

## PLANT-PARASITIC NEMATODES OF CROPS IN BELIZE

J. Bridge,<sup>1</sup> D. J. Hunt,<sup>1</sup> and P. Hunt<sup>2</sup>

International Institute of Parasitology, 395A Hatfield Road, St Albans, Herts AL4 OXU, U.K.<sup>1</sup> and Government of Belize/NRI Plant Protection Project, Central Farm, Cayo District, Belize.<sup>2</sup>

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### ABSTRACT

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Plant nematode surveys were made at 55 farm sites in six Districts of Belize, Central America, during February, November and December, 1993. Crops sampled included banana and plantain, cassava, citrus, coconut, cocoyam, corn, ginger, papaya, passion fruit, peanut, pigeon pea, pineapple, potato, rice, sugar cane, yam, and vegetables (beans, cabbage, carrot, cowpea, onion, peppers, tomato, okra, cucumber, pea, eggplant). Soil and root samples also were taken from primary forest soils. A total of 47 plant-parasitic nematode species were identified. Of these, the important crop pests found were the root-knot nematodes, *Meloidogyne arenaria*, *M. incognita*, and *Meloidogyne* sp., on vegetable and other crops; the root lesion nematodes, *Pratylenchus brachyurus* on a range of crops, *P. coffeae* on yams and plantain, *P. zae* on rice and corn; the burrowing nematode, *Radopholus similis*, on banana and plantain, the red ring nematode, *Rhadinaphelenchus cocophilus*, on coconut; the reniform nematode, *Rotylenchulus reniformis*, on papaya, beans, cowpea and pigeon pea in particular; the citrus nematode, *Tylenchulus semipenetrans* on citrus; and some spiral nematodes especially *Helicotylenchus multicinctus* and *H. mucronatus* on a variety of crops. Many of the nematodes were widely distributed throughout Belize on different crops, although some were specific to certain hosts (e.g. *R. cocophilus* on coconut, *Radopholus similis* on banana and plantain, and *T. semipenetrans* on citrus).

*Key words:* Belize, Central America, crops, distribution, plant-parasitic nematodes.

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### RESUMEN

Bridge, J., D. J. Hunt y P. Hunt. 1996. Nematodos parásitos de plantas de los cultivos en Belice. *Nematrópica* 26:111-119.

Durante Febrero, Noviembre y Diciembre de 1993 se realizaron muestreos para nematodos de plantas en 55 granjas de seis comarcas de Belice, América Central. Los cultivos muestreados incluyeron banano y plátano, yuca, cítricos, coco, cocoyam, maíz, jengibre, papaya, maracuyá, cacahuete, gandul, piña, papa, arroz, caña de azúcar, camote, y hortalizas (frijol, repollo, zanahoria, caupi, cebolla, pimiento, tomate, okra, pepino, guisante, berenjena). Se tomaron también muestras de raíces y suelo procedentes de suelos primarios de bosques. Se identificaron 47 especies de nematodos parásitos de plantas. Entre ellos, las importantes plagas de los cultivos que se encontraron, fueron los nematodos agalladores, *Meloidogyne arenaria*, *M. incognita* y *Meloidogyne* sp., sobre hortalizas y otros cultivos; el nematodo lesionador de las raíces, *Pratylenchus brachyurus*, sobre diferentes cultivos, *P. coffeae*, sobre camotes, banana y plátano, *P. zae* sobre arroz y maíz; el nematodo barrenador, *Radopholus similis*, sobre banano y plátano; el nematodo del anillo rojo, *Rhadinaphelenchus cocophilus* sobre el coco; el nematodo reniforme, *Rotylenchulus reniformis* sobre la papaya, frijol, gandul y caupi en particular; el nematodo de los cítricos, *Tylenchulus semipenetrans*, y algunos nematodos espirales especialmente *Helicotylenchus multicinctus* y *H. mucronatus* sobre una variedad de cultivos. Muchos de los nematodos se distribuyeron ampliamente a lo largo de Belice sobre cultivos diferentes, mientras que otros fueron específicos de hospederos determinados (por ejemplo *R. cocophilus* sobre coco, *Radopholus similis* sobre banano y plátano y *T. semipenetrans* sobre cítricos).

*Palabras clave:* América Central, Belice, cultivos, distribución, nematodos parásitos de plantas.

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## INTRODUCTION

There are few published reports on the existence or importance of plant nematodes in Belize. Pinochet and Ventura (1977) identified nematodes associated with bananas, and citrus nematodes also have been recorded in the country (Anonymous, 1970). Other published reports on nematodes are by Mulk and Siddiqi (1982), Brathwaite *et al.* (1981) and by the Belize (British Honduras) Ministry of Agriculture (Anonymous, 1953, in Dean, 1979).

This work was part of the Government of Belize National Plant Protection Project based at Central Farm, Cayo District, Belize, Central America. Two plant nematode surveys were completed during February and November/December, 1993 (Bridge, 1995). The procedures followed in the two surveys were designed to establish the presence of nematodes, their accurate identification, their distribution, and their pest status in relation to other constraints in the different areas of Belize. All the important agricultural crops, grown by both commercial and smallholder farmers, were surveyed.

## MATERIALS AND METHODS

Samples totalling 160 were taken at 55 sites from the major and minor crops grown in the six Districts of Belize - Cayo, Corozal, Orange Walk, Belize, Stann Creek, and Toledo.

*Sampling:* Farms or fields in which crops were giving poor yields, or showing foliar symptoms indicating disease or poor growth, abnormal root growth or necrosis, or other symptoms suggesting nematode damage, were selected for sampling with the help of local District Agricultural Officers and farmers. Some random sampling of adjacent healthy plants and in fields with no symptoms was also done. In addi-

tion, farmers' fields in Cayo District were also selected in which crops had recently been planted after forest clearance. Cropping histories of the areas sampled were obtained from the farmers. Soil and root samples were collected from depths of 5 to 25 cm and processed in the laboratory as soon after sampling as possible, normally within 48 hrs. Other samples were taken from the stems of coconut palms and from corms and tubers.

*Extraction and processing:* Nematodes were extracted from soil samples by a modified tray extraction method (Hooper, 1990) in Belize using locally bought materials where possible. Plastic baskets (colanders) fitting into plastic saucers were found to be particularly suitable. Extraction of nematodes from plant roots, stems, and tubers was by cutting or shredding a known weight of the material onto tissue paper in a Petri dish of water and leaving for up to 72 hrs. With some crops such as citrus, root pieces were fixed in 5% formalin and later stained in acid fuchsin-lactoglycerol (Bridge *et al.*, 1982; Hooper, 1990) and examined directly for nematodes and nematode damage.

Preliminary generic and species identifications were done at the Central Farm Laboratory, Belize. Processed and fixed material was returned to the U.K. and detailed identifications of the nematodes were done at the International Institute of Parasitology.

## RESULTS

*Nematodes identified from Belize:* Various types of farms were sampled from the 55 areas visited in the six Districts. Most were small-scale farms with relatively small field plots, but some were large commercial enterprises. In the small farms, both mixed and mono-cropping were practiced and normally a wide range of crops was grown.

Twenty plant-parasitic nematode genera and 47 species were found associated with crops and known to feed on plant tissues, although not necessarily of economic pest significance (Table 1). Many of these nematodes are recorded for the first time in Belize. The nematodes known to be important crop pests are: the root-knot nematodes, *Meloidogyne* spp.; the root lesion nematodes, *Pratylenchus brachyurus*, *P. coffeae*, and *P. zaei*; the banana burrowing nematode, *Radopholus similis*; the red ring nematode, *Rhadinaphelenchus cocophilus*; the reniform nematode, *Rotylenchulus reniformis*; the citrus nematode, *Tylenchulus semipenetrans*; and some spiral nematodes, particularly *Helicotylenchus multicinctus* and *H. mucronatus*. Many of the nematodes were widely distributed throughout Belize on different crops, although some were specific to certain hosts, e.g. *Rhadinaphelenchus cocophilus* on coconut, *Radopholus similis* on banana and plantain, and *T. semipenetrans* on citrus.

*Nematodes in crops and distribution in Belize:* The plant nematodes found associated with the different crops sampled in the surveys are described separately under each crop together with their actual or potential importance as crop pests.

**Bananas and Plantains (*Musa* spp.):** Samples of *Musa* spp. were taken from both large commercial banana plantations and smallholder farms. Bananas were of the dessert Cavendish subgroups, mainly cv. Grande Naine. Plantains were grown by smallholder farmers, sometimes in comparatively large groves; bananas were less commonly grown by these farmers, and were normally present as solitary mats or stands.

The major nematode pest found in all the commercial banana plantations was *R. similis*. This species was present and causing root damage to all the banana plants sampled in the three commercial planta-

tions in Stann Creek and Toledo Districts. The least root damage (less than 25% cortical root necrosis) occurred in the plantation where nematicides had been applied on a twice yearly basis. Maximum infestation and root damage by *R. similis* (50 to 75% cortical root necrosis) was found in the plantation where nematicides had not been applied, and the characteristic symptom of severe nematode damage, uprooting or 'toppling' of plants, was common. *Radopholus similis* was also found causing necrosis of plantain roots in a plantation at the Belize Agricultural College farm, Cayo District. The other nematode pests found on banana in the plantations were of minor importance when compared to *R. similis*. *Helicotylenchus multicinctus* was present in roots causing cortical necrosis, and both *Meloidogyne* spp. and *R. reniformis* occurred, but were not associated with obvious damage.

Smallholder farms were generally free of major nematode pests on plantains and bananas. Plantains were sampled from farms in 19 different areas and *R. similis* was found in roots in only one farm in Succotz, Cayo District. Another important nematode, *P. coffeae*, was only extracted from plantain roots on one of the farms sampled in the Silk Grass area of Stann Creek District. The less damaging nematode species, *H. multicinctus*, occurred in plantain roots in 16 out of the 19 farms sampled; *Meloidogyne* spp. and *R. reniformis* were also commonly found. The other nematodes extracted from plantain soil were *Criconebella onoensis*, *Helicotylenchus erythrinae*, *H. dihystra*, *H. mucronatus*, *Longidorus laevicapitatus*, *Paratylenchus* sp., *Peltamigratus christiei*, and *Xiphinema* cf. *rivesi*. *Quinisulcius capitatus* occurred at one site on bananas in Cayo District.

**Citrus (*Citrus* spp.):** Fifteen species of plant-parasitic nematodes were found associated with citrus roots but the only species

Table 1. Nematode genera and species found associated with crops in Belize.

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 Plant parasites:

- Criconemella onoensis* (Luc, 1959) Luc and Raski, 1981  
*Criconemella ornata* (Raski, 1958) Luc and Raski, 1981  
*Criconemella sphaerocephala* (Taylor, 1936) Luc and Raski, 1981  
*Gracilacus* sp.  
*Helicotylenchus curvatus* Román, 1965  
*Helicotylenchus dihystra* (Cobb, 1893) Sher, 1961  
*Helicotylenchus dihystreroideus* Siddiqi, 1972  
*Helicotylenchus erythrinae* (Zimmermann, 1904) Golden, 1956  
*Helicotylenchus microcephalus* Sher, 1966  
*Helicotylenchus microlobus* Perry, Darling, and Thorne, 1959  
*Helicotylenchus multicinctus* (Cobb, 1893) Golden, 1956  
*Helicotylenchus mucronatus* Siddiqi, 1974  
*Helicotylenchus* cf. *platyurus* Perry, Darling, and Thorne, 1959  
*Helicotylenchus pseudorobustus* (Steiner, 1914) Golden, 1956  
*Heterodera* sp. (?)  
*Longidorus laevicapitatus* Williams, 1959  
*Meloidogyne arenaria* (Neal, 1889) Chitwood, 1949  
*Meloidogyne incognita* (Kofoid and White, 1919) Chitwood, 1949  
*Meloidogyne* n.sp. (?)  
*Paratrophurus costarricensis* Lopez, 1986  
*Paratylenchus* sp.  
*Peltamigratus christiei* (Golden and Taylor, 1956) Sher, 1964  
*Pratylenchus brachyurus* (Godfrey, 1929) Filipjev and Schuurmans Stekhoven, 1941  
*Pratylenchus coffeae* (Zimmermann, 1898) Filipjev and Schuurmans Stekhoven, 1941  
*Pratylenchus zaeae* Graham, 1951  
*Pratylenchus* sp.  
*Quinisolcius capitatus* (Allen, 1955) Siddiqi, 1971  
*Quinisolcius curvus* (Williams, 1960) Siddiqi, 1971  
*Quinisolcius* n.sp.  
*Radopholus similis* (Cobb, 1893) Thorne, 1949  
*Rhadinaphelenchus cocophilus* (Cobb, 1919) J. B. Goodey, 1960  
*Rotylenchulus reniformis* Linford and Oliveira, 1940  
*Rotylenchus* cf. *calvus* Sher, 1965  
*Trichodorus* sp.  
*Tylenchorhynchus annulatus* (Cassidy, 1930) Golden, 1971  
*Tylenchorhynchus* sp.
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Table 1. (Continued) Nematode genera and species found associated with crops in Belize.

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<i>Tylenchulus semipenetrans</i> Cobb, 1913
<i>Xiphinema brevicolle</i> Lordello and Da Costa, 1961
<i>Xiphinema elongatum</i> Schuurmans Stekhoven and Teunissen, 1938
<i>Xiphinema</i> cf. <i>rivesi</i> Dalmasso, 1969
<i>Xiphinema</i> n.sp.1
<i>Xiphinema</i> n.sp.2
Other stylet bearing nematodes:
<i>Aphelenchoides</i> spp.
<i>Aphelenchus avenae</i> Bastian, 1865
<i>Coslenchus costatus</i> (de Man, 1921) Siddiqi, 1978
<i>Ditylenchus</i> sp.
<i>Filenchus</i> sp.
<i>Kantbhala</i> n.sp.
<i>Psilenchus</i> sp.
<i>Tylenchus</i> ( <i>sensu lato</i> ) spp.

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that could be considered of actual or potential economic importance was the citrus nematode, *T. semipenetrans*. It was present in many different areas including some of the main commercial groves in Stann Creek Valley. In some locations, the presence of *T. semipenetrans* was associated with unhealthy growth and twig dieback symptoms. The numbers of *T. semipenetrans* females on citrus roots was generally low at the two sampling times, less than 100 females/g root, although population levels of 1 100 juveniles/100 ml soil were found at some of the sites sampled. Other plant nematodes extracted from soil around citrus roots were *Criconemella* sp., *Ditylenchus* sp., *Helicotylenchus dihystreroides*, *H. dihystrera*, *H. mucronatus*, *H. multincinctus*, *Longidorus laevicapitatus*, *Meloidogyne* sp., *Paratylenchus* sp., *Peltamigratus christiei*, *Pratylenchus* sp. and *R. reniformis*. Heteroderid juveniles, possibly *Heterodera* sp., were also found although no cysts were recovered.

Vegetables: Root-knot nematodes were the major nematode pests of vegetable

crops. Three species were found on vegetables, *M. arenaria*, *M. incognita*, and *Meloidogyne* sp., possible a new species. *Meloidogyne incognita* was the most damaging pest observed, causing severe root galling on bean (*Phaseolus vulgaris*), okra (*Hibiscus sabdariffa*), cabbage (*Brassica oleracea*), sweet pepper (*Capsicum annuum*), tomato (*Lycopersicon esculentum*), and chili pepper (*Capsicum frutescens*). Other vegetable crops grown in Belize which are very susceptible to *M. incognita* (although galling was not observed in these surveys) are cowpea (*Vigna unguiculata*), carrot (*Daucus carota*), eggplant (*Solanum melongena*), and passion fruit (*Passiflora edulis*). *Meloidogyne arenaria* was present on okra, pepper, and tomato.

Many other species of plant-parasitic nematodes occurred on the different vegetable crops including the known pests of vegetables, *R. reniformis* and *P. brachyurus*, but their relative importance could not be assessed by field observations alone. *Rotylenchulus reniformis* was present in large

numbers (1 450/100 ml soil) around okra at Santa Rita, Corozal District, and probably causing yield loss at this site. Other nematodes possibly damaging to vegetables were *Peltamigratus christiei*, *Paratrophurus costarricensis*, *Trichodorus* sp., and *Xiphinema* spp. One unusual observation was the presence of very large numbers of *Quinisulcius curvus* (2 500/100 ml soil) around roots of cabbage in Santa Elena, Corozal District. This nematode is not reported to cause yield loss of cabbage, but these populations suggest that the species could be a damaging pest. *Xiphinema* species, *X.* cf. *brevicolle*, *X. elongatum*, *X.* cf. *rivesi*, and *Xiphinema* n.sp.1, were extracted from vegetable soils, the latter from around okra roots. The *Helicotylenchus* species occurring with vegetables were *H. curvatus*, *H. dihystra*, *H. microcephalus*, *H. microlobus*, *H.* cf. *pseudorobustus*, and *H. multincinctus*.

Coconut (*Cocos nucifera*): The red ring nematode, *Rhadinaphelenchus cocophilus*, was extracted from coconut tissues in the districts of Cayo and Toledo on palms showing the characteristic symptoms of red ring disease (initial leaf yellowing and wilt followed by death). Stem breakage was also observed in moribund palms where large numbers of the palm weevil, *Rhyncophorus palmarum*, the insect vector of the nematode, had been attracted to diseased trees. When the trunks of palms showing symptoms were cut, the typical orange to reddish colored ring 2-4 cm-wide was observed about 5 cm from the outside of the trunk. Red ring disease of coconut is a serious problem in Belize. However, a more important problem occurring in the area at the time of sampling was lethal yellowing, which could be confused with the nematode disease. Two parasitic nematode species, *H. dihystra* and *Xiphinema* n.sp.1, were extracted from coconut soils.

Rice (*Oryza sativa*): A number of plant nematode pests were found associated with

upland rice (*C. onensis*, *Helicotylenchus* cf. *platyurus*, *H. dihystra*, *Paratrophurus costarricensis*, *Pratylenchus zae*, *R. reniformis*, *Tylenchorhynchus annulatus*). The root lesion nematode, *P. zae*, was found in Cayo District and in Hopkins, Stann Creek District. Maximum soil populations of *P. zae* from rice in these surveys was 400 nematodes/100 ml soil. Some root damage was observed in the form of dark lesions, but not in serious proportions. No plant-parasitic nematodes were found with irrigated lowland rice in the fields that were sampled.

Root and Tuber Crops: Yam (*Dioscorea* sp.) tubers sampled in Stann Creek Valley near Dangriga, Stann Creek District, were found to be infested with *P. coffeae* which was associated with the characteristic 'dry rot' disease of tubers known to be caused by this nematode. The rot occurred as a dark brown band of necrotic tissues in the outer edges of the tubers which was observed when tubers were cut in half.

The other root and tuber crops sampled were potato (*Solanum tuberosum*), cassava (*Manihot esculenta*), cocoyam (*Colocasia esculenta*) and ginger (*Zingiber officinale*). Nematodes extracted from soil around these crops were: *Helicotylenchus dihystra*, *Meloidogyne* sp., and *Xiphinema* cf. *rivesi* on cassava; *Criconemella ornata*, *M. arenaria*, and *R. reniformis* on cocoyam; *Helicotylenchus pseudorobustus*, *M. incognita*, *P. costarricensis*, *R. reniformis*, *Trichodorus* sp., and *Xiphinema* sp. on ginger.

Papaya (*Carica papaya*): Of the five plant-parasitic species associated with papaya (*Criconemella sphaerocephala*, *H. dihystra*, *Meloidogyne* sp., *P. christiei*, and *R. reniformis*), only *R. reniformis* was found in sufficient numbers to cause damage. *Meloidogyne* juveniles were found at one site but were not associated with any root galling. Large soil populations of *R. reniformis* (in excess of 1 400/100 ml soil) were

found at one papaya plantation, in San Andres, Corozal District, associated with stunted plants.

Sugarcane (*Saccharum officinarum*): Samples of sugarcane roots and soils were taken mainly from Corozal District with a few from Orange Walk. Plantations showing signs of poor growth in six different areas were sampled. In some plantations, populations of nematodes found in soil and roots from poor plants were compared to those from apparently healthy plants. Nine species of plant-parasitic nematodes were found with sugarcane (*C. sphaerocephala*, *Helicotylenchus curvata*, *H. microlobus*, *H. microcephalus*, *Meloidogyne* sp., *Peltamigratus christiei*, *Pratylenchus* sp., *R. reniformis*, *Tylenchorhynchus* sp.). Species from the genera *Pratylenchus* and *Meloidogyne* are known pests of the crop, but there was no association between these nematode populations and symptoms of damage to sugarcane in the form of root lesions or galls.

Pineapple (*Ananas comosus*): Many different plant-parasitic nematodes were found with pineapple at the different sites (*H. dihystra*, *H. microcephalus*, *H. mucronatus*, *H. multicinctus*, *Meloidogyne* sp., *Peltamigratus christiei*, *Pratylenchus brachyurus*, *R. reniformis*, *X. cf. rivesi*, *Xiphinema* n. sp.1). There were no symptoms of damage on the crop that could be directly attributable to the nematodes at the sites sampled, but a number of these are important nematodes known to cause damage to pineapple in other countries. *Meloidogyne* sp., *R. reniformis*, and *P. brachyurus* were present with the crop in Stann Creek District and have to be considered as potential pests of pineapple in Belize. They are most likely to become pests where the crop is grown on a continuous basis. Other possible pests could be *H. microcephalus* and *H. mucronatus*.

Corn (*Zea mays*): The nematodes extracted from soil around corn were *H. dihystra*, *H. microlobus*, *H. microcephalus*, *H.*

*multicinctus*, *M. incognita*, *P. brachyurus*, *P. zae*, *Q. capitatus*, *Quinisulcius* n. sp., *R. reniformis*, and *Xiphinema* cf. *brevicolle*. *Pratylenchus zae* was also found endoparasitic in corn roots. In the Blackwater area of Orange Walk District, *M. incognita* was causing galling of corn roots in fields where the crop was grown as a mixed crop with beans which were also severely galled by the nematode.

Other Crops and Samples: Nematodes extracted from peanut (*Arachis hypogaea*) soils were *H. dihystra*, *R. reniformis*, and *Meloidogyne* sp., but no galling or damage was observed; *H. pseudorobustus* and *R. reniformis* were found in pigeon pea (*Cajanus cajan*) soils but not in the roots; *P. christiei* and *R. reniformis* occurred in soils around star fruit trees (*Averrhoa carambola*), and *R. reniformis* was also found in soils around passion fruit (*Passiflora edulis*) plants. The plant nematodes recovered from primary forest soils were *Criconemella* sp., *Gracilacus* sp., *Meloidogyne* sp., *Rotylenchus* cf. *calvus*, *X. cf. rivesi* and *Xiphinema* n.sp.2.

## DISCUSSION

Surveys of this nature, while providing an accurate identification of the nematodes encountered and pointers to the relative importance of the species associated with crop damage, can also produce a number of new, unanswered questions. Of the 47 plant-parasitic nematode species identified on crops throughout Belize, those that can be considered as important pests are the root-knot nematodes, *Meloidogyne* spp., on vegetables and other crops; the root lesion nematodes, *Pratylenchus* spp., on a range of crops; the burrowing nematode, *Radopholus similis*, on banana and plantain; the red ring nematode, *R. cocophilus*, on coconut; the reniform nematode, *R. reniformis*, on papaya, beans, cowpea and pigeon pea in particular; the citrus nema-

tode, *T. semipenetrans*, on various citrus; and possibly some others such as the spiral nematodes, especially *H. multincinctus* and *H. mucronatus*, on a variety of crops. Many of these species are probably common to Central American countries and are similar, for example, to those found by Pinochet and Ventura in Honduras (1980). The coconut red ring nematode is known to occur throughout Central America (Dean, 1979) and was first recorded from Belize in 1952 (Anonymous, 1953, in Dean, 1979).

The major banana nematode, *R. similis*, is not indigenous to Belize and has almost certainly been imported into the country on infested banana planting material. The absence of *R. similis* from all but one of the smallholder farms sampled and its presence on all plants in the commercial banana plantation supports this view. An earlier survey of banana plantations in 1977 (Pinochet and Ventura, 1977) also found a high percentage of infestation by *R. similis*. This was surprising, considering that the commercial banana planting material first introduced to Belize in 1973 had been heat treated prior to planting in an area that had no previous history of banana growing. One of the reasons given to explain this infestation was that the planting material had not been adequately treated.

The lesion nematode, *P. coffeae*, was causing root necrosis of plantains and dry rot of yam tubers but only at two sites. This contrasts to its widespread occurrence and predominance on plantains, coffee, citrus and bananas in the nearby country of Honduras (Pinochet and Ventura, 1980). Across the border from Belize in Mexico, dry rot disease of yam tubers is reported to be caused by another species, *P. brachyurus* (Roman, 1977), which has also been found associated with wild yam in Guatemala (Jenkins and Bird, 1962).

Further investigations are needed to establish the most suitable nematode control methods for the farmers, particularly with root-knot nematodes on vegetables, and root parasites of banana. It will also be necessary to determine the importance of some nematodes in relation to other constraints on production, e.g. *R. reniformis* on papaya, *T. semipenetrans* on citrus, and *P. zaeae* on rice and corn, all known pests of these crops. The large populations of *R. reniformis* found with papaya could be directly causing stunting and yield loss, but the species is also reported to interrelate with fungal pathogens to cause disease in other crops (Gaur and Perry, 1991). The citrus nematode, *T. semipenetrans*, in some locations was associated with unhealthy growth and twig dieback symptoms but other possible causes, e.g. *Phytophthora* root rot, may also be associated with this disease complex. The numbers of *P. zaeae* found on upland rice suggests that populations at the sites sampled had not reached seriously damaging levels at time of sampling, but if rice is continually cultivated on the same lands, damaging population levels could easily develop.

Other nematodes observed to be possible pests are not so well known and require further study, such as the ectoparasite, *Quinisulcius curvius*, found in large populations around the roots of cabbage, and the commonly occurring spiral nematode, *H. mucronatus*.

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