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Status of weeds as reservoirs of plant parasitic nematodes in banana fields in Martinique

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Abstract

During a survey of the nematodes associated with weeds in banana fields in Martinique, 41 weed species in 37 genera from 20 plant families were collected to extract nematodes from the roots. Results of this survey showed that 24 weed species were hosts of *Radopholus similis*, 23 were hosts of *Helicotylenchus* spp., 13 were hosts of *Pratylenchus* spp., 13 were hosts of *Hoplolaimus seinhorsti*, 29 were hosts of *Meloidogyne* spp. and 24 were hosts of *Rotylenchulus reniformis*. The presence of the burrowing nematode was more consistently found within three families, the Euphorbiaceae, Poaceae and Solanaceae. In some weed species such as *Caladium bicolor*, *Commelina diffusa*, *Echinochloa colona* and *Phenax sonneratii*, the levels of nematodes recovered were similar to, or greater than the numbers recovered from *Musa* roots. These results clearly show that certain weeds can be significant reservoirs of plant parasitic nematodes including *R. similis* in banana fields. This information is crucial in devising appropriate nematode control measures for use with rotation crops or fallow before re-planting banana fields with nematode free planting material.

Keywords: Burrowing nematode; *Helicotylenchus* spp.; Martinique; *Meloidogyne* spp.; *Musa*; Nematode control; *Pratylenchus* spp.; *Radopholus similis*; *Rotylenchulus reniformis*; Weeds

1. Introduction

In the French West Indies, several species of nematodes are parasites of banana plants. The burrowing nematode, *Radopholus similis* (Cobb), remains the primary nematode problem in banana fields (Loridat, 1989; Gowen and Quénéhervé, 1990). It may reduce plant production by more than 50% (Chabrier et al., 2005) and decrease the production duration of banana fields: after 5 years, growers often have to choose between abandoning their plantation or applying nematicide.

Other nematode species may seriously damage banana root systems: *Pratylenchus* spp. damage resembles *R. similis* injuries, and are serious pests in tropical highland areas. *Helicotylenchus* spp., and *Meloidogyne* spp. are commonly found in banana roots, *Hoplolaimus seinhorsti*, and *Rotylenchulus reniformis*, are detected more sporadically.

Current recommendations, instituted more than a decade ago, are to apply nematicides from 1 to 3 times per year to manage nematode problems. To reduce pesticide application, crop systems combining banana nematode-free in vitro-plantlets and fallow period have been developed.

However, weeds may serve as transitional hosts for plant parasitic nematodes, providing a reservoir for the survival of nematodes in fields: in Central America and the Caribbean (Ayala and Roman, 1963; Edwards and Wehunt, 1971; Rivas and Roman, 1985), Brazil (Zem, 1983), South Africa (Keetch, 1972) and Ivory Coast (Mateille et al., 1994). Several weed families have been found to be potential hosts of the burrowing nematode. But host status of a specific group may vary from one site

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to another; for instance, maize and coffee have been good hosts in South Africa (Milne and Keetch, 1976) but non hosts in Porto-Rico (Rivas and Roman, 1985).

This study reports the findings of a survey of the nematodes recovered from weeds in Martinique between 2000 and 2002. The objective of this survey was to determine the level of nematode infestation, particularly that of the burrowing nematode, *R. similis* (Cobb, 1893), among weeds in order to improve the control strategy before replanting fields with nematode-free in vitro propagated plants.

2. Materials and methods

Twenty-eight banana fields, established for at least 5 years and representative of various ecological situations in terms of soil type, climate and field history were selected. In each field, five separate samples of each prevalent weed species were collected at random both within and between banana rows, amounting to a total of 487 samples for nematological analysis. Each sample was comprised of the aerial part of the plant and the corresponding roots with adhering soil collected between the 5 and 30 cm depth. After identification of the plant to species (Fournet, 1978; Fournet et Hammerton, 1991), all root samples were carefully washed under tap water to remove soil particles and fine entangled banana roots. The nematodes were extracted from a fresh root sub-sample (ca. 20 g) carefully picked out under a magnifier and placed in a mist chamber for a 2-week period (Seinhorst, 1950). In addition, 27 *Musa* root samples (from 27 banana fields) were also collected for nematode extraction. Nematode numbers were determined using a counting dish and a stereomicroscope and expressed as the number of nematodes per gram of dry roots (roots were placed at 60 °C in a drying oven after the mist chamber).

According to the number of nematodes recovered per gram of dry root, differential host status of the weeds were arbitrarily defined (Quénéhervé et al., 1995) for each nematode genus encountered and rated as: poor, 0–10 *R. similis*, *Pratylenchus* spp., *Helicotylenchus* spp., *H. seinhorsti* or 0–100 *Meloidogyne* spp., *R. reniformis*; Good, 11–100 *R. similis*, *Pratylenchus* spp., *Helicotylenchus* spp., *H. seinhorsti* or 101–1000 *R. reniformis*, or 101–10,000 *Meloidogyne* spp.; Excellent, >101 *R. similis*, *Pratylenchus* spp., *Helicotylenchus* spp., *H. seinhorsti*, >1000 *R. reniformis*, or >10,000 *Meloidogyne* spp.

3. Results

3.1. Weeds associated with banana fields

During this survey, 41 weed species in 37 genera from 20 families were collected in the various banana-growing areas (Table 1). Soils in these areas were classified as Ultisol (73%), Andosol (24%) and Vertic soils (3%). The collected weeds belonged mainly to six families: Poaceae 27.5%; Euphorbiaceae 10.5%; Solanaceae 10.7%; Urticaceae 9.2%; Araceae 7.2% and Amaranthaceae 4.9%. Among these weeds, seven species were very common and found on most banana farms: Poaceae: *Eleusine indica* (7.8%) and *Echinochloa colona* (6.2%); Urticaceae: *Phenax sonneratii* (7.2%); Solanaceae: *Solanum americanum* (5.1%) and *S. torvum* (4.1%); Euphorbiaceae: *Euphorbia heterophilla* (4.7%); Asteraceae: *Mikamia micrantha* (3.3%).

3.2. Nematodes associated with weeds

Nematode species from six genera were extracted from weed roots (Tables 2 and 3):

- the burrowing nematode *R. similis* Cobb, 1913;
- the spiral nematodes, *Helicotylenchus multicinctus* (Cobb, 1893) Golden, 1956; *H. dihystera* (Cobb, 1893) Sher, 1961; *H. erythrinae* (Zimmerman, 1904) Golden, 1956 and *H. pseudorobustus* (Steiner, 1914) Golden, 1956;
- the lesion nematodes, *Pratylenchus coffeae* (Zimmerman, 1898) Filipj. Schuur. Steck. 1941, *P. zeae* Graham, 1951 and *P. brachyurus* (Godfrey, 1929) Filipj. Schuur. Steck. 1941;
- the lance nematode *H. seinhorsti* Luc 1958;
- the root-knot nematodes, *Meloidogyne incognita* (Kofoid and White, 1919) Chitwood, 1949; *M. arenaria* (Neal, 1889) Chitwood, 1949 and *Meloidogyne* sp.;
- the reniform nematode *R. reniformis* Lindford and Oliveira, 1940.

Only three weed species were free of any nematode species (*Centrosoma pubescens*, *Sida acuta* and *Spermacocce verticilliata*). Therefore 93% of the weeds were hosts for at least one nematode species.

3.3. Nematode-host associations

Ninety-two samples (19%) from 24 weed species contained adults and juveniles of the burrowing nematode, *R. similis*. This species was more consistently recovered from three plant families, the Euphorbiaceae, the Poaceae and the Solanaceae. The levels of nematode infection in some weeds species such as *Caladium bicolor*, *Commelina diffusa*, *E. colona* and *P. sonneratii* equalled or exceeded the level of infection in *Musa* roots.

One hundred and five samples (22%) from 23 weeds species contained spiral nematodes, *Helicotylenchus* spp. The levels of nematode infection in the Amaranthaceae were similar to that in *Musa* roots.

Twenty-four samples (5%) from 13 weed species contained the lesion nematode *Pratylenchus* spp. High numbers of *P. coffeae* were only recovered from the roots of volunteer plants of the edible Araceae *Colocasia esculenta*. Lower numbers of *P. coffeae* were recovered from *Amaranthus dubius*, *Phyllanthus amarus*, *Mimosa*

Table 1
Scientific, common and vernacular names of weeds collected in association with *Musa* AAA and associated soil types in Martinique

Plant species	Common and vernacular name	Occurrence		
		Andosol	Ultisol	Vertic
Amaranthus dubius Mart.	Calalu, Epinard pays		19	
Amaranthus spinosus L.	Prickly calalu, Epinard rouge		5	
Caladium bicolor (Ait.) Vent.	Wild eddoe, Palette du peintre		5	
Cecropia sp	Bois canon		8	
Centrosoma pubescens Benth.	Pois batard, Pois-pois marron		5	
Cleome aculeata L.	Grand caya, Grand mouzambé		11	
Cleome rutidosperma DC.	Feefee, Caya blanc, Mouzambé blanc		5	
Clidemia hirta (L.) D. Don	Soap bush, Herbe côtelette		10	
Colocasia esculenta Schott	Dasheeen, Taro	15		
Commelina diffusa Burm.	Pond grass, Herbe grasse		15	
Cyperus esculentus L.	Nutgrass, Petit coco, Chiencoq	10	4	
Dieffenbachia seguine (Jacq.) Schott	Tue belle-mère		5	
Digitaria horizontalis Willd.	Finger grass, Herbe fine	5	5	
Echinochloa colona (L.) Link	Jungle rice, Herbe à riz		25	5
Eleusine indica (L.) Gaertn	Chedddah, Pied poule	25	13	
Eragrostis pilosa (L.) Beauv.	Herbe à bouquet		5	
Euphorbia heterophylla L.	Red milkweed, Grosse malnommée		18	5
Euphorbia hirta (L.) Millsp.	Milk weed, Herbe malnommée	3	5	
Ipomea sp	Liane douce		5	
Laportea aestuans (L.) Chew	Stinging neetle, Ortie brûlante	5		
Leptochloa filiformis Beauv.	Spangle top, Herbe fine		11	
Mikamia micrantha HBK	Guaco, Locataire	6	10	
Mimosa pudica L.	Shame weed, Marie honte		12	
Oxalis barrelieri L.	Oseille savanne, Oseille marron		5	
Panicum maximum Jacq.	Guinea grass, Herbe de Guinée		5	
Paspalum fasciculatum Willd.	Calumet blanc		10	
Passiflora sp	Passion		5	
Peperomia pellucida (L.) Kunth.	Pepper elder, Herbe à couresse		11	
Phenax sonneratii (Poir.) Wedd.	Ortie batârde, Ortie savane	14	21	
Phyllantus amarus Schum. & Thonn.	Seed under leaf, Graines en bas feuilles blanc	5	15	
Physalis angulata L.	Cow pops, Herbe à poc	5	2	
Pilea microphylla (L.) Liebm.	Baby puzzle, Petite teigne blanche		5	
Roettboellia cochinchinensis (Lour.) Clayton	Itch grass, Herbe à canne		5	5
Setaria barbata (Lam) Kunth	Corne grass, Herbe canot	5	10	
Sida acuta Burm. F.	Broomweed, Balai onze heures, Balai savane		5	
Solanum americanum Mill.	Bitter gouma, Herbe à calalou	12	13	
Solanum torvum Sw.	Shooshoo bush, Bélangère bâtarde		20	
Spermacoce verticillata L.	White broom	6		
Urena lobata L.	Ballard bush, Cousin mahaut, Gros cousin		8	
Vernonia cinerea (L.) Less	Inflammation bush, Bouton blanc		5	
Xanthosoma nigrium (Vell.) Stellfeld	Chou-cochon, Chou batard		10	

pudica and *Roettboellia cochinchinensis*. In the other species, *P. zeae and P. brachyurus* species were observed.

Twenty-nine samples (6%) from 13 weed species contained the lance nematode, *H. seinhorsti*. This species was recovered in very high numbers from roots of *C. diffusa*, *M. pudica* and *E. colona* and in lower numbers from *Musa* roots.

One hundred and thirty-five samples (28%) from 29 weed species contained the root-knot nematode *Meloidogyne* spp. While most of these weeds were good hosts of *Meloidogyne* spp., some of them were rated as excellent hosts, such as *A. dubius*, *C. esculenta*, *Xanthosoma nigrium* and *Peperomia pellucida* from which >1000 juveniles per gram of dry root were recovered. Only these weed species exhibited the typical characteristics of *Meloidogyne* infection with numerous galls and deformed roots, while the other weeds exhibited either slight or no symptoms of root-knot infections. Species identifications performed on the *Meloidogyne* species associated with banana plants during the same survey (Quénéhervé et al., 2000) showed the presence of *M. incognita*, two distinct populations of *M. arenaria* and one unknown species based on isozymes phenotypes.

One hundred and twenty-three samples (25%) from 24 weed species contained the reniform nematode *R. reniformis*. While most of these weeds were good host of *R. reniformis*, some of them were rated as excellent hosts such as *X. nigrium*, *C. diffusa* and *P. sonneratii* from which >1000 juveniles per gram of dry root were recovered.

Table 2
Level of nematode infestation (burrowing, spiral and lesion nematodes) and host status of weeds from older banana fields in Martinique

Plant	No.[a]	*Radopholus similis*		*Helicotylenchus* spp.		*Pratylenchus* spp.	
		N/g dw[b]	Host qlty[c]	N/g dw	Host qlty	N/g dw	Host qlty
Amaranthaceae							
Amaranthus dubius	19	151±104	**	888±1968	***	67±48	**
Amaranthus spinosus	5	0		2354±2415	***	0	
Araceae							
Caladium bicolor	5	6824±3353	***	0		0	
Colocasia esculenta	15	0		30	**	441±336	***
Dieffenbachia seguine	5	0		0		0	
Xanthosoma nigrium	10	46±7	**	308±124	***	0	
Asteraceae							
Mikania micrantha	16	5	*	8±2	*	0	
Vernonia cinerea	5	0		0		0	
Capparidaceae							
Cleome aculeata	11	0		0		5	*
Cleome rutidosperma	5	12	*	11	**	0	
Commelinaceae							
Commelina diffusa	15	7145±7601	***	136±109	***	50	*
Convolvulaceae							
Ipomea sp	5	0		0		0	
Cyperaceae							
Cyperus esculentus	14	4	*	25±30	**	0	
Euphorbiaceae							
Euphorbia heterophylla	23	72±110	**	362±361	***	6	*
Euphorbia hirta	8	85±40	**	0			
Phyllantus amarus	20	27±17	**	656±532	***	125	**
Fabaceae							
Centrosoma pubescens	5	0		0		0	
Malvaceae							
Sida acuta	5	0		0		0	
Urena lobata	8	0		8	*	20	*
Melastomataceae							
Clidemia hirta	10	31±28	**	0		0	
Mimosaceae							
Mimosa pudica	12	0		0		13±8	*
Moraceae							
Cecropia sp	8	16	**	59±55	**	0	
Oxalidaceae							
Oxalis barrelieri	5	0		50	**	0	
Passifloraceae							
Passiflora sp.	5	0		0		0	
Piperaceae							
Peperomia pellucida	11	0		0		0	
Poaceae							
Digitaria horizontalis	10	0		247	***	0	
Echinochloa colonna	30	1896±1890	***	541±744	***	0	
Eleusine indica	38	172±284	***	410±953	***	5	*
Eragrostis pilosa	5	4	*	0		0	
Leptochloa filiformis	11	15±5	**	0		36	*
Panicum maximum	5	5	*	0		0	
Paspalum fasciculatum	10	181±194	***	29	**	3	*
Roettboellia cochinchinensis	10	30±29	**	25±12	**	53±3	**
Setaria barbata	15	117±76	***	182±152	***	0	

Table 2 (*continued*)

Plant	No.[a]	*Radopholus similis*		*Helicotylenchus* spp.		*Pratylenchus* spp.	
		N/g dw[b]	Host qlty[c]	N/g dw	Host qlty	N/g dw	Host qlty
Rubiaceae							
Spermacocce verticillata	6	0		0		0	
Solanaceae							
Physalis angulata	7	51±34	**	222±242	***	36	**
Solanum americanum	25	135±156	***	122±90	***	0	
Solanum torvum	20	137±143	***	614	***	0	
Urticaceae							
Laportea aestuans	5	0		0		0	
Phenax sonneratii	35	620±888	***	411±599	***	0	
Pilea microphylla	5	0		0		0	
Musaceae							
Musa AAA Cavendish	20	416±710	***	2700±4575	***	9	*

[a]Number of collected weeds.
[b]Numbers of nematodes per gram of dry mass in positive samples.
[c]Host quality (* poor, ** good, *** excellent).

Table 3
Level of nematode infestation (lance, root-knot and reniform nematodes) and host status of weeds from older banana fields in Martinique

Plant	No.[a]	*Hoplolaimus seinhorsti*		*Meloidogyne* spp.		*Rotylenchulus reniformis*	
		N/g dw[b]	Host qlty[c]	N/g dw	Host qlty	N/g dw	Host qlty
Amaranthaceae							
Amaranthus dubius	19	0		1471±2229	***	729±447	**
Amaranthus spinosus	5	0		33	*	0	
Araceae							
Caladium bicolor	5	0		0			
Colocasia esculenta	15	0		6217±10753	***	227±188	**
Dieffenbachia seguine	5	13	*	72±92	*	43±41	*
Xanthosoma nigrium	10	0		17680±35034	***	3690±5032	***
Asteraceae							
Mikania micrantha	16	0		8±6	*	787±1851	**
Vernonia cinerea	5	0		61	*	0	
Capparidaceae							
Cleome aculeata	11	28±18	**	165	**	44±43	*
Cleome rutidosperma	5	7	*	34	*	0	
Commelinaceae							
Commelina diffusa	15	1266±1174	***	63	*	14230±24178	***
Convolvulaceae							
Ipomea sp.	5	0				6	*
Cyperaceae							
Cyperus sp.	14	0		336±372	**	2±2	*
Euphorbiaceae							
Euphorbia heterophylla	23	0		81±69	*	134±21	**
Euphorbia hirta	8	3	*	0		164	**
Phyllantus amarus	20	0		39±36	*	14±3	*
Fabaceae							
Centrosoma pubescens	5	0		0		0	
Malvaceae							
Sida acuta	5	0		0		0	
Urena lobata	8	0		71±63	*	0	

Table 3 (*continued*)

Plant	No.[a]	*Hoplolaimus seinhorsti*		*Meloidogyne* spp.		*Rotylenchulus reniformis*	
		N/g dw[b]	Host qlty[c]	N/g dw	Host qlty	N/g dw	Host qlty
Melastomataceae							
Clidemia hirta	10	0		17±16	*	0	
Mimosaceae							
Mimosa pudica	12	460±197	***	261±338	**	37±20	*
Moraceae							
Cecropia sp.	8	0		16	*	158±124	**
Oxalidaceae							
Oxalis barrelieri	5	0		0		25	*
Passifloraceae							
Passiflora sp.	5	20	*	20	*	620	**
Piperaceae							
Peperomia pellucida	11	0		3129±2672	***	0	
Poaceae							
Digitaria horizontalis	10	0		0		0	
Echinochloa colonna	30	650±666	***	638±574	**	0	
Eleusine indica	38	52±47	**	886±1882	**	16±7	*
Eragrostis pilosa	5	129	***	0		0	
Leptochloa filiformis	11	0		181±194	**	45	*
Panicum maximum	5	0		0		0	
Paspalum fasciculatum	10	0		85±115	*	4	*
Roettboellia cochinchinensis	10	0		0		22±4	*
Setaria barbata	15	74±18	*	222±164	**	81	*
Rubiaceae							
Spermacocce verticillata	6	0		0		0	
Solanaceae							
Physalis angulata	7	0		0		0	
Solanum americanum	25	0		764±1480	**	227±339	**
Solanum torvum	20	0		41±7	*	174±322	**
Urticaceae							
Laportea aestuans	5	0		1750	*	0	
Phenax sonneratii	35	125	*	426±725	**	1882±3512	***
Pilea microphylla	5	10	*	350	**	0	
Musaceae							
Musa AAA Cavendish		75±103	**	575±1120	**	13±7	*

[a]Number of collected weeds.
[b]Numbers of nematodes per gram of dry mass in positive samples.
[c]Host quality (* poor, ** good, *** excellent).

4. Discussion

Our survey found that four of the 10 weeds ranked worst in the world (Holm et al., 1977), *A. spinosus*, *Cyperus esculentus*, *E. colona* and *E. indica* were present in banana fields in Martinique and supported plant parasitic nematodes. Of the nematode species recovered, *Meloidogyne* spp. and *R. reniformis* had the largest weed host range in this survey, followed closely by the burrowing nematode *R. similis* and *Helicotylenchus* spp. In Martinique and elsewhere in the world, the most damaging nematode on banana is the burrowing nematode, *R. similis* (Loridat, 1989; Gowen and Quénéhervé, 1990). Information is limited on the host range of this nematode outside Florida where it has been extensively studied from a quarantine point of view (Lehman, 1980; Esser et al., 1984). In Central America and the Caribbean (Ayala and Roman, 1963; Edwards and Wehunt, 1971; Rivas and Roman, 1985), Brazil (Zem, 1983), South Africa (Keetch, 1972) and Ivory Coast (Mateille et al., 1994) different studies have shown how weeds could be hosts of the burrowing nematode. In South Africa, additional observations were made on more than 100 plant species, including value crops (Milne and Keetch, 1976).

In this survey in Martinique, of the 41 weed species sampled 24 were hosts of *R. similis* with all life stages being present in the cortical tissue of the roots. Four weed species, *C. bicolor*, *C. diffusa*, *E. colona* and *P. sonneratii* contained levels of *R. similis* that were similar to levels in *Musa* roots and could be useful as bioindicators of the level of *R. similis* in fallow fields before replanting banana. It is also interesting to note that many plants from the Poaceae family were hosts of this nematode. This suggests that banana's cultivation, which favours the regrowth of these weeds, may favour the survival of *R. similis* and help explain the re-infestation of in vitro propagated plantlets after a fallow period. This information is essential in an integrated pest management program on bananas. Depending on ecological conditions, an alternative may be the use of no-tillage cultural practices that favour less suitable weed hosts (e.g. *Ipomea* spp., *M. micrantha,* poor or non host of *R. similis* in this study) in old banana fields in order to reduce the development of better host species of *R. similis* (e.g. Poaceae, Solanaceae and Urticaceae). Cultural practices under study recently in Martinique, using no-tillage and herbicide destruction of old banana plants showed promising nematological and horticultural results (Chabrier and Quénéhervé, 2003).

The host range of the spiral nematode, mostly *H. multicinctus,* was fairly similar (23 of 41 weed species) to that of the burrowing nematode with many weed families and species good hosts for this species such as in the Amaranthaceae, Euphorbiaceae, Poaceae, and the Solanaceae. It is interesting to note that as soon as infection levels were high and consistent the species identified was *H. multicinctus* in *A. dubius* and *A. spinosus, X. nigrium*, *C. diffusa*, *E. heterophylla*, most of the Poaceae and the Solanaceae and the Urticaceae *P. sonneratii*. Very rarely, we observed a mixture of *H. dihystera*, *H. erythrinae* or *H. pseudorobustus*. It is also interesting to remark that these 2 non-native nematode species, *R. similis* and *H. multicinctus*, were never found on plants outside the vicinity of infested banana fields even though bananas were introduced into Martinique in the sixteenth century and have been intensively cultivated for more than 50 years.

The number of plants found to host *Pratylenchus* spp. and *H. seinhorsti* was half of the number found to host other nematode species and a few weeds were good hosts of these nematodes. The frequent presence of the lesion nematode, *P. coffeae,* on volunteer plants of *C. esculenta* is enough to ban this crop from being grown in rotation in banana cultivation in Martinique. This nematode is already known to parasitize numerous weeds associated with crops in the Caribbean (Fournet et al., 1990; Quénéhervé et al., 1995). The high numbers of *H. seinhorsti* on *C. diffusa*, *M. pudica* and *E. colona* suggests that these weeds could also serve as a primary bioindicator for this nematode.

The host ranges of the root-knot and reniform nematodes were by far the most extensive. These findings confirm results from previous work in other regions of the world (Bendixen, 1988; Robinson et al., 1997) and in the Caribbean (Ayala and Ramirez, 1964; Fournet et al., 1990; Quénéhervé et al., 1995). This study adds seven additional host plants for *R. reniformis* to the list established by Robinson in 1997 including *Cecropia* sp., *Dieffenbachia seguine*, *E. hirta*, *Leptochloa filiformis*, *M. micrantha*, *M. pudica* and *Oxalis barielieri*.

The control of weeds before replanting with banana in vitro-plants appears essential to limit the reinfection by the burrowing nematode *R. similis*. Moreover, the presence of other nematode species, e.g. *Meloidogyne* spp., has already been observed to be harmful to young banana plants produced from in vitro-plants. As a first step, in the French West Indies, all banana fields are now established with in vitro-plants of Cavendish banana after either a fallow period or a rotation crop in an attempt to obtain burrowing nematode free fields. To maximize the benefits of these nematode management techniques, strict weed control on the rotation crop and/or a regular weeding during the fallow period is required.

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