Chemical Control of Nematodes in Plantains (*Musa acuminata* × *M. balbisiana*, AAB)[1]

J. Román, X. Rivas, J. Rodríguez, D. Oramas[2]

ABSTRACT

An experiment was conducted to evaluate the effectiveness of various nematicides in the control of nematodes that affect plantains (*Musa acuminata* × *M. balbisiana*, AAB). The results obtained indicated that application of the nematicides Nemacur G, Dasanit G, Mocap G, Temik G, Furadan G, Vydate G, and Nemagon E. C., at their recommended dosages and frequency, prevented reduction in yield of plantain plants due to nematode attack. Use of these nematicides has made possible for the first time in Puerto Rico the harvest of three successive crops of plantains without renovating the plantation after the first harvest.

INTRODUCTION

Plantain (*Musa acuminata* × *M. balbisiana*, AAB) is the most important starch crop grown in Puerto Rico. According to Espinet-Colón et al. (7), plantain production increased from 191 million fruits in 1961–62 to 253 million in 1969–70; and production has been maintained at that level since 1970. These investigators also reported that the agricultural gross income derived from plantains has increased steadily since 1961–62 to the extent that this crop probably will soon become second in economic importance on the Island. Plantains are a difficult crop to grow successfully. Normally, relatively good yields are obtained the first year, but yields decline so rapidly thereafter that frequently a second crop is not economically feasible. Ogier and Merry (14), and Hutton and Chung (9) described a similar situation in Trinidad and Jamaica, respectively. In Trinidad yield reductions that occurred in spite of otherwise good growing conditions and careful management were shown to be associated with destruction of the plant root system by the parasitic nematodes *Pratylenchus* spp. Decker et al. (5) reported that *Radopholus similis* is the main problem in plantain production in Cuba.

Previous research conducted in Puerto Rico by Ayala and Román (3) demonstrated the importance of the nematode *R. similis* in plantain

[1] Manuscript submitted to Editorial Board April 18, 1975.

[2] Nematologist and Research Assistants, respectively, Agricultural Experiment Station, College of Agricultural Sciences, Mayagüez Campus, University of Puerto Rico, Río Piedras, P.R. Thanks are expressed to Mr. Rafael Inglés of this Station for his partial assistance in the field work.

production. Ayala in 1969 (2) reported that in addition to *R. similis* other nematode species such as *Meloidogyne incognita*, *Pratylenchus coffeae*, *Rotylenchulus reniformis*, and *Helicotylenchus* spp. are also commonly encountered. Román et al. (15) found that *R. similis* is the causal organism of the "black head-toppling disease" of plantains in Puerto Rico. This disease is characterized by heavy necrosis and subsequent rotting of the root system and rhizomes and premature falling of the plants. It was first described in bananas (*Musa acuminata*, AAA) by Ashby (1) who named it "black head" and later by Leach (10) who added the term "toppling." A more detailed account of the disease in bananas was published by Loos and Loos (12). Subsequently, other investigators have also reported on nematode problems of bananas and their control (4,6,8,11,16,17).

The research reported herein was undertaken to determine the effectiveness of various nematicides in controlling nematodes that attack plantains in Puerto Rico.

MATERIALS AND METHODS

An experiment was established in December 1970 at the Corozal Agricultural Experiment Substation in an area previously known to be infested with the nematode *R. similis*. This area consisted of a Corozal clay with pH 6.06. The common Dwarf plantain cultivar was used as propagating material. Prior to planting, the rhizomes or "seeds" were peeled to discard necrotic tissue, immersed in a solution of Nemagon 70 E.C.[3] (1,064 cm^3/100 gal of water) for 5 min and planted 24 hr later. The experimental plots consisted of six "seeds" planted in double rows 1.52 m apart, 2.74 m between the double rows, and 1.52 m between plants, to accommodate approximately 2,471 plants/ha (1,000 plants/acre). Fourteen treatments were replicated six times in a balanced incomplete block design (table 1). The nematicides used consisted of granular formulations of Nemacur (Phenamiphos), Nemagon (1,2-dibromo-3-chloropropane), Dasanit (Fensulfothion), Mocap (Prophos), Furadan (Carbofuran), Temik (Aldicarb), Vydate (Oxamyl), and the liquid formulations of Nemagon, E-D-B (ethylene dibromide), and D-D (1,3-dichloropropene-1,2-dichloropropane). The granular formulations were applied at planting time by mixing the nematicide with the soil covering the "seeds" and thereafter every 6 or 12 months on the soil surface in a ¾ m radius around the plant. For this operation a small calibrated plastic

[3] Mention of any product or trade name in this publication does not constitute an endorsement of the product by the Agricultural Experiment Station nor indicate superiority to other similar products not mentioned.

TABLE 1.—*Mean number of plant-parasitic nematodes recovered from 300 cm³ of soil from the rhizosphere of plantains treated with various nematicides*[1]

Treatment per plant[2]	Sampling date									
	Dec. 1970	Jan. 1971	May 1971	Sept. 1971	Jan. 1972	May 1972	Sept. 1972	Jan. 1973	May 1973	Sept. 1973
1. Control	1000	1080	586	920	2013	440	3146	1546	720	520
2. Nemacur 15G, 20 g/6 months	626	93	266	546	40	186	93	27	66	13
3. Nemagon 8.6G, 48 g/year	626	173	173	893	1540	560	346	520	386	575
4. Dasanit 15G. 40 g/6 months	493	66	560	320	493	133	26	160	66	66
5. Nemagon 70 E.C., 9 cm³/year	226	140	53	200	200	760	493	466	260	80
6. Nemagon 70 E.C., 9 cm³/6 months	306	80	53	266	173	53	0	160	0	26
7. Nemagon 70 E.C., 9 cm³/4 months	293	186	26	40	140	26	40	53	53	120
8. Mocap 10G, 30 g/6 months	506	213	506	1053	26	13	0	146	146	66
9. Temik 10G, 30 g/6 months	533	333	480	520	80	386	0	253	40	66
10. Furadan 10G, 30 g/6 months	573	293	440	480	53	93	13	26	160	93
11. Vydate 10G, 30 g/6 months	453	626	173	506	306	293	40	13	200	53
12. Nemagon 8.6G, 48 g/6 months	306	213	80	333	360	666	506	773	253	266
13. E-D-B W-85, 9 cm³ (pre-plant)	320	80	260	320	373	493	1460	1013	986	506
14. D-D, 30 cm³ (pre-plant)	280	120	40	240	306	213	946	530	320	840

[1] Numbers correspond to a mixed population of *R. similis*, *Helicotylenchus* spp., *R. reniformis*, *M. incognita*, *Pratylenchus* spp., *Tylenchus* spp., *Aphelenchoides* spp., and *Aphelenchus* spp.

[2] Treatments were made on Dec. and June of each year (for D-D and EDB, the first and only treatment was given on Nov. 1970; treatments of Nemagon E.C. every 4 months were made on Dec., April and August of each year).

container was used. The liquid formulations were injected into the soil at an approximate depth of 20 cm with a hand injector. These nematicides were applied either pre-plant by treating an area approximately 1 m^2 where the "seed" was to be planted, or at planting time and every 4, 6 or 12 months after planting by injecting the nematicide in a circle 60 cm from the seed.

Dieldrin 15%, at the rate of 2 gal/100 gal of water, was applied every 6 months to control the corm weevil, *Cosmopolites sordidus*. Weeds were controlled with post-emergence applications of Gramoxone at the rate of 473 cm^3/ha. A 10-10-10 fertilizer was applied at 1 and 5 months after planting at the rate of 227 and 454 g/plant, respectively. Thereafter, every 5–6 months an 8-8-13 fertilizer was applied at the rate of 454 g/plant.

Soil samples were collected every 4 months for nematode counts. Root samples were collected immediately after the first harvest, but none thereafter, to prevent damage to the plant root system. All soil samples were processed following the routine sieving-decanting, Baermann-funnel method. Root samples were comminuted and blended for 15 s and processed in the same way as the soil samples. Nematodes collected were identified and counted under a microscope.

Ten months after planting, trunk diameter was measured at a height 1 m above the soil surface. At harvest time the number of fruits and bunch weights were recorded.

RESULTS AND DISCUSSION

The fluctuation in the number of stylet bearing nematodes throughout the duration of the experiment is presented in table 1. This population consisted of the following species: *Radopholus similis*, *Rotylenchulus reniformis*, *Helicotylenchus* spp., *Meloidogyne incognita*, *Pratylenchus* spp., *Tylenchus* spp., *Aphelenchoides* spp., and *Aphelenchus* spp.

Table 1 shows that in the majority of the samplings more nematodes were recovered from the control than from the nematicide-treated plots. In certain cases, however, relatively high populations were observed in the treated plots, especially in those treated with Nemagon granules, E-D-B and D-D, which were found to be the least effective nematicides.

The population of the endoparasitic nematode *R. similis* in 100 g of roots at the time of the first harvest is presented in figure 1. In general, *R. similis* infestation was low in the majority of the treated plots. This low infestation, which was associated with overall growth and vigor of the plants throughout the duration of the experiment and with their high yield, indicates that *R. similis* is the most important parasitic nematode recovered in this study. The population of *R. similis* in plantains does not have to reach extremely high numbers in order to cause damage. Studies

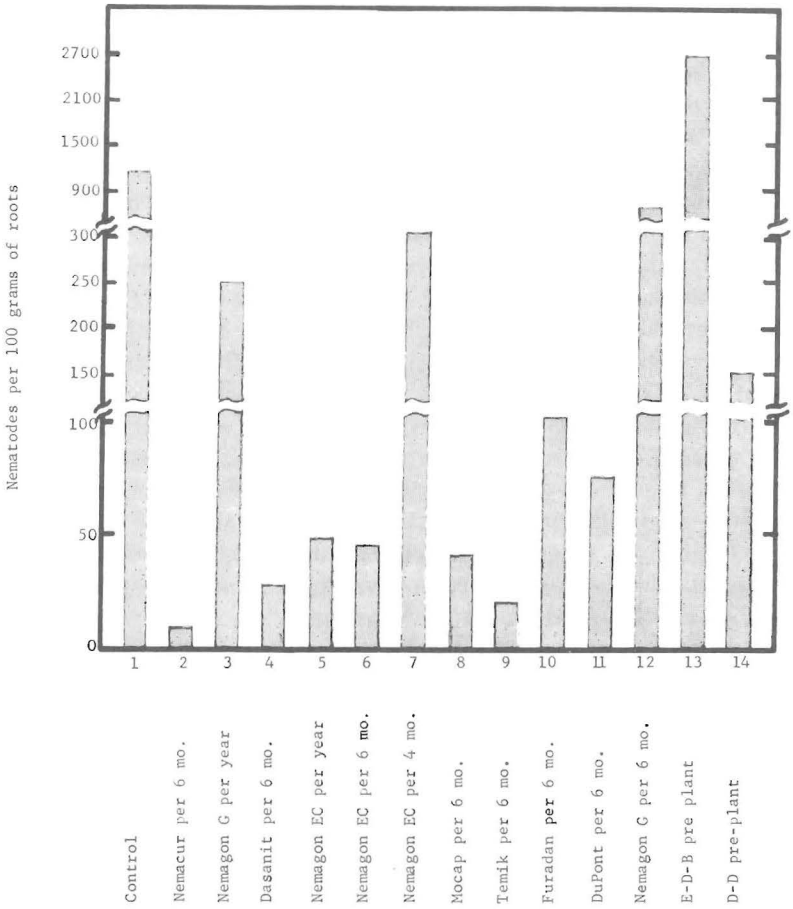

FIG. 1.—Number of *Radopholus similis* during the first harvest of plantains treated with different nematicides.

to date have not established the minimum level of infestation required to cause detrimental effects. However, these experiments indicate that this level is lower than the 10,000 nematodes per 100 g of roots that was established for bananas by the *Compañía Bananera Atlántica* of Costa Rica, Central America.[4] This might indicate that bananas can tolerate higher infestations of *R. similis* than plantains.

Table 2 presents the mean pseudostem circumference of the plants. Ten months after planting, the average pseudostem circumference in all plants treated with nematicides was greater than that of the controls. According to Lossois (13), in bananas the circumference of the pseud-

[4] Personal communication from nematologist Manuel F. Jiménez.

stem at flowering time is correlated with the weight of the bunch. This correlation also seems to be true for plantains since the data presented in tables 2 and 3 indicate a tendency of plants with thicker pseudostem to bear heavier bunches and vice versa. A similar relationship seems to occur for the pseudostem circumference and number of fruits.

Data similar to that mentioned above could not be taken for the following 2 years (first and second ratoon crops) because plants from ineffective treatments were greatly affected in growth during the first ratoon and gradually died thereafter. One of the most striking differences observed during the first ratoon was the effect on growth (fig. 2).

The mean plantain yield for 3 consecutive years is presented in table 3. The best treatments, which produced at least 71,412 fruits/ha (28,900 fruits/acre) with a weight of 16.03 metric tons/ha (14,300 lb/acre) or over in the plant crop, were the granular forms of Nemacur, Dasanit, Mocap, Temik, Furadan and Vydate and the Nemagon emulsifiable form applied every 4 and 6 months. There were no significant differences between the above-mentioned treatments. However, the differences between these treatments and the control were highly significant. The effectiveness of the majority of these treatments was maintained throughout the duration of the experiment. The plants treated with Nemagon E. C. every 4, 6 and 12 months produced significant yields for the first and second crops. However, after the second crop the plants treated every 4 and 12 months began to lose vigor and finally died. The 6-month treatment seemed to be the most effective time interval for the application of this nematicide.

TABLE 2.—*Mean pseudostem circumference of 10-month-old plantain plants treated with various nematicides*

Treatment per plant	Circumference[1]
	cm
1. Control	26.3
2. Nemacur 15G, 20 g/6 months	31.2
3. Nemagon 8.6 G, 48 g/year	33.5
4. Dasanit 15 G, 40 g/6 months	45.3
5. Nemagon 70 E.C., 9 cm^3/year	36.4
6. Nemagon 70 E.C., 9 cm^3/6 months	42.3
7. Nemagon 70 E.C., 9 cm^3/4 months	39.8
8. Mocap 10 G, 30 g/6 months	44.8
9. Temik 10 G, 30 g/6 months	40.8
10. Furadan 10 G, 30 g/6 months	41.3
11. Vydate 10 G, 30 g/6 months	36.3
12. Nemagon 8.6 G, 48 g/6 months	36.3
13. E-D-B, W-85, 9 cm^3 (pre-plant)	38.1
14. D-D, 30 cm^3 (pre-plant)	35.2

[1] Measured at 1 m above the soil surface.

TABLE 3.—*Estimated mean number and weight of marketable fruits per hectare of plantain plants treated with various nematicides*

Treatment per plant	Yield per hectare[1]					
	Plant crop		First ratoon		Second ratoon	
	Fruits	Weight	Fruits	Weight	Fruits	Weight
	Number	*Metric tons*	*Number*	*Metric tons*	*Number*	*Metric tons*
1. Control	34,100	5.16	395	0	0	0
2. Nemacur 15G, 20 g/6 months	83,767**	19.39**	38,308**	5.99**	38,053	2.58
3. Nemagon 8.6G, 48 g/year	41,513	7.06	6,133	1.20	0	0
4. Dasanit 15G, 40 g/months	80,060**	20.18**	92,598**	18.48**	57,327	4.82
5. Nemagon 70 E.C., 9 cm^3/year	68,447**	16.14**	37,962**	4.67*	0	0
6. Nemagon 70 E.C., 9 cm^3/6 months	96,122**	23.76**	82,606**	15.19**	55,103	6.39
7. Nemagon 70 E.C., 9 cm^3/4 months	98,099**	23.65**	73,488**	11.31**	0	0
8. Mocap 10G, 30 g/6 months	82,215**	21.97**	67,770**	11.90**	39,536	3.59
9. Temik 10G, 30 g/6 months	83,767**	19.95**	57,184**	8.88**	29,405	3.25
10. Furadan 10G, 30 g/6 months	78,578**	21.63**	48,854**	8.60**	23,475	2.35
11. Vydate 10G, 30 g/6 months	71,412**	16.03**	36,756**	5.36*	30,146	3.03
12. Nemagon 8.6G, 48 g/6 months	61,281*	11.66*	6,565	0.93	0	0
13. E-D-B, W-85, 9 cm^3 (pre-plant)	58,069	9.98	7,653	1.13	0	0
14. D-D, 30 cm^3 (pre-plant)	62,516**	11.32*	14,596	2.04	0	0

[1] 1 hectare = 2.47 acres.

** Significant difference (1%) over the control.

* Significant difference (5%) over the control.

FIG. 2.—Plantain plants of the second crop: front plot, untreated control; back plot, treated with the granular nematicide Dasanit.

During the first ratoon the treatments with Nemagon granules, D-D and E-D-B, at the dosages and time intervals applied, proved their ineffectiveness by the relatively low yields obtained. At the time of the second ratoon, plants from these treatments had died.

Increases in yield and number of crops obtained by the use of granular nematicides like Nemacur, Dasanit, Mocap, Temik, Furadan and Vydate are not their only advantages. The granular form in which they are formulated permits fast, easy and economic application to the soil surface without using special applicators. This is especially important in Puerto Rico where labor is scarce and wages are high.

RESUMEN

Un ensayo se efectuó con el propósito de evaluar la eficacia de varios nematicidas en el control de los nematodos que atacan el platanero (*Musa acuminata* × *M. balbisiana*, AAB). Los resultados obtenidos indicaron que los nematicidas Nemacur G, Dasanit G, Mocap G, Temik G, Furadan G, Vydate G y Nemagon C. E. usados adecuadamente protegen las plantas del ataque de nematodos al extremo de que se evitan reducciones en el rendimiento causadas por los nematodos. Mediante el uso indicado de estos compuestos ha sido factible por primera vez en Puerto Rico, producir hasta tres cosechas de plátanos sin necesidad de resembrar la plantación después de la primera cosecha como es la práctica corriente.

LITERATURE CITED

1. Ashby, S. F., Notes on cultivated crops observed in 1913–14—Banana diseases, Bull. Dep. Agr. Jamaica 2:316–317, 1915.
2. Ayala, A., Nematode problems in Puerto Rican agriculture, In Proc. Symp. Trop. Nematology p. 135–145, Agr. Exp. Sta. Univ. P. R., 1969.
3. Ayala, A., and Román, J., Distribution and host range of the burrowing nematode in Puerto Rican soils, J. Agr. Univ. P. R. 47(1):28–37, 1963.
4. Blake, C. D., Root rot of bananas caused by *Radopholus similis* (Cobb) and its control in New South Wales, Nematologica 6(4):295–310, 1961.
5. Decker, Heinz, Casamayor-García, Roberto y Rodríguez-Fuentes, María Elena, Nuevas investigaciones sobre tratamientos de los rizomas del plátano con agua caliente y nematicidas contra nematodos parasíticos, Cartas ALAF no. 51–52:7, marzo-abril, 1973.
6. Edmunds, J. E., Banana nematode control, WINBAN Adv. Bull. Univ. West Indies, July, 1969.
7. Espinet-Colón, G. R., González-Villafañe, E., Muler-Manzanares, L. y Chavarría de Gracia, O., Análisis económico de la producción y mercadeo del plátano a nivel del productor, Puerto Rico, 1971–72, Est. Exp. Agr., Univ. P. R., Publicación 82, 1973.
8. Gowen, S. R., Banana nematode control with DBCP and four granular nematicides in the Windward Islands, Nematropica 4(2):17, 1974.
9. Hutton, D. G., and Chung, D. C., Effect of post-planting applications of the nematicide DBCP to plantain, Nematropica 3(2):45, 1973.
10. Leach, R., Blackhead toppling disease of bananas, Nature 181(4603):204–5, 1958.
11. Loos, Clive A., and Loos, Sarah B., Preparing nematode-free banana "seed", Phytopathology 50(5):383–6, 1960.
12. Loos, C. A., and Loos, S. B., The blackhead disease of bananas (*Musa acuminata*), Proc. Helminthol. Soc. Wash. 27(2):189–93 1960.
13. Lossois, P., The development of a technique for crop forecasting in banana cultivation, p. 145–160, In The Banana Industry and Research, Caribbean Organization, Hato Rey, Puerto Rico, 1965.
14. Ogier, T. P., and Merry, C. A. A. F., Yield decline of plantains. *Musa paradisiaca*, in Trinidad associated with the nematode *Pratylenchus* sp., Turrialba 20(4):407–12, 1970.
15. Román, J., Rivas, X., y Rodríguez, J., Control de los nematodos del plátano, Est. Exp. Agr., Univ. P. R., Adelantos Científicos Núm. 1:1-2 agosto 1973.
16. Villardebo, A., Nemacur para el control de nematodos en bananos en Africa Occidental, Pflanzenschutz-Nachrichten Bayer 24: 159–75 (Edición española), 1971.
17. Wehunt, E. J., and Holdeman, Q. L., Nematode problems of the banana plant, Proc. Soil Crop Sci. Fla. 19:436–443, 1959.