Soil Distribution of Fenamiphos Applied by Overhead Sprinkler Irrigation to Control *Meloidogyne incognita* on Vegetables

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ABSTRACT

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Fenamiphos applied to squash and cucumber to control *Meloidogyne incognita* at 4.5, 6.7, 9.0, and 18.0 kg a.i./ha via injection into a sprinkler irrigation system was compared with fenamiphos granules spread on the soil surface at 9.0 kg a.i./ha and incorporated into the top 15 cm of soil. Nematode populations in the soil and root-gall indexes were lower and yields were greater in treated than in untreated plots. Root-gall indexes did not differ between methods of application of fenamiphos at 9 kg a.i./ha on most sampling dates; however, root-gall indexes of cucumber in broadcast and incorporation plots were lower than those in irrigation plots after the final harvest. Based on root-gall indexes, fenamiphos concentrations above 1.5 μg/g of soil in the 0–15 cm soil layer for 10 days appear to be adequate for controlling root-knot nematodes on squash and cucumber. Concentrations of fenamiphos in the 0–15 cm soil layer were below 1 μg/g of soil 30 days after application at all rates.

Additional key words: *Cucumis sativus, Cucurbita pepo*

In the Georgia coastal plain, almost all commercial vegetable plots are irrigated with overhead sprinklers and participate in a pest management program. Many growers use their irrigation systems to apply fertilizers. The same equipment may be used to apply pesticides to control fungi (5), weeds (C. C. Dowler, *personal communication*), and insects (6,7). However, information on the response of crops treated with nematicides applied through sprinkler irrigation is limited (2,4,5), and we know of no reports on the movement and concentration of nematicides in the soil when applied in this manner.

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MATERIALS AND METHODS

Plots were established in April 1980 on Lakeland sand (93.5% sand, 2.9% silt, and 3.6% clay, pH 6.0–6.7) infested with race 1 of the southern root-knot nematode, *Meloidogyne incognita* (Kofoid & White) Chitwood, and the ring nematode, *Macroposthonia ornata* (Raski) de Grisse & Loof. Fenamiphos (3 SC and 15 G) was applied through overhead sprinklers at rates of 4.5, 6.7, 9.0, and 18.0 kg a.i./ha with 178,000 L of water per hectare or as granules broadcast at 9.0 kg a.i./ha and incorporated 15 cm deep with a tractor-drawn Rototiller. Untreated plots served as controls.

The experimental design was a randomized complete block with treatments replicated four times. Plots were two beds 1.8 × 12.2 m. Fertilizer (5-10-15) was applied at 1,120 kg/ha to all plots at planting with ground applicators, and 124 kg of nitrogen per hectare was applied by irrigation on 23 May, 20 June, and 1 July. The rototill treatment was applied to two beds; one bed in each plot was planted to squash (*Cucurbita pepo* L. 'Dixie Hybrid') and one to cucumber (*Cucumis sativus* L. 'Sprint') on 10 April. The irrigation treatments were applied the next day. Insecticides and fungicides were applied as needed with ground sprayers and through irrigation. Plots received a total of 32.6 cm of water (rainfall plus supplemental irrigation) up to 45 days after application of fenamiphos.

Soil samples—composites of 20 cores (2.5 × 15 cm) collected randomly from the root zone of plants—were assayed for nematodes each month from April through July. The composite samples were mixed thoroughly, and a 150 cm^3 aliquot for each treatment was processed by the centrifugal flotation method (1) to separate nematodes from the soil. Extracted nematodes were then placed in 20 ml of water in calibrated dishes for identification and counting.

Soil samples (1,000 cm^3) for fenamiphos analyses were collected 0–8 and 8–15 cm deep with a trowel immediately after application and 1, 2, 3, 5, 10, 30, and 45 days after application. Additional samples were collected with a tractor-mounted hydraulic soil sampler from 15–30 and 30–46 cm deep in plots 10 days after irrigation and rototill treatment with fenamiphos at 9 kg a.i./ha. Composite soil samples from 10 sites in each plot were mixed thoroughly and stored at −20 C until being analyzed for fenamiphos. Fortified samples of untreated soil from check plots were prepared and stored with the field samples for use as calibration and recovery standards. Soil samples were removed from the freezer, air-dried to 0.5% moisture, sieved through a 2-mm mesh screen, and analyzed for fenamiphos as described earlier (3).

RESULTS

Numbers of *M. ornata* were low, variable, and unaffected by nematicide treatments. Population densities of *M. incognita* second-stage juveniles were low and were not affected by fenamiphos until July, when their numbers were lower in all treated plots than in untreated controls. Numbers of juveniles did not differ among fenamiphos-treated plots (Table 1). Numbers of *M. incognita* juveniles in the soil in July were correlated ($P = 0.05$) with root-gall indexes; correlation coefficients (r) were 0.80 and 0.72 for squash and cucumber, respectively.

Root-gall indexes of both crops recorded in June and July were lower in treated plots than in untreated controls (Table 1). Root-gall indexes of squash were lower in plots treated with 18 kg a.i./ha than in those treated with 4.5 kg a.i./ha in June. Differences ($P = 0.05$) in root-gall indexes between irrigation and rototill treatments at 9 kg a.i./ha were observed on cucumber in July. Root-gall indexes were correlated ($P = 0.05$) inversely with yields of squash ($r = -0.59$) and cucumber ($r = -0.60$).

Yields of squash generally increased

Table 1. Influence of fenamiphos treatments on soil populations of *Meloidogyne incognita*, yield, and root-gall indexes of squash and cucumber

Treatment	Rate (kg a.i./ha)	Method of application[w]	Number of *M. incognita* juveniles per 150 cm³ of soil[x,y]		Yield (quintals/ha)[y]		Root-gall index[y,z]			
			Squash	Cucumber	Squash	Cucumber	Squash		Cucumber	
							4 June	8 July	13 June	8 July
Control	...	...	132 a	119 a	218.1 c	102.8 c	4.41 a	4.98 a	3.78 a	4.98 a
Fenamiphos	4.5	Irrigation	18 b	47 b	289.1 bc	164.2 b	1.75 b	2.92 b	1.54 b	2.23 b
Fenamiphos	6.7	Irrigation	18 b	2 b	286.4 bc	208.8 ab	1.41 bc	1.65 cd	1.03 b	1.33 cd
Fenamiphos	9.0	Irrigation	18 b	4 b	325.7 ab	184.3 ab	1.56 bc	1.78 cd	1.10 b	1.53 c
Fenamiphos	18.0	Irrigation	4 b	0 b	372.4 a	245.2 a	1.03 c	1.08 d	1.03 b	1.00 e
Fenamiphos	9.0	Rototiller	12 b	14 b	341.3 ab	189.5 ab	1.32 bc	1.92 c	1.66 b	1.18 de

[w] Irrigation means that nematicide was applied through overhead sprinklers with 178,000 L of water per hectare. Rototiller means that granules of nematicide were broadcast and incorporated 15 cm deep with a tractor-drawn Rototiller.
[x] Soil samples were collected and assayed for nematodes on 20 July 1980.
[y] Numbers within columns followed by different letters are significantly different ($P = 0.05$), according to Waller-Duncan's multiple range test.
[z] Rated on a 1–5 scale, where 1 = no galls, 2 = 1–25% of roots galled, 3 = 26–50% galled, 4 = 51–75% galled, and 5 = 76–100% of roots galled.

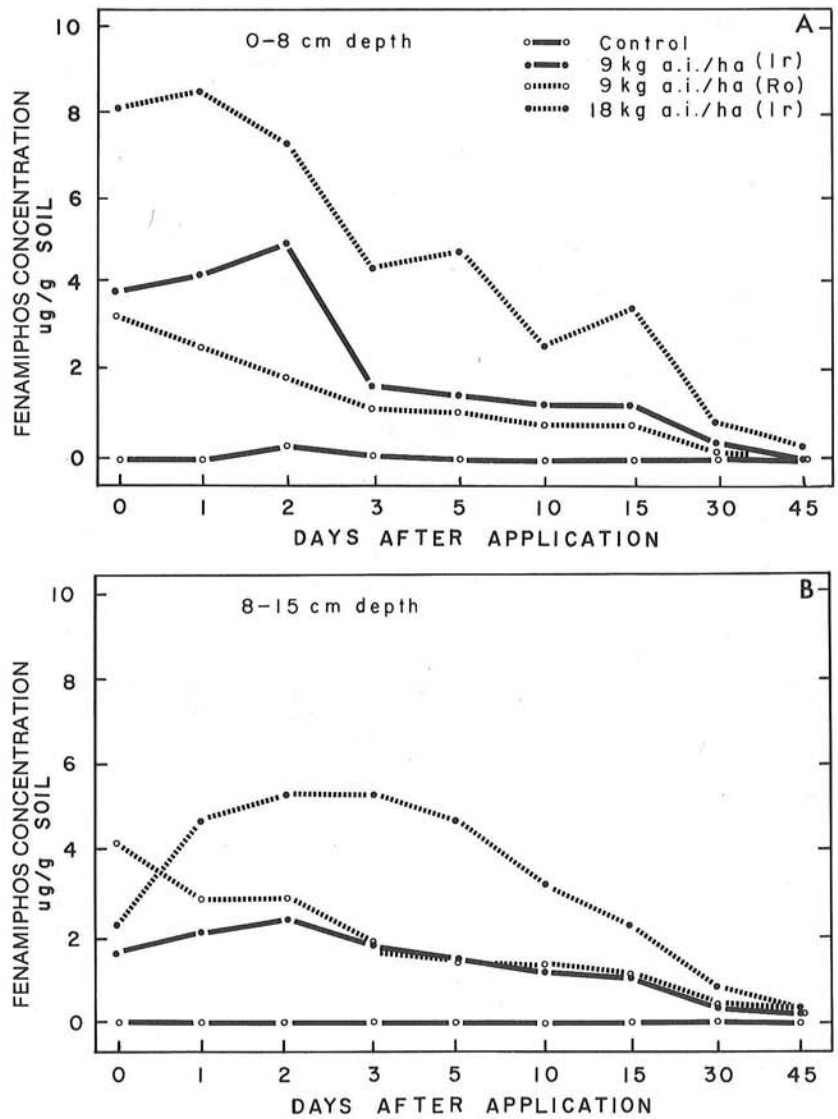

Fig. 1. Concentration of fenamiphos in soil 0–8 cm deep (**A**) and 8–15 cm deep (**B**) after application via overhead sprinkler irrigation (Ir) and as granules broadcast and incorporated 15 cm deep with a tractor-drawn Rototiller (Ro).

with higher dosages of irrigation-applied fenamiphos (Table 1). Yields from plots treated with fenamiphos at 9 kg a.i./ha by the two methods did not differ significantly ($P = 0.05$).

Yields of cucumber from all treated plots were greater ($P = 0.05$) than those from untreated plots (Table 1). Again, yields from plots treated with fenamiphos at 9 kg a.i./ha did not differ significantly ($P = 0.05$) between the two application methods.

The concentration of fenamiphos at 0–8 cm soil depths was near 8 μg/g of soil 0, 1, and 2 days after application of 18 kg a.i./ha but fell below 1 μg/g of soil 30 days after application (Fig. 1A). The concentration of irrigation-applied fenamiphos at 9 kg a.i./ha was about 4 μg/g of soil until day 2 and declined to about 2 μg/g of soil on day 3, while the concentration of rototill-applied fenamiphos at the same rate fell from near 3 μg/g of soil on day 0 to less than 2 μg/g of soil 3 days after application. Concentrations of the nematicide in soil in both treatments (9 kg a.i./ha) gradually declined after day 3 and were below 1 μg/g of soil 30 days after treatment.

The concentration of fenamiphos at soil depths of 8–15 cm was about 2 μg/g of soil on day 0 at 18 kg a.i./ha, rose to about 5 μg/g of soil from day 1 through day 5, and fell to about 1 μg/g of soil 30 days after application (Fig. 1B). Concentrations of fenamiphos (9 kg a.i./ha) were greater ($P = 0.05$) at this depth in rototill plots than in irrigation plots from day 0 until day 3. After day 3, the concentrations were similar and were below 1 μg/g of soil 30 days after application.

The mean concentration of fenamiphos 15–30 cm deep was 0.17 μg/g of soil (range 0.09–0.34) 10 days after rototill application at 9 kg a.i./ha, compared with less than 0.01 μg/g of soil in plots treated with a similar dosage by irrigation. Only traces (less than 0.01 μg/g of soil) of nematicide were found 30–46 cm deep in both plots.

DISCUSSION

Our results indicate that fenamiphos applied through a sprinkler irrigation system can effectively control nematodes on squash and cucumber. Based on numbers of *M. incognita* juveniles in the soil, root-gall indexes, and yield, the efficacy of fenamiphos applied through irrigation at 9 kg a.i./ha was not different on most sampling dates from that applied with a Rototiller at the same rate. When differences occurred, root-gall indexes were significantly lower in rototill plots than in irrigation plots.

Fenamiphos concentration was less than 1 μg/g of soil 0–15 cm deep after 30 days even when applied at 18 kg a.i./ha, which is two to four times the recommended dosage for controlling root-knot nematodes on vegetable crops.

Root-gall indexes indicate that fenamiphos concentrations above 1.5 μg/g of soil 0–15 cm deep for 10 days are adequate for controlling *M. incognita* on squash and cucumber. This supports findings in similar investigations (3). Fenamiphos concentrations of 4.0–8.0 μg/g of soil suppressed *M. incognita* to barely detectable or undetectable levels on turnip and field corn. The advantages of applying nematicides through sprinkler irrigation have been reported (4).

Fenamiphos has a low water solubility (0.04–0.07%) that prevents rapid leaching from Tifton sandy loam soils by allowing enough time for plants to adsorb nematicidal concentrations (3). Data shown in Figure 1 and data collected from 15–30 and 30–46 cm deep 10 days after application showed no evidence of excessive leaching of the nematicide in the soil profile. Intensive sampling both over time and soil depth is needed to determine the likelihood of fenamiphos becoming a pollutant when applied via overhead sprinkler irrigation. Because no symptoms of phytotoxicity were observed and yields of squash and cucumber were greatly increased by applying fenamiphos through an overhead sprinkler irrigation system, the results of this study are encouraging.

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