Effect on yam (*Dioscorea rotundata* Poir) of soil spray and seed treatment with the nematicide-insecticide Oxamyl L, and soil treatments with Phenamiphos 15G[1]

Domingo Oramas,[2] José Rodríguez[3] and Angel L. González[4]

ABSTRACT

Two experiments were conducted, one each at Utuado and Corozal, to evaluate the effect of a soil spray and a seed treatment with the systemic nematicide-insecticide Oxamyl L and soil treatments of Phenamiphos 15G for the control of the nematode *Pratylenchus coffeae* (Zimmerman) Filip. Schuur-Stekh. and the white-grub, *Diaprepes abbreviatus* (L.), in yam (*Dioscorea rotundata* Poir). The soil was sprayed at the base of the plant with a 20 ml automatic applicator (Spot Gun). At Utuado, two doses of oxamyl, 0.3 ml (7,410 μg a.i./ml) and 0.6 ml (15,297 μg a.i./ml) per plant applied every two months were evaluated alone and in combination with a seed immersion in 2,400 p/m a.i. of oxamyl/15 min. Also seed immersion was evaluated when combined with foliar sprays of Oxamyl L (4.68 l/ha every 15 and 60 days). At Corozal soil spray of Oxamyl L [0.6 and 0.9 ml (23,700 μg a.i./ml)/plant], 0.3 and 0.6 ml/plant plus seed treatment (2400 p/m a.i./15 min), Oxamyl L sprayed at 4.68 l/ha/15 days and soil treatments of Phenamiphos (0.64, 0.93 and 1.27 g/plant) were evaluated. Harvested tubers were classified in quality categories based on the cortical dry-rot damage caused by *P. coffeae*: high (0-25%), medium (26-50%) and poor (51-100%); and based on perforations made by the larvae of *D. abbreviatus*: tunneled (tubers with one or more perforations) and marketable (high and medium quality tubers without tunnels). Significant yield increases ($P=0.01$) of high quality yams over the control were obtained at both locations with all Oxamyl L treatments. Highest yields were obtained at Utuado with 0.3 ml/plant combined with seed immersion and with 0.6 ml/plant without seed treatment. An increase from 0.6 to 0.9 ml of Oxamyl L did not increase yields significantly at Corozal. At Utuado there was no significant reduction in tunneled yams attributable to foliar spray or soil treatments. Infestation of *D. abbreviatus* at Corozal was very low.

RESUMEN

Efecto del nematicida-insecticida Oxamyl L en aspersión del suelo, inmersión de la semilla y del tratamiento del suelo con Phenamiphos 15 G en ñame (*Dioscorea rotundata* Poir)

Se establecieron dos ensayos de campo en dos sitios de Puerto Rico (Utuado y Corozal) para evaluar la eficacia de la aspersión al suelo y la inmersión de la semilla del nematicida-insecticida Oxamyl L y el

[1]Manuscript submitted to Editorial Board 6 October 1989.

[2]Assistant Nematologist, Department of Crop Protection.

[3]Associate Agronomist, Department of Agronomy and Soils.

[4]Assistant Professor, University of Puerto Rico Regional College, Utuado, P.R.

tratamiento al suelo con Phenamiphos 15G en la represión del nematodo, *Pratylenchus coffeae* (Zimmermann) Filip. Schuur-Stekh y del gusano blanco, *Diaprepes abbreviatus* (L) en ñame (*Dioscorea rotundata* Poir). Las aspersiones al suelo con Oxamyl L se dirigieron a la base de la planta con un dosificador automático de 20 ml. comúnmente llamado "pistola." En Utuado, dos dosis de Oxamyl L, 0.3 ml. (7,410 μg p. a./ml.) y 0.6 ml. (15,297 μg p. a./ml.) por planta aplicado cada 2 meses, se evaluaron solos y en combinación con la inmersión de semilla en 2,400 p./m. p. a. de Oxamyl L por 15 min. También la inmersión de semilla se evaluó al combinarse con aspersiones foliares de Oxamyl L (4.68 l./ha. cada 15 y 60 días). En Corozal se evaluó la aspersión al suelo de Oxamyl (0.6 y 0.9 ml. p.a./planta cada 2 meses), 0.3 y 0.6 ml. p.a./planta aplicado cada 2 meses combinado con inmersión de la semilla (2,400 p./.m. p. a./15 min.), aspersión foliar a razón de 4.68 l./ha./15 días y tratamientos al suelo con Phenamiphos 15G (0.64, 0.93 y 1.27 g./planta). Al momento de la cosecha los tubérculos se agruparon en categorías de calidad según el grado de pudrición seca causado a la corteza por *P. coffeae*: alta (0-25%), intermedia (26-50%) y pobre (51-100%); y a base de las perforaciones hechas por la larva de *D. abbreviatus* en las categorías vendibles (tubérculos de alta y mediana calidad sin barrenos) y barrenado (tubérculos con 1 ó más perforaciones). En ambos sitios se lograron aumentos significativos (P=0.01) sobre el testigo en el rendimiento de ñames de alta calidad. En Utuado se obtuvieron los rendimientos más altos con 0.3 ml./planta combinado con inmersión de la semilla y con 0.6 ml./planta sin inmersión de la semilla. Las aspersiones de Oxamyl L al suelo (0.3 y 0.6 ml./planta cada 2 meses) no redujeron significativamente el daño causado al tubérculo por la larva de *D. abbreviatus*. Los tratamientos comparables aplicados al follaje tampoco redujeron significativamente el daño causado por la larva. En Corozal se demostró que un aumento en la dosis de 0.6 a 0.9 ml. por planta no aumentó significativamente la calidad ni el rendimiento del ñame. La incidencia del gusano blanco fue bien baja en el ensayo de Corozal.

INTRODUCTION

Yam (*Dioscorea* spp.) is an important staple food and the most important root crop grown in Puerto Rico. In 1979-80, production peaked to 340,000 cwt, whereas in 1984-85 it declined to 274,000 cwt, i.e. 19.4% below that of 1979-80 (1). Diseases and pests, among other factors, play a major role in this declining trend. The Florido (*D. alata*) cultivar, which was one of the most extensively cultivated yams in the Island, is disappearing because of anthracnose, caused by the fungus *Colletotrichum gloesporioides* Penz (11). Thus, farmers have been inceasingly favoring the Habanero cultivar, also known as Guinea, which is resistant to anthracnose but susceptible to nematodes. It has been shown that the dry-rot disease of yams is caused by nematodes (16). Two species are associated with the disease in Puerto Rico, the lesion nematode, *Pratylenchus coffeae* (Zimmerman) Filip & Schuurm. Stekh. and the yam nematode, *Scutellonema bradys* (Steiner & Lehen) Andrassy. According to Acosta and Ayala (2) *P. coffeae* is considered of greater importance. These organisms attack the cortical tissue of the edible root; thus,

producing dry-black lesions which reduce development, quality, yield and, therefore, its farm value.

During the past years effective control has been achieved with nematicides (13,14,15). In 1971, Ayala and Acosta (4) reported the results of the first trial on nematode control conducted in yam in Puerto Rico. Data from research by Román et al. (13,14,15), from 1977 to 1982, led to registration of Aldicarb 10G (0.68 - 1.36 lkg a.i./acre at planting) and Oxamyl L (seed treatment: 1,200 - 2000 p/m a.i./15 min; foliar treatment: 4.68 l/ha every 15 days).

Yams are planted in the mountain region of the Island and are harvested after 7 to 12 months. Because of the short planting distance and close growing habits of the plant, multiple applications of granular nematicides are very difficult by furrow treatment. With the exception of Aldicarb, granular nematicides were not effective at low dosages or in single applications for nematode control in yam in Puerto Rico (14). In 1982 (10), Garabedian and Hague demonstrated the efficacy of soil spray with Oxamyl L to reduce the invasion of *Heterodera sacchari* juveniles in sugarcane. The effectiveness of soil treatment with Oxamyl L was also demonstrated in banana by Robalino et al. (12) and Figueroa and Shillingford (9). In both instances the spot-gun applicator was used. This is considered an easy, practical and effective method for the application of liquid nematicides.

The work herein reported was conducted in order to evaluate the efficacy of soil sprays and seed treatment of Oxamyl L and soil treatment with Phenamiphos for the control of nematodes and white grub in yam plantings in Puerto Rico.

MATERIALS AND METHODS

Two experiments were conducted, one in Utuado and one in Corozal. In Utuado, the experiment was established at the farm of the Colegio Regional de la Montaña in May 1984. The soil was classified as Viví (Fluventic Eutropepts, coarse-loamy, mixed, isohyperthermic) with a pH of 4.65 and 1.67% organic matter. The selected field was free of *P. coffeae* and *S. bradys*. At planting time, tuber pieces of yam (*D. rotundata*) of approximately 227 g, heavily infected with *P. coffeae*, were selected to provide nematodes. Two months after planting, soil treatments were applied at the base of the plant with an automatic applicator (spot-gun) MK 111 of the NJ Phillips Pty, Ltd.[5] calibrated to apply 10 ml of solution per plant. Dilution rates were 1:32 and 1:15.6 for 0.3 and 0.6 ml/plant, respectively. Eight treatments were replicated 4 times and arranged in

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

a partially balanced incomplete block design. The following Oxamyl L treatments were included: 1) seed immersion (2,400 p/m a.i./15 min.); 2) 0.3 ml (7,410 μg a.i./ml)/plant every 2 months; 3) 0.6 ml (15,297 μg a.i./ml)/plant every 2 months; 4) seed immersion combined with 0.3 ml/plant every 2 months; 5) seed immersion combined with 0.6 ml/plant every 2 months; 6) seed immersion combined with foliar spray of 4.68 l/ha every 15 days; 7) seed immersion combined with foliar spray of 4.68 l/ha every 60 days; 8) a check without nematicide. Seeds of the Guinea Negro cultivar were spaced at 0.43 x 1.5 m (15,946 plants/ha) in 3 x 4.5 m plots with 20 plants per plot. Two and a half months after planting, a 15-5-10 fertilizer was applied at the rate of 3,445 kg/ha. Benlate was applied as needed for foliar fungi.

The experiment established at Corozal was begun early in April 1986. The soil was a Corozal clay (Aquic Tropudults, clayey, mixed, isohyperthermic) with a pH of 4.61 and 2.29% of organic matter. As in Utuado, the selected field was free of *P. coffeae* and *S. bradys*; thus, seed pieces of approximately 227 g, infected with *P. coffeae*, were selected to provide nematodes. Soil spray treatments were applied also with a spot-gun calibrated to apply 10 ml per plant of solution. The experiment consisted of 9 treatments, replicated 4 times arranged in a complete balanced block design. The following Oxamyl L treatments were included: 1) 0.6 ml (15,297 μg a.i./ml)/plant every 2 months 2) 0.9 ml (23,700 μg a.i./ml)/plant every two months; 3) seed immersion (2,400 p/m a.i./15 min combined with 0.3 ml (7,410 μg/ml)/plant every 2 months; 4) seed immersion combined with 0.6 ml/plant every two months; 5) seed immersion combined with foliar application of 4.68 l/ha every 15 days; 6) Phenamiphos 15G, 0.64 g/plant (9.19 kg/ha) applied in bands at planting; 7) Phenamiphos 15G, 0.93 g/plant (13.34 kg/ha) applied in bands at planting; 8) Phenamiphos 15G, 1.29 g/plant (18.24 kg/ha) applied in bands at planting; and 9) check (no nematicide). Seeds of the Guinea Blanco cultivar were spaced at 0.46 × 1.5 m (14,352 plants/ha) in 3.6 × 4.5 m plots.

Soil samples were taken for nematode determination prior to treatment, six weeks afterwards and at harvest. Nematodes were isolated from 250-g soil samples by the method described by Christie and Perry (7). At harvest, tubers were grouped in 3 categories in terms of the degree of cortical dry-rot damage. Categories were as follow: 1) high quality (0-25% cortical infection), 2) medium quality (26-50% infection) and 3) poor quality (51-100% infection).

Data on insect (*Diaprepes abbreviatus* L.) damage was grouped in the following categories: 1) marketable yams (high and medium quality tubers without tunnels), 2) tunneled yams (tubers damaged by one or more perforations).

TABLE 1.—*Effect of the systemic nematicide-insecticide Oxamyl L in yield of yam (*Dioscorea rotundata*) by the control of the dry-rot nematode* Pratylenchus coffeae*—Utuado, P. R.*

Treatments[1]	Average production[2] (Tons/ha)			
	High quality (0-25%)	Medium quality (26-50%)	Poor quality (51-100%)	Infection percentage[3]
1. SI	14.62 a[4]	6.85 ab	6.48 b	47.7 bc
2. 0.3 ml	16.98 a	14.11 ab	4.01 bc	51.6 b
3. 0.6 ml	23.67 a	3.33 c	0.40 c	13.6 d
4. SI + 0.3 ml	23.04 a	3.72 c	0.00 c	13.9 d
5. SI + 0.6 ml	17.86 a	3.81 c	0.00 c	17.6 cd
6. SI + FS/15 days	14.35 a	4.09 c	9.72 ab	49.0 b
7. SI + FS/2 mo.	15.33 a	2.91 c	8.59 ab	42.9 bc
8. CHECK	2.15 b	16.43 a	13.50 a	93.3 a

[1]SI = seed immersion in 2,400 p/m a.i. of Oxamyl L/15 min.;
FS = foliar spray at 4.68 l/ha, treatments 2, 3, 4, and 5 applied with spot gun to each plant every 2 months.

[2]Based on 15,946 plants/ha.

[3]Infection percentage = Medium + poor quality yams/total production × 100.

[4]Means in the same column followed by one or more letters in common do not differ significantly at 0.05 probability level according to Duncan's Multiple Range Test.

RESULTS

Tables 1 and 2 show the results of the trial at Utuado. Table 1 shows that significant increases ($P=0.01$) in yield of high quality yams were obtained with all Oxamyl L treatments. No significant differences between treatments were observed. Differences in medium and poor quality tuber attributable to treatments were obtained. Regarding medium quality tubers, all treatments except seed immersion alone and 0.3 ml of Oxamyl L without seed treatment yielded significantly less. Applications of 0.3 and 0.6 ml per plant of Oxamyl L with seed immersion and 0.6 ml without seed treatment produced the few poor quality yams. There were no significant differences in high and medium quality yams between soil spray and foliar spray of Oxamyl L to seed treated plots. However, a significant lower yield of poor quality tubers was produced by soil spray than by foliar treatment of seed-treated plants. Check plants produced significantly more damaged tubers than the other treatments.

Table 2 summarizes data on damage caused by *D. abbreviatus* larvae on yams. The highest production of bored yams was found in plants treated with 0.3, 0.6 ml of Oxamyl L and with 0.3 ml of Oxamyl L combined with a seed treatment. No significant differences were found with other treatments. No significant differences were found in terms of

TABLE 2.—*Effect of the nematicide-insecticide Oxamyl L in yields of yams (*Dioscorea rotundata*) highly infected by* Diaprepes abbreviatus*—Utuado, P. R.*

Treatments[1]	Average production[2]		
	Tunneled t/ha	Marketable t/ha	Infection percentage[3]
1. SI	8.55 bc[4]	12.40 a	40.8 ab
2. 0.3 ml	21.79 a	10.99 a	66.5 a
3. 0.6 ml	14.80 ab	11.77 a	53.7 a
4. SI + 0.3 ml	14.97 ab	11.50 a	56.6 a
5. SI + 0.6 ml	10.63 bc	13.74 a	43.6 ab
6. SI + FS/15 days	9.41 bc	9.49 a	49.8 ab
7. SI + FS/2 months	10.59 bc	8.92 a	54.3 a
8. CHECK	3.89 c	15.09 a	20.5 b

[1]SI + seed immersion in 2,400 p/m a.i. of oxamyl L./15 min.;
FS + foliar spray at 4.68 l/ha; treatments 2, 3, 4, and 5 applied with spot gun to each plant every 2 months.

[2]Based on 15,946 plants/ha.

[3]Infection percentage = tunneled yams/total production.

[4]Means in the same column followed by one or more letters in common do not differ significantly at 0.05 probability level according to Duncan's Multiple Range Test.

yield of marketable yams. Production differences between treatments was eliminated by standardization in percentage of infection. No significant differences were observed between Oxamyl L treatments. The check ranked lowest with a significantly lower percentage of infection than the infection with 0.3, 0.6 ml of Oxamyl L, 0.3 ml of Oxamyl L combined with seed immersion treatment, and foliar spray every 2 months of Oxamyl L combined with seed treatment.

Table 3 presents data of the experiment conducted at Corozal. Best treatments for the production of high quality tubers were 0.6 ml of Oxamyl L alone and combined with seed treatment, 0.9 ml and 0.3 ml of Oxamyl L plus seed immersion and 2 qt of Oxamyl L applied every 15 days. Oxamyl L at 0.6, 0.9, 0.6 plus seed immersion (4.68 l/15 days) produced the fewest intermediate damaged tubers. No significant differences in poor quality yams were observed. A dose increase from 0.6 to 0.9 ml of Oxamyl did not reflect significant differences in high, medium or poor quality yam among the treatments. The infection percentage reflects a pattern similar to that obtained for high quality yams.

No evidence of phytotoxicity was observed in these trials. Nematode populations in soil were very low in all treatments and no significant difference was found in plants without nematicide.

DISCUSSION

At Utuado more nematode and insect damage was observed than at Corozal. Insect damage at Corozal was insigificant.

TABLE 3.—*Effect of the systemic nematicides Oxamyl L / 15G and* Phenamiphos *in yield of yams (*Dioscorea rotundata*) by the control of the dry-rot nematodes—Corozal, P. R.*

Treatments[1]	Average production[1] (Tons/ha) High quality (0-25%)	Medium quality (26-50%)	Poor quality (51-100%)	Infection percentage[2]
1. Oxamyl L, 0.6 ml/p	24.70 a[3]	5.38 bcd	0.64 a	19.6 b
2. Oxamyl L, 0.9 ml/p	20.66 ab	3.17 cd	0.32 a	14.5 b
3. Oxamyl L, .3 ml/p + 2400 p/m/15 min.	22.73 a	7.78 abc	3.36 a	32.9 ab
4. Oxamyl L, .6 ml/p + 2400 p/m/15 min.	23.35 a	0.13 d	0.20 a	1.4 b
5. Oxamyl L, 4.68 l/15 days	23.10 a	5.30 bcd	2.02 a	24.1 ab
6. Phenamiphos 15G, .64 g/p	4.97 c	7.02 abc	6.87 a	73.6 a
7. Phenamiphos 15G, .93 g/p	8.06 bc	8.22 abc	4.35 a	60.9 a
8. Phenamiphos 15G, 1.27 g/p	7.46 bc	10.16 ab	6.35 a	68.9 a
9. Check	8.77 bc	12.71 a	5.86 a	67.9 a

[1]Based on 14,352 plants per hectare.

[2]Infection percentage = medium + poor quality yams/total production × 100.

[3]Means in the same column followed by one or more letters in common do not differ significantly at the 0.05 probability level according to Duncan's Multiple Range Test.

For the production of high quality yams, seed immersion treatment proved to be as effective as all other treatments. However, when yams were classified in mean and poor quality tubers the seed immersion treatment alone was not as effective as when 0.3 and 0.6 ml of Oxamyl L were combined with seed treatment (table 1). Román et al. (15) found that seed treatment alone was highly effective for production of high quality yams. Similar results were obtained by Coates-Beckford (8) in Jamaica and Badra and Caveness (6) in Nigeria. Previous to these results, Ayala and Acosta found that treating the seed with hot water, Fensulfothion or dibromocloropropane was effective in contolling nematodes in yam (5).

Soil spray treatments on seed-treated plants were more effective than treatments by foliar spray in the reduction of poor quality tubers (table 1). Oxamyl L soil applications could be reduced at least to 60% of the amount used with biweekly foliar treatment. This is in agreement with Attilano and Van Gundy (3), who found that it was necessary to apply three times more Oxamyl L by foliar spray than by soil treatment to inhibit penetration and development of nematodes. In Costa Rica, Figueroa and Shillingford (9) obtained an increase in the persistance of Oxamyl L in roots up to 90 days after the last soil application of pure product. These data suggest that at the high product concentrations evaluated in the present study the frequency of soil applications in yam could be reduced even more than 60 percent.

Regarding infection or damage by nematodes and *Diaprepes* grubs, we observed that plants from treated plots were frequently bored by *Diaprepes*. This finding probably indicates that treated tubers having more healthy tissue are more attractive to the grubs than nematode-infected ones. Apparently, this observation has not been reported in the literature. It is noted that there is scarce information regarding the combined effect of nematodes and *Diaprepes* on yam tubers. Therefore, further investigation is necessary.

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