

Chemical Control of Coffee Nematodes in Seedbeds in Puerto Rico^{1, 2}

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ABSTRACT

Pre-plant soil treatments with granular formulations and foliar sprays with the nematicides phenamiphos (Nemacur), oxamyl, (Vydate) and fensulfothion (Dasanit) reduced populations of *Meloidogyne incognita* and *Pratylenchus coffeae* in coffee (*Coffea arabica* L.) cv. Puerto Rico Selecto roots. Significant ($P = 0.05$) increases in growth and development of the treated plants were obtained in the greenhouse. Best results were obtained with 11.20 kg ai/ha of phenamiphos applied to the soil 15 days prior to planting, combined with foliar sprays of 1.12 kg ai/ha of the same systemic nematicide 15 days after transplanting or two foliar sprays with 0.56 kg ai/ha applied at intervals of 30 days; 0.56 kg ai/ha of oxamyl applied to the foliage 30 and 60 days after transplanting; and 4 granular soil applications of 300 mg of fensulfothion at 30-day intervals. Dipping roots in a solution containing 400 p/m of phenamiphos and 600 p/m of oxamyl also reduced nematode populations in roots and soil. Significant differences in root-knot index were found among those treatments and the controls, but plant growth was not affected. The higher dosages (2.24 kg ai/ha) of phenamiphos and fensulfothion when applied to the leaves twice after transplanting were phytotoxic to the coffee seedlings resulting in early defoliation, but not killing the plants.

INTRODUCTION

In Puerto Rico 52,000 ha are cultivated in coffee, producing 11,428 t of shelled coffee (5). Coffee production is limited by a number of factors, among which the attack by phytopathogenic nematodes is one of the most important. Many plantings in Puerto Rico are only marginally profitable because intensive cultivation practices are not employed (20). Fundamental to more intensive cultivation of coffee is the production of seedlings free of nematodes. Nematodes that could be controlled at the seedbed level may not be controlled when widely dispersed in the plantation. Even if possible, plantationwide control of phytopathogenic nematodes may be prohibitively expensive (14). This is a report of studies on the control of phytopathogenic nematodes in coffee seedbeds by various chemical treatments.

MATERIALS AND METHODS

The research was conducted in greenhouses at the University of Puerto Rico, Mayagüez Campus. Coffee cv. Puerto Rico Selecto was sown in an

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Ultisol-cachaza (1:1) mixture (pH 7.2) and grown in the greenhouse (air temperature 25–40° C and soil temperature 23–40° C).

Nematodes (*Meloidogyne incognita*, *Pratylenchus coffeae*, and *Rotylenchulus reniformis*) were isolated from infected coffee plants in the field and increased in coffee seedlings grown in the above-mentioned soil mixture in polyethylene bags. Test plants at the seedling stage (cotyledons fully expanded) were inoculated by being transplanted into the bags where nematodes were increased.

The nematode population levels were determined by using 100 cm³ soil samples taken before nematicide application, 1 month afterwards, and at the end of the experiment. Root samples (1 and 5 g) were taken at the end of the experiment. Nematodes were extracted by the Baermann funnel technique and Cobb's sieving method (9).

A randomized complete block design was used in all tests. The following parameters were evaluated at the 8- to 9-month stage: plant height, root length, number of leaves and branches, fresh and dry weights of foliage and roots. Root-knot index (0–5 Sasser scale), necrosis index (0–5 standard scale) and nematode populations were also evaluated.

Granular phenamiphos (Nemacur 15G, 35L),⁴ carbofuran (Furadan 5G, 40.64 EG), fensulfothion (Dasanit 15G, 63.5 L) and oxamyl (Vydate 10 G, 24L) were applied to the soil at the rates of 75, 150 and 300 mg of the commercial product per plant. Applications were made four times every 30 days, starting when the plants were 3 months old. Each treatment was replicated four times.

Emulsifiable concentrates of the same chemicals were also evaluated by spraying the foliage twice at 30-day intervals after transplanting, using 0.56, 1.12 and 2.24 kg ai/ha. These treatments were replicated five times.

Granular phenamiphos containing 11.2 and 22.4 kg ai/ha were applied to the soil 15 days before transplanting, followed by either one or two foliar applications at 0 and/or 1.12 kg ai/ha; 15 and 45 days after transplanting. The same method of application was used with granular (22.4 and 44.8 kg ai/ha) and sprayed (0 and/or 1.12 kg ai/ha) oxamyl. These treatments were replicated four times.

Three dosages (0, 11.2 and 22.4 kg ai/ha) of phenamiphos were incorporated into the soil 15 days prior to transplanting, followed by foliar sprays with the same chemical at 0, 0.56, 1.12, and 2.24 kg ai/ha every 30 days. The first foliar application was made 1 month after the pre-transplant soil treatment. Treatments were replicated five times.

The roots of coffee seedlings (60 days old) were immersed for 5 and 10

⁴Trade names in this publication are used only to provide specific information. Mention of a trade name does not constitute a warranty of equipment of material by the Agricultural Experiment Station of the University of Puerto Rico, nor is this mention a statement of preference over other equipment or materials.

min in solutions of phenamiphos containing 200, 400 and 800 p/m. The same method was used with oxamyl at 600, 1,200, and 2,400 p/m. The check plants' roots were immersed in distilled water for the same period of time. All treatments were replicated five times.

RESULTS AND DISCUSSION

FREQUENCY OF PRETRANSPLANT APPLICATIONS USING GRANULAR AND SPRAY FORMULATIONS

In general, granular nematicides improved growth and development of coffee seedlings; this was especially true with fensulfothion at the rate of 300 mg of the commercial product per plant (table 1), which significantly increased the number of leaves over the controls. Similar results were

TABLE 1.—*Effect of post-transplant applications of granular nematicides on the growth and development of Coffee Coffea arabica L. cv. Puerto Rico Selecto seedlings*

Treatment ¹		Leaves	Foliar dry weights	Root weight	
Nematicide	Dosis mg/plant			Fresh	Dry
		No.	g	g	g
Fensulfothion	300	69.50 a ²	22.32 a	46.87 a	6.55 ab
Phenamiphos	300	56.25 ab	17.75 ab	33.92 ab	4.60 ab
Carbofuran	300	54.00 ab	18.15 ab	35.67 ab	5.23 ab
Oxamyl	300	45.25 ab	16.95 ab	16.95 ab	4.30 ab
Control (No treatment)	—	32.50 b	11.27 b	22.02 ab	3.05 b

¹ Plants were treated 1, 2, 3, and 4 months after transplanting.

² Means in the same column followed by the same letters do not differ significantly at the .05 level by Duncan's new Multiple Range Test.

obtained by Abrego (1, 2) and Monterroso (17). Bee (7) and Roman et al. (19) reported that multiple doses of fensulfothion improved yields of sorghum and bananas, respectively.

Foliar applications with .56 kg ai/ha (lower doses) of oxamyl, 1 and 2 months after transplanting also improved the growth and development of coffee seedlings; foliar fresh weights and plant height were greater than those of the checks. Phenamiphos increased plant height and was significantly better also than the controls and fensulfothion (table 2). The higher dosis (2.24 kg ai/ha) caused phytotoxicity. Abrego and Cardona (4), and Monterroso (17) recommended oxamyl and phenamiphos for the control of parasitic nematodes on coffee seedbeds. Ayala et al. (16) and Hanania (12) reported that the higher dosages of phenamiphos and oxamyl were phytotoxic to papaya and soybean, respectively.

PRE-TRANSPLANT AND FOLIAR APPLICATIONS OF PHENAMIPHOS AND OXAMYL

Table 3 illustrates the results of a second greenhouse experiment to determine the frequency of application for phenamiphos and oxamyl. Granular phenamiphos at 11.2 kg ai/ha, applied to the soil 15 days prior

TABLE 2.—*Effect of foliar applications with four nematicides on the growth and development of coffee Coffea arabica L. cv. Puerto Rico Selecto) seedlings*

Treatment ¹		Weight of foliage		Root dry weight	Plant height
Nematicide	Dosis	Fresh	Dry		
	(Kg ai/ha)	g	g	g	cm
Oxamyl	0.56	24.92 a ²	7.78 a	2.38 a	26.20 ab
Phenamiphos	0.56	21.38 ab	6.60 ab	1.46 ab	27.20 a
Carbofuran	0.56	19.62 ab	5.88 ab	1.28 ab	23.50 abc
Fensulfothion	0.56	19.06 ab	6.00 ab	1.32 b	19.60 bcd
Control	—	16.04 b	5.52 ab	1.64 ab	11.40
(No treatment)					

¹ Nematicides were foliarly applied 1 and 2 months after transplanting the coffee seedlings.

² Means in the same column followed by the same letters do not differ significantly at the .05 level by Duncan's new Multiple Range Test.

TABLE 3.—*Effect of pre- and post-transplant applications of phenamiphos and oxamyl on the development and growth of coffee (cv. Puerto Rico Selecto) seedlings*

Nematicide	Dose		Plant height	Leaves	Weight of foliage	
	Pre-transplant ¹	Post-transplant ²			Fresh	Dry
	Kg ai/ha		cm	No.	g	g
Phenamiphos	11.2	1.12	35.62 a ³	14.00 a	24.90 a	7.63 a
Oxamyl	22.4	1.12	20.62 bc	9.00 ab	13.42 b	3.78 b
Oxamyl	22.4	1.12, 1.12	18.25 bc	10.00 ab	12.82 b	3.70 b
Phenamiphos	11.2	1.12, 1.12	16.37 c	8.50 b	10.70 b	3.05 b
Controls	—	—	15.70 c	10.50 ab	17.60 ab	5.15 ab

¹ Granular application 15 days before transplanting.

² Two foliar applications; the first, 15 days after transplanting, and the second, 1 month later.

³ Means in the same column followed by the same letters do not differ significantly at the 0.5 level by Duncan's new multiple range test.

to transplanting and followed by one foliar spray (1.12 kg ai/ha) increased plant height over the remaining treatments, including the controls. Abrego (3), Abrego and Cardona (4), and Gómez (11) reported similar results with combinations of granular and foliar sprays of phenamiphos on coffee seedbeds. The best time for the application of this nematicide seemed to be 15 days before and after transplanting.

GRANULAR AND LIQUID FORMULATIONS OF PHENAMIPHOS

Results demonstrated that one application of 11.2 kg/ha of granular phenamiphos incorporated into the soil 15 days prior to transplanting, followed by two foliar applications (0.56 kg/ha) 15 and 45 days afterwards improved growth and development of coffee seedlings. Good control of phytoparasitic nematodes was obtained (table 4). Abrego (3), using lower and multiple dosages of phenamiphos, effectively controlled coffee nematodes at El Salvador. Higher doses of the chemical adversely affected the coffee seedlings; phytotoxicity symptoms were developed during the first 4 months after transplanting. Similar phytotoxicity symptoms were

TABLE 4.—*Fluctuations of nematode populations and coffee plant growth after applying phenamiphos 15 days prior to transplanting and followed by two foliar applications 15 and 45 days afterwards*

Nematicide	Dose		Nematode populations				Plant growth	
	Pre-transplant	Post-transplant	Soil sampling sequence (100 cm ³) ¹			Harvested root (1 g)	Height	Root length
			0	1	2			
	<i>Kg ai/ha</i>						<i>cm</i>	<i>cm</i>
Phenamiphos	11.2	0.56, 0.56	80	52	16	20	20.90 a ²	13.80 a
Phenamiphos	11.2	2.24, 2.24	64	64	0	5	18.70 ab	8.50 d
Phenamiphos	11.2	1.12, 1.12	80	76	0	6	17.72 abc	13.30 ab
Control	—	—	32	32	48	80	9.80 c	9.50 bcd

¹ 0 = Application prior to transplanting; 1 = 1 month after; 2 = end of the experiment.

² Means in the same column followed by the same letters do not differ significantly at the .05 level by Duncan's new multiple range test.

TABLE 5.—*Nematodes recovery from 100 cm³ of soil and 1 g of roots, nodulation and necrosis indexes when coffee root systems were immersed in solutions of two systemic nematicides*

Treatment		Immersion time	Nematode populations		Roots (g)	Index ³	
Nematicide	Dose		Soil sampling sequence (100 cc)			Nodulation	Necrosis
		<i>p/m</i>	<i>min</i>	Before ¹	After ²		
Phenamiphos	400	10	504	20	16	0.25 c ⁴	0.25 b
Phenamiphos	600	10	800	80	12	0.25 c	1.50 ab
Oxamyl	1200	10	740	40	80	1.25 bc	1.75 ab
Phenamiphos	200	10	720	60	52	1.50 bc	0.25 b
Controls	—	—	790	1540	164	3.5 a	2.00 ab

¹ Nematode populations before treating with nematicides.

² Nematode populations at the end of the experiment.

³ Nodulation index: 0 (no nodules) to 5 (more than 100 nodules). Necrosis index: 0 (no necrosis) to 5 (very severe necrosis).

⁴ Means in the same column followed by the same letters do not differ significantly at the .05 level by Duncan's new multiple range test.

observed by Ayala et al. (6), Inserra et al. (13) and Pessoa (18) with higher doses of phenamiphos in papaya, gardenia and bananas, respectively.

ROOT DIPS USING OXAMYL AND PHENAMIPHOS

Coffee roots immersed for 10 min in solutions of 400 p/m of phenamiphos and 600 p/m of oxamyl had a lower galling index than those of the controls and fewer endoparasitic nematodes in the soil (tables 5, 6). Miller (15) reported that a solution containing 400 p/m of phenamiphos effectively controlled root knot nematodes in gardenia roots.

In general, the results indicated that at the end of the experiments nematode populations were lower in soil treated with nematicides than in the controls. Populations of *P. coffeae* recovered from the soil and coffee roots were lower than those of *M. incognita*. This may have been

TABLE 6.—*Fluctuations of phytoparasitic nematode populations in 100 cm³ of soil and 1 g of roots from coffee root system immersed in solutions of two nematicides*

Treatment		Immersion time	<i>M. incognita</i>				<i>P. coffeae</i>			
Nematicide	Dosis		Soil Sampling ¹			Roots	Soil Sampling			Roots
			0	1	2		0	1	2	
	<i>p/m</i>	<i>min</i>								
Phenamiphos	200	10	300	154	15	40	50	46	10	12
Phenamiphos	400	10	208	100	10	10	40	20	0	6
Oxamyl	600	10	200	50	20	4	180	50	20	8
Oxamyl	1200	10	200	104	10	60	160	102	10	20
Control	—	10	200	255	490	112	191	253	280	52

¹ Soil sampling sequence: 0 = before root immersion; 1 = one month after; and 2 = at the end of the experiment.

due to the high temperatures prevailing during the experiments, which reduced the reproductive potential or the pathogenic capabilities of *P. coffeae*. According to Miller and Rich (16) populations of the lesion nematode in soil decreased when temperatures were high (10–30° C). Chapman and Turner (8) suggested that root knot nematode populations affect the population levels of the lesion nematode when attacking the same host. The life cycle of the root knot nematode (20–30 days) is shorter than that of the lesion nematode (50–60 days); the root knot nematode is more prolific (1500 vs. 10 eggs) and has an efficient reproductive system (parthenogenesis vs. amphimixis of lesion nematode).

RESUMEN

Formulaciones granuladas de phenamiphos (Nemacur), oxamyl (Vydate) y fensulfothion (Dasanit) aplicadas al suelo y emulsiones concen-

tradas al follaje mantuvieron bajas las densidades poblacionales de *Meloidogyne incognita* y *Pratylenchus coffeae*, incrementando significativamente (P:0.05) en el invernadero el desarrollo y crecimiento de plántulas de café, cultivar Puerto Rico selecto. Los mejores resultados se obtuvieron con los siguientes tratamientos: phenamiphos a razón de 11.20 kg ia/ha aplicado al suelo 15 días antes del transplante, combinado con una aspersión al follaje de 1.12 kg ia/ha 15 días después del transplante o con dos aspersiones de 0.56 kg ia/ha al follaje 30 y 60 días después del transplante; dos aspersiones de oxamyl (0.56 kg ia/ha) a intervalos de 30 días y fensulfothion granulado a razón de 300 mg del material comercial por planta en cuatro aplicaciones a intervalos de 30 días, comenzando un mes y terminando 7 meses después del transplante. La inmersión de las raíces de café durante 10 minutos en una solución de 400 ppm de phenamiphos y 600 ppm de oxamyl, respectivamente, redujeron los niveles poblacionales de los nematodos noduladores y lesionadores en el suelo y en las raíces. Aunque se encontraron diferencias significativas (P:0.05) en el índice de nodulación entre estos tratamientos y el testigo, el incremento en el desarrollo y crecimiento de las plantas no fue significativo. Dosificaciones altas de phenamiphos y fensulfothion (2.24 kg ia/ha) asperjadas más de una vez al follaje después del transplante causaron fitotoxicidad y defoliación parcial durante los primeros meses del crecimiento, pero sin ocasionar la muerte de las plantas.

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