam soils A and B were determined by bioassay. Concentrations of 21.6 and 24 μg/ml of oxamyl (90W) a.i. (soil-water basis) were mixed into sandy-loam soils A and B, respectively, in a twin-shell blender. The oxamyl-treated and nontreated soils were stored in covered 8-liter stainless-steel pails at 24 C. At treatment time and at 4-day intervals up to 60 days, four 200-g aliquants of each soil were placed in polyethylene plastic bags, 10,000 L2 were mixed into the soil, and the bags were stored at 24 C for 5 days. Then duplicate 50 cm^3 samples of soil from each bag were placed on Baermann funnels for 2 days and the larvae obtained were counted.

Approximately 20 μg/ml of oxamyl (90W) (soil-water basis) were mixed into sandy loam soils A and B in a twin-shell blender. Soil A contained 8.2% and soil B, 9.5% water. Oxamyl-treated and nontreated soils were stored in covered 8-liter stainless steel pails at 24 C. At the time of treatment and at 7-day intervals for 7 weeks, approximately 5 months old (8-12 cm high) Homosassa sweet orange seedlings were planted singly in 1-liter plastic pots, with four pots of each treatment. Seven days after planting, approximately 50,000 L2 were added to the soil in each pot. The pots were maintained in a water bath at 26 C in a greenhouse. Seven weeks after inoculation, the numbers of adult females on the seedlings were determined (1).

RESULTS

Foliar sprays on citrus trees: Sweet orange trees in pots that received two or three sprays of oxamyl 1 μg/ml a.i. yielded 36% and 65% more larvae from roots (NS), and 36-46% more second-stage larvae (L2) from soil (P = 0.05) than nontreated trees, respectively. Roots of trees that received one spray contained 15% less and the soil 33% more larvae than the nonsprayed trees. One to three sprays of 4:1000 μg/ml oxamyl a.i. decreased numbers of larvae in soil and roots by 0-29%, but the differences were NS from the nontreated (P = 0.05).

Single oxamyl foliage sprays applied to 7- or 14-year-old navel orange trees produced no (P = 0.05) change in the number of larvae on roots or soil at depths of 2-60 cm.

Soil treatments: Drenches that gave 40, 80, 160, or 320 μg/g of oxamyl in the soil (dry soil basis) of sweet orange seedlings in pots decreased the number of larvae on roots by 86%, 90%, 94%, and 96%, and in soil by 40%, 63%, 79%, and 97%, respectively. Differences in treated vs. nontreated pots were significant ($P = 0.05$).

Three applications of oxamyl (18 kg/ha a.i.) in the bottoms of two irrigation furrows, near 8-year-old navel orange trees on Troyer citrange rootstock, depressed numbers of larvae in the soil at 0-30 cm and at 30-60 cm depth by 91% and 83% respectively. Beneath the ridge, mid-distance (45 cm) between the furrows, larvae were decreased by 43% and 21% at the two depths, respectively. Oxamyl apparently moved through the soil in irrigation water and gave high levels of control beneath the furrows and lesser control in the area between the furrows.

Oxamyl (35.8 kg a.i./ha) incorporated into the surface 5 cm of soil and then irrigated by sprinklers for 24 or 48 h gave 94% and 81% decreases of larvae in the 0-60 cm depth of soil, respectively, in a 14-year-old navel orange orchard (Table 1). Numbers of larvae obtained from nonwashed roots in the oxamyl-24h-irrigation and the oxamyl-48h-irrigation were 55% lower and the same as from nontreated roots, respectively. However, washed oxamyl-treated roots yielded 182% and 152% more larvae during the first 4 days in a mist chamber than nontreated roots. There were no differences in the hatch of larvae during the second 4 days in the mist chamber.

An oxamyl drench of 5 μg/ml of soil water in basins on one side of 3-year-old orange trees in sandy-loam soils A and B affected the number of adult female nematodes that developed from inoculations made 9 and 21 days after the drench (Table 2). Roots in the oxamyl drench area of soil A contained 89% fewer adult females than roots on the nonoxamyl treated trees that were inoculated at the 9- and 21-day periods. Roots on the side of the tree opposite to the oxamyl-drench area contained 22% and 160% more adult females for the inoculations made 9 and 21 days after the drench, respectively, than developed from inoculations made on nontreated roots. In the oxamyl-treated area of sandy loam soil B, 34% and 85% more, and on the opposite side of the tree to the oxamyl drench, 256% and 45% more adult female nematodes/g of roots developed from inoculations made 9 and 21 days after the oxamyl drench, respectively. Oxamyl protected roots from infection for 9 and 21 days after treatment in sandy-loam soil 'A', but it did not in sandy-loam soil "B'.

Oxamyl-treated and nontreated sweet orange roots were inoculated with oxamyl-treated or nontreated L2 in various combinations. No adult female nematodes were found on sweet orange seedlings that had been planted in a sandy-loam 8 days after 5 or 10 μg/g of oxamyl and citrus nematode L2 (Table 3). Numbers of adult female nematodes that developed on sweet orange roots (after they grew 8 days in soil that contained 5 or 10 μg/g oxamyl) were 56% and 48% less, respectively, than on nontreated roots. The number of adult females decreased by 48% and 57% when both roots and larvae were treated with 5 or 10 μg/g or ml of oxamyl for 8 days before inoculation, respectively. Storing larvae in 5 or 10 μg/ml oxamyl for 8 days before inoculation increased the number of adult female nematodes that developed on sweet orange roots by 102% and 65%, respectively.

Effects of concentration of oxamyl and soil type on toxicity to citrus nematode larvae: Newly hatched citrus nematode L2 [after 10 days in 5 or 10 μg/ml oxamyl (90W)] showed slight or moderate movement, whereas 80% of those in water at 26C were active. Approximately 10% of the larvae in 20 μg/ml oxamyl solution showed slight movement, whereas 98-100% of those in 50 or 100 μg/ml were dead after 10 days. Most of the larvae in 5 or 10 μg/ml oxamyl became active when they were washed and then placed in water for 4 h. These larvae were highly infective and appeared to have recovered completely from the nematistasis. Dead larvae were straight and motionless, and the oesophageal region was granular. When larvae in 50 μg/ml oxamyl solution for 10 days were washed and placed in water for 2 days, approximately 50% of the adult males (but no L2) were active.

TABLE 1. Effects of oxamyl soil treatment on citrus nematode larvae on Cleopatra mandarin.[a]

Treatment		Larvae from 1 g soil		Larvae from 1 g nonwashed roots		Larvae from 1 g washed roots in mist chamber			
						0-4 days incubation		4-8 days incubation	
Oxamyl (kg a.i./ha)	Sprinkling period (h)	Number (1000's)	Difference (%)	Number (1000's)	Difference (%)	Number (1000's)	Difference (%)	Number (1000's)	Difference (%)
35.8	24	6**	—94	.6*	—55	12.9**	+182	3.1	— 7
none	24	93		1.4		4.6		3.3	
35.8	48	17**	—81	1.3	0	6.9	+152	3.0	+10
none	48	86		1.3		2.7		2.7	

[a]Sampled 1 month after treating, average for four replications; larvae were obtained during 48 h on Baermann funnels; * and ** indicate significant difference from control at $P = 0.05$ and 0.01, respectively.

TABLE 2. Effects of oxamyl-drench in two soils on infection of sweet orange roots with the citrus nematode.

Tree No.	Treatment	Days between drench and inoculation	Number of ♀/g of root[a]	Increase or decrease in number of females (%)
Sandy loam A				
1	Oxamyl area	9	25**	— 89
		21	53**	— 89
1	Nontreated area	9	289	+ 22
		21	1,282**	+160
2	Nontreated	9	236	
		21	494	
Sandy loam B				
3	Oxamyl area	9	543	+ 34
		21	861*	+ 85
3	Nontreated area	9	1,444**	+256
		21	674	+ 45
4	Nontreated	9	404	
		21	465	

[a]* and ** indicate that the differences between the number of nematodes on the roots of oxamyl-treated trees 1 and 3 differ from those on the nontreated trees 2 and 4 at $P = 0.05$ and 0.01 respectively.

TABLE 3. Effects of oxamyl treatments on development of citrus nematode on sweet orange seedlings.

No.	Treatments	Average number of adult ♀/tree[z]	Percent increase (+) or decrease (—)[z]
1	Larvae in soil with 5 μg/g of oxamyl (soil-water basis) for 8 days before planting trees	0	—100
2	Same as #1, except 10 μg/g of oxamyl	0	—100
3	Roots in soil with 5 μg/g oxamyl (soil-water basis) for 8 days, washed, replanted, and inoculated with nontreated larvae	232[a]	— 56
4	Same as #3, except 10 μg/g of oxamyl	273[a]	— 48
5	Roots and larvae were treated with 5 μg/g of oxamyl for 8 days	273[a]	— 48
6	Same as #5, except 10 μg/g of oxamyl	225[a]	— 57
7	Larvae were treated in 5 μg/g oxamyl for 8 days before inoculation	1063[c]	+102
8	Same as #7, except 10 μg/g oxamyl	865[c]	+ 65
9	Larvae in soil 8 days before planting trees	683[b]	0
10	Larvae in water for 8 days before inoculation	525[b]	0

[z]Averages not followed by the same letter are different according to Duncan's Multiple Range Test ($P = 0.05$). Percent change based on nontreated controls.

Sandy-loam soils A and B, which contained approximately 21.6 and 24 μg/ml of oxamyl, respectively (soil-water basis), were bioassayed for toxicity to citrus nematode larvae during 0-60 days storage. Differences in numbers of larvae recovered from the various treatments reflect toxicity of oxamyl. Between 75-97% fewer larvae were recovered from oxamyl-soil than from nontreated A during 60 day's storage (Table 4). Numbers of active larvae recovered from oxamyl-soil B increased from 5 to 75% during 0-45 days and to 123% at 60 days, in comparison to those from nontreated soil.

The number of adult females that developed on sweet-orange seedlings in sandy loam soil A decreased by 90, 69, and 68%, and then increased by 19, 17, 70, and 13% after 0, 1, 2, 3, 4, 5, and 7 weeks' storage before planting and inoculation, respectively (Table 4). In sandy loam soil B, adult female nematodes increased by 24% and then decreased by 35 and 11% after 0, 1, and 2 weeks' storage; they then increased by 212, 113, 215, and 51% after 3, 4, 5, and 7 weeks' storage, respectively. Oxamyl apparently degraded slowly in soil A, and numbers of adult females increased less than in soil B, in which it degraded rapidly.

DISCUSSION

Increased numbers of L2 on the roots of young sweet orange trees in pots that were sprayed with 1 μg/ml oxamyl may be due to stimulation of egg production, as has been shown for *A. rutgersi* (10), and to more egg-laying females that might have accrued from increased infections, as occurred in the present investigations. The decrease in numbers of L2 1-3 mo after foliar sprays of 4 μg/ml oxamyl on orange trees in pots might have resulted from nematistasis of adult females and decreased egg-laying. However, the observed decrease of larvae likely was due to interference with larval hatch, as has been shown for the citrus nematode and for other nematodes (3, 4, 9, 11). The two to three-fold increase of numbers of L2 from washed, oxamyl-treated roots, in comparison to those from nonwashed roots, apparently was due to interference of larval-hatch. It is assumed that oxamyl interfered with larval-hatch and was removed during washing. Oxamyl-soil drench more effectively decreased populations of L2 than foliar spray, even when the sprayed trees were covered to aid in the absorption of oxamyl by leaves.

The nematicidal effects of oxamyl decreased on the treated side of 3-year-old

TABLE 4. Changes of nematicidal properties of oxamyl to citrus nematodes after storage in two soils.

Number of days between treatment and bioassay	Percent of larva recovered from oxamyl-treated soil[a]		Percent decrease or increase in numbers of adult females on sweet orange seedlings	
	A	B	A	B
0	—96	—95	—90	+24
4	—88	—87		
7			—69	—35
8	—91	—61		
12	—96	—76		
14			—68	—11
16	—94	—80		
20	—97	—50		
21			+19	+212
24	—93	—41		
28	—96	—64	+17	+113
35			+70	+215
36	—75	—20		
45	—88	—25		
49			+13	+51
60	—92	+23		

[a]Based on number of larvae recovered from nontreated soil.

sweet orange trees in sandy loam soil B 9 and 21 days after treatment, a circumstance which indicated that degradation of oxamyl had occurred before inoculation. On the opposite side of the tree, infection increased more than two-fold. This increase suggests that a degradation product that increased infection was translocated from the treated to the nontreated side of the trees (Table 2).

The fairly uniform and rapid rate at which the toxicity of oxamyl to L2 decreased during storage in soil [especially in sandy-loam soil B (Table 4)] is assumed to be related to a decrease of toxicant and to the concomitant formation of other unknown substances. The great increase in numbers of adult females that developed in oxamyl-treated soil B at 3 or more weeks after treatment is believed to be due to degradation products rather than to low concentrations of oxamyl. It is postulated that, if high levels of infection on the nontreated side of the trees were due to low concentrations of oxamyl, peak populations likely would have occurred within 21 days of treatment in soil A, since low concentrations of oxamyl on the nontreated side would be expected to occur early. Populations of adult females peaked earlier in soil B than in soil A and were related to more rapid decrease of toxicity of oxamyl in soil B.

Larvae after eight days in 5 or 10 μg/ml oxamyl were more infective than those in water; however, no stimulation was observed when only orange seedlings or when both orange seedlings and L2 were treated with 5 or 10 μg/ml of oxamyl for eight days before inoculation. This response indicates that the nematistatic effect of oxamyl on the seedlings was greater than the stimulatory effect of a degradation product on the L2.

After they were washed, orange seedlings that had been growing in oxamyl-soil were infected slightly with the citrus nematode. The treated roots apparently repelled the larvae. Birchfield (3), Miller (9), and Radewald (13) reported that oxamyl showed nematistatic properties. The nematicidal properties of some organic compounds may be rather complex and depend on various modes of action. To make the fullest use of the nematicidal potentials of a compound, it is important to assess and evaluate the different factors involved. DiSanzo (4) has shown that carbofuran affects the attractiveness of tomato to *Meloidogyne incognita* (Kofoid and White) Chitwood and to *Pratylenchus penetrans* (Cobb) Chitwood. Methanesulfonate had a similar mode of action and prevented infection of cotton and tomato by *Meloidogyne* spp. (7), and also infection of sweet orange by the citrus nematode (2).

Drench applications of oxamyl effectively decreased numbers of citrus nematode L2 and appeared to be a promising method of application. Since oxamyl interfered with hatch of larvae and degraded rapidly in a sandy-loam soil, frequent applications of oxamyl would be needed to nullify the stimulatory effect on larvae, especially on perennial plants.

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