Populations of nematodes in soils under banana, cv. Poyo, in the Ivory Coast. 1. The nematofauna occurring in the banana producing areas

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SUMMARY

A study of plant parasitic nematodes occurring in the banana (*Musa* AAA cv. Poyo) cultivated areas of the Ivory Coast registered 21 species belonging to 17 genera. Eight species from seven genera were recorded in the Ivory Coast for the first time. Two of them, *Paratrophurus clavicaudatus* and *Paratylenchus aquaticus* had not yet been found before in banana rhizosphere. *Pratylenchus coffeae* was registered for the first time in the Ivory Coast; its possible mode of introduction is discussed. Besides the major parasites (*Radopholus similis, Helicotylenchus multicinctus* and *Hoplolaimus pararobustus*), *P. coffeae* and *Rotylenchulus reniformis* are mentioned as potential threats to banana culture. Frequency, abundance and diversity of nematode species are discussed in relation to banana culture.

RÉSUMÉ

Populations de nématodes dans les sols sous bananier, cv. Poyo, en Côte d'Ivoire. 1. La nématofaune observée dans les aires de production bananière.

L'étude des nématodes phytoparasites dans l'ensemble de la région productrice de bananes de Côte d'Ivoire a permis de dresser la liste des 21 espèces, appartenant à 17 genres, trouvées sur *Musa* AAA cv. Poyo. Huit espèces appartenant à sept genres ont été rencontrées pour la première fois en Côte d'Ivoire. Deux d'entre elles, *Paratrophurus clavicaudatus* and *Paratylenchus aquaticus*, ont été notées dans la rhizosphère du bananier pour la toute première fois dans le monde. *Pratylenchus coffeae* est enregistré pour la première fois en Côte d'Ivoire; les causes de son introduction sont envisagées. A côté des parasites les plus importants (*Radopholus similis, Helicotylenchus multicinctus* et *Hoplolaimus pararobustus*), *P. coffeae* et *Rotylenchulus reniformis* sont présentés comme des parasites potentiellement dangereux du bananier. La fréquence, l'abondance et la diversité de la nématofaune sont considérées en relation avec la culture du bananier.

Since the very first surveys on *Musa* spp. in the Ivory Coast and Guinea by Luc and de Guiran (1960) and Luc and Vilardebó (1961), scarce information was added (Luc, 1961; Goodey, 1962; Luc & Baujard, 1983; Baujard, 1984) and no general survey of the nematofauna of banana in the Ivory Coast had been conducted. The present paper gathers the results of a five years long survey from 1980 to 1985 in the whole banana (cv Poyo) planted area of the Ivory Coast. It completes the former list established by the previous authors who mentionned twelve different genera occurring on *Musa* AAA cv. Poyo. Nowadays, this cultivar is the only one to be cultivated in a intensive way (more than 100 000 tons of bananas are exported every year) and nematodes are known as one of the major limiting factors (Vilardebó, 1984).

Material and methods

The banana planted areas are located in the South-Eastern part of the Ivory Coast. Four main regions are distinguished, where most of the industrial plantations are located (Fig. 1) :

— region I : the lagoon valley of Nieky and its surroundings (2 850 ha)

— region II : the region of Azaguié-Anyama (3 150 ha)

— region III : the region around Aboisso and Ayamé (1 100 ha)

— region IV : the region of Abengourou-Adzopé (200 ha).

The plant parasitic nematofauna of a total of 33 different locations was analyzed, corresponding to 11, 13, 5

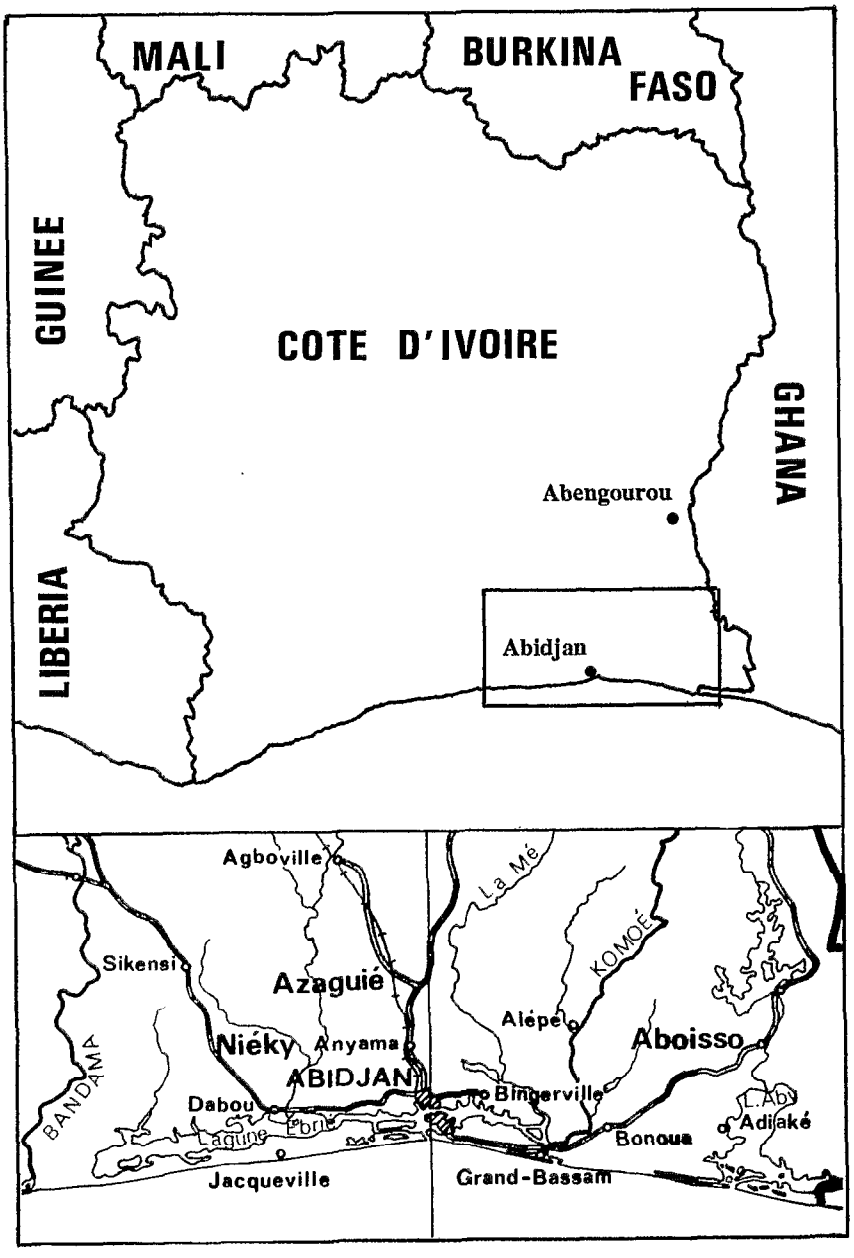

Fig. 1. Sketch map showing the four banana producing areas : regions of Nieky, Azaguié-Anyama, Aboisso-Ayamé and Abengourou-Adzopé, with an enlargement of the South-Eastern region of the Ivory Coast where three of them are located.

and 4 locations from the regions I, II, III and IV, respectively.

For each geographical location, and every month for some of them, the species inventory was done from samples of roots and rhizosphere soil. Banana trees were uprooted and the underground vegetative system was sampled as previously described by Quénéhervé and Cadet (1986). Soil samples were collected between 0 and 70 cm depth. Standardized extraction techniques were used for soil (Seinhorst, 1962), and roots (Seinhorst, 1950).

For each species, frequency and abundance were calculated as in Fortuner and Merny (1973) :

— the frequency corresponds to the number (%) of

Table 1

The species occurring on banana cv. Poyo in the Ivory Coast
(* : new reccord)

Species	*Records*
APHELENCHOIDIDAE	
Aphelenchoides sp. :	Luc & Vilardebó (1961).
Ektaphelenchoides musae Baujard, 1984	Baujard (1984); this report.
TYLENCHIDAE	
Tylenchus sp. :	Luc & Vilardebó (1961).
Cephalenchus emarginatus (Cobb, 1983) Geraert, 1962 :	Goodey (1962); this report.
BELONOLAIMIDAE	
Trophurus imperialis Loof, 1956 :	Luc & de Guiran (1960); Luc & Vilardebó (1961).
Paratrophurus clavicaudatus (Seinhorst, 1963) Andrássy, 1973 :	this report*.
HOPLOLAIMIDAE	
Hoplolaimus pararobustus (Sch. Stek. & Teun., 1938) Sher, 1963 :	Luc & de Guiran (1960); Luc & Vilardebó (1961); this report.
Helicotylenchus multicinctus (Cobb, 1893) Golden, 1956 :	Luc & de Guiran (1960); Luc & Vilardebó (1961); this report.
Helicotylenchus sp. :	Luc & de Guiran (1960); Luc & Vilardebó (1961).
Rotylenchulus reniformis Lindford & Oliveira, 1940 :	this report*.
PRATYLENCHIDAE	
Radopholus similis (Cobb, 1893) Thorne, 1949 :	Luc & de Guiran (1960); Luc & Vilardebó (1961); this report.
Pratylenchus brachyurus (Godfrey, 1929) Filipjev & Sch. stek., 1941 :	this report*.
Pratylenchus coffeae (Zimmermann, 1898) Filipjev & Sch. Stek., 1941 :	this report*.
HETERODERIDAE	
Meloidogyne incognita (Kofoid & White, 1919) Chitwood, 1949 :	Luc & de Guiran (1960); Luc & Vilardebó (1961); Fargette (1984); this report.
CRICONEMATIDAE	
Hemicycliophora oostenbrinki Luc, 1958 :	Luc (1958); Luc & de Guiran (1960); Luc & Vilardebó (1961); this report.
Criconemella sp. :	this report*.
Paratylenchus aquaticus Merny, 1966 :	this report*.
LONGIDORIDAE	
Xiphinema attorodorum Luc, 1961 :	this report*.
Xiphinema hygrophilum Southey & Luc, 1973 :	Luc (1961); Luc & Vilardebó (1961).
Xiphinema stenocephalum Luc & Baujard, 1983 :	Luc & Baujard (1983).
Xiphinema tarjani Luc, 1975 :	Luc (1975).
Xiphinema sp. :	Luc & Vilardebó (1961).
Longidorus laevicapitatus Williams, 1958 :	this report*.

locations where the species is found; a species occurring in more than 30 % of the locations is considered as frequent;

— the abundance of a species corresponds to log N, where N is the mean number, calculated on the samples where the species is present, of the individuals present in 1 dm^3 of soil or 1 gram of root; one species which is more numerous than 300 individuals per dm^3 of soil (log 300 = 2.47) or 30 individuals per gram of root (log 30 = 1.47) is considered as abundant.

Results

Twenty-one species, belonging to seventeen genera, have been identified on banana in the Ivory Coast, including those recorded in this survey. They are listed in Table 1. Eight species from seven genera were recorded for the first time on the Poyo cultivar in the Ivory Coast. Furthermore, two of them, *Paratrophurus clavicaudatus* and *Paratylenchus aquaticus,* had been noticed on banana for the very first time in the world.

Frequency and abundance, both in soil and roots, of the different species (15 species) of our own inventory are shown in Figure 2 (A & B, respectively). Distribution and frequency of the different species in the four main regions are given in Table 2.

Three groups of species can be distinguished according to their global frequency and abundance in soil (Fig. 2, A) :

— *the nematodes of the first group* (points situated in the upper right region of the diagram) occurred very

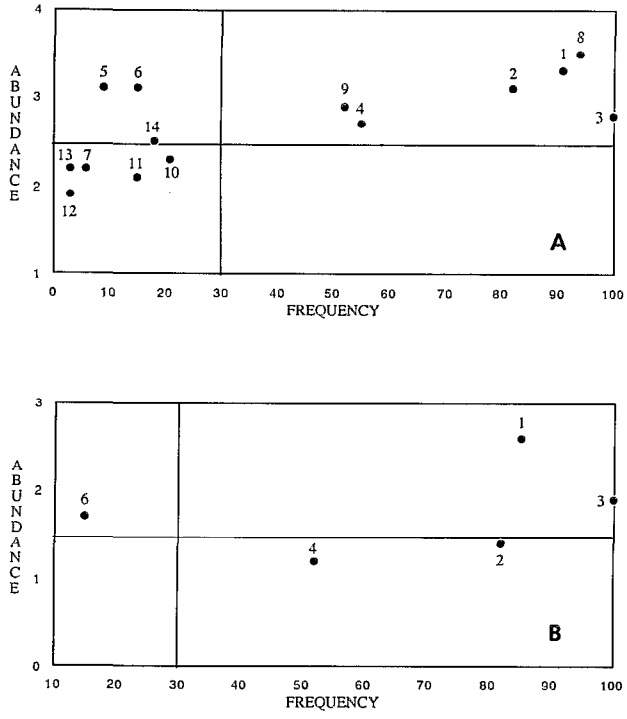

Fig. 2. Occurrence frequency and abundance index of the species found in soil (A) and in roots (B) - 1 : *Helicotylenchus multicinctus* - 2 : *Hoplolaimus pararobustus* - 3 : *Radopholus similis* - 4 : *Meloidogyne incognita* - 5 : *Rotylenchulus reniformis** - 6 : *Pratylenchus coffeae* - 7 : *Pratylenchus brachyurus* - 8 : *Cephalenchus emarginatus* - 9 : *Hemicycliophora oostenbrinki* - 10 : *Paratrophurus clavicaudatus* - 11 : *Paratylenchus aquaticus* - 12 : *Criconemella* sp. - 13 : *Ektaphelenchoides musae* - 14 : *Xiphinema attorodorum* and *Longidorus laevicapitatus***.

* *R. reniformis* was only scarcely recorded in the roots because the mistchamber technique does not collect females settled in the corm. So point 5 is not present in diagram B.

** *X. attorodorum* and *L. laevicapitatus* were not separated when counted and abundance values are confounded for both species.

often (in more than 50 % of the places examined) and were abundant. Two sub-groups can be more precisely defined :

- *Radopholus similis, Helicotylenchus multicinctus, Hoplolaimus pararobustus, Cephalenchus emarginatus,* occurring in more than 80 % of the places.
- *Meloidogyne incognita, Hemicycliophora oostenbrinki,* occurring in about one half of the places surveyed.

— *the nematodes of the second group* (points located in the upper and left side of the diagram) did not occur often but were numerous when present :

- *Pratylenchus coffeae* and *Rotylenchulus reniformis.*

— *the nematodes of the third group* (points located in the lower left side of the diagram) occurred only in a few places (less than 25 % of the places) and then were only scarcely present :

- *Pratylenchus brachyurus, Paratrophurus clavicaudatus, Xiphinema attorodorum, Longidorus laevicapitatus, Paratylenchus aquaticus, Criconemella* sp. and *Ektaphelenchoides musae.*

Endoparasites are pretty to quite numerous in the roots and so quite able to develop on banana tree (Fig. 2, B).

Discussion

R. similis and *H. multicinctus* have already been recorded in the Ivory Coast as dangerous parasites of banana trees (Luc & Vilardebó, 1961). On the contrary, *H. pararobustus* was only scarcely present before 1961 but was noted to be a potential danger for banana, due to planting material from Cameroon newly introduced without control into the Ivory Coast. Twenty-five years later, il appears that *H. pararobustus* is widespread in the whole banana planted area. It has now become one of the major nematodes, with *R. similis* and *H. multicinctus,* associated with banana in the Ivory Coast. This nematode is common in rhizosphere soil as well as in root system. A study of its pathogenicity on banana, which has not been achieved before, probably because of its very scarce occurrence in other places of the world, becomes a necessity.

P. coffeae and *R. reniformis* could become a problem for banana in the future. Presently these species are still scarcely present in banana planted areas but banana is obviously a suitable host for them as they are abundant (Fig. 2, A & B), still not yet frequent. Furthermore, these species are endoparasites and so can spread very easily and quickly with the use of contaminated planting material. Indeed *P. coffeae* is already known to occur on banana in many places such as Central America (Wehunt & Holdeman, 1960), South Africa (Jones, 1979), and *R. reniformis* in Central America (Ayala & Ramirez, 1964; Edmunds, 1971). *R. reniformis* was already and very often encountered in the Ivory Coast; on the contrary, *P. coffeae* is encountered in the Ivory Coast for the first time. It is present only in the region of Aboisso, but in every location examined in that region. As *P. coffeae* was recorded on plantains in Ghana by Addoh (1971), this nematode could have been transfered with planting material from Ghana to the neighbouring region of Aboisso-Ayamé. On the other hand, the largest banana plantation in the region of Aboisso-Ayamé was settled twenty years ago on an area which was previously cultivated with coffee-shrub. But the introduction of *P. coffeae* with planting material is unlikely as only seeds of

Table 2

Occurrence frequency in soil (S) and in roots (R) of each species encountered in each of the four main regions of the banana cultivated area.
The number of locations examined in each region is given (*); a total of 33 locations have been examined.

	I (11*)		II (13*)		III (5*)		IV (4*)	
	S	R	S	R	S	R	S	R
R. similis	11	11	13	13	5	5	4	4
H. multicinctus	11	10	10	9	5	5	4	4
H. pararobustus	8	8	13	13	2	2	4	4
C. emarginatus	11	—	12	—	4	—	4	—
M. incognita	—	—	13	12	2	2	3	3
H. oostenbrinki	4	—	8	—	5	—	—	—
P. coffeae	—	—	—	—	5	5	—	—
R. reniformis	—	—	2	1	1	1	—	—
P. clavicaudatus	—	—	7	—	2	—	1	—
P. brachyurus	1	—	1	—	—	—	—	—
P. aquaticus	2	1	3	—	—	—	—	—
Criconemella sp.	—	—	1	—	—	—	—	—
X. attorodorum	—	—	3	—	2	—	—	—
L. laevicapitatus	—	—	1	—	—	—	1	—
E. musae	—	—	1	—	—	—	—	—

coffee were introduced into the Ivory Coast (Berthaud, 1984). In any case, these two species may become important parasites in the future if no control of the planting material exchanges is achieved.

M. incognita is globaly an important parasite of banana but it is curiously absent in region I. Ecological characteristics, especially soil characters, may explain this absence and need to be considered.

Though widespread in soil around banana roots, *C. emarginatus* (an ubiquitous species) and *H. oostenbrinki* (absent in region IV) are not likely to be of major importance as these nematodes are ectoparasites and not strictly related to banana; actually, their effects on banana development are not known.

The species which belong to the third group, *P. brachyurus, P. clavicaudatus, X. attorodorum* and *L. Laevicapitatus, P. aquaticus, Criconemella* sp., even if they do not constitute a major threat to banana culture in the Ivory Coast, are, however, important to notice for they are all, except *E. musae* recorded for the first time on the cv. Poyo in the Ivory Coast. Two of them, *P. clavicaudatus* and *P. aquaticus,* are recorded for the first time in the world associated with banana. Banana has been expanding for the last twenty years and settled on various soils previously occupied, most of the time, by forest, with concomitant various nematofauna. Indeed, these species are the most frequently encountered in the region of Azaguié which shows a particularly diverse nematofauna (fourteen species). It is of interest to note that some plantations in this region are rather new banana cultivated areas and that, every year, banana is introduced on newly cleared forest land. The primary wild nematofauna of the forest biotope, rich in different species, has probably not yet been submitted to selection pressure by the banana culture and parasitic nematodes adapted to the banana monoculture have not yet settled. In the same way, *P. brachyurus* was found in two areas previously cultivated with pineapple on which this nematode is known to be the major pathogen in the Ivory Coast (Guérout, 1975). It can be considered as a trace nematode of this previous culture. On the contrary, region I (seven species recorded) is a very old banana planted area (50 years old), where the nematofauna has been confronted to banana monoculture for a long time. Indeed, most of the few species recorded in region I, except for *H. pararobustus,* are those known to be typical of banana culture everywhere in tropical countries (Luc & Vilardebo, 1961; Blake, 1972; Wehunt & Edwards, 1968; Ambrose, 1984; Mac Sorley & Parrado, 1986). Their high population level in soil (and roots for most of them) likely reflect an equilibrium between host plant, biotope and nematodes. This selection phenomenon may explain the absence of some species both frequent and abundant elsewhere. In time populations of nematodes which are not strictly adapted to banana (not abundant) may decline and even disappear, explaining then the low frequency of such species. Similar evolution of nematofauna under monoculture has already been observed.

REFERENCES

ADDOH, P. G. (1971). The distribution and economic importance of plant parasitic nematodes in Ghana. *Ghana J. agric. Sci.*, 4 : 21-32.

AMBROSE, E. (1984). Research and development in banana crop protection (excluding Sigatoka) in the English Speaking Caribean. *Fruits*, 39 : 234-247.

AYALA, A. & RAMIREZ, C. T. (1964). Host-range, distribution and bibliography of the reniform nematode, *Rotylenchulus reniformis*, with special reference to Puerto Rico. *J. Agric. Univ. P. Rico*, 48 : 140-161.

BERTHAUD, J. (1984). *Les ressources génétiques pour l'amélioration des caféiers africains diploïdes.* Thèse Doct. Sci., Univ. Paris XI, 363 p.

BAUJARD, P. (1984). Remarques sur la sous-famille des Ektaphelenchinae Paramonov, 1964 et proposition *d'Ektaphelenchoides* n. gen. (Nematoda : Aphelenchoididae). *Revue Nématol.*, 7 : 147-171.

BLAKE, C. D. (1972). Nematode diseases of banana plantations. In : Webster, J. M. (Ed.), *Economic Nematology.* London, UK, Academic Press : 245-267.

EDMUNDS, J. E., 1971. Association of *Rotylenchulus reniformis* with " Robusta " banana and *Commelina* sp. roots in the Windward Islands. *Trop. Agric., Trinidad*, 48 : 55-61.

FARGETTE, M. (1984). *Utilisation de l'électrophorèse dans l'étude de la systématique de deux organismes d'intérêt agricole :* Trichogramma *supersp.* evanescens *(Hymenoptera, Chalcidoidea)* et Meloidogyne *spp. (Nematoda, Tylenchida).* Thèse Dr. Ing., Ecole natn. sup. agron. Montpellier, 189 p.

FORTUNER, R. & MERNY, G. (1973). Les nématodes parasites des racines associés au riz en Basse Casamance (Sénégal) et en Gambie. *Cah. ORSTOM, sér. Biol.*, 21 : 3-20.

GOODEY, J. B. (1962). *Tylenchus (Cephalenchus) megacephalus* n. sgn., n. sp. *Nematologica*, 7 : 331-333.

GUÉROUT, R. (1975). Nematodes of pineapple : a review. *Pest Articles & News Summ.*, 21 : 123-140.

JONES, R. K. (1979). Nematodes associated with bananas in South Africa. *Phytophylactica*, 11 : 79-81.

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LUC, M. (1958). Trois nouvelles espèces du genre *Hemicycliophora* de Man, 1921 (Nematoda, Criconematidae). *Nematologica*, 3 : 15-23.

LUC, M. (1961). *Xiphinema* de l'Ouest africain (Nematoda, Dorylaimidea). Deuxième note. *Nematologica*, 6 : 107-122.

LUC, M. (1975). Trois nouvelles espèces de *Xiphinema* Cobb, 1913 à queue arrondie-mucronée (Nematoda : Longidoridae). *Cah. ORSTOM, sér. Biol.*, 10 : 293-302.

LUC, M. & BAUJARD, P. (1983). *Xiphinema stenocephalum* n. sp. (Nematoda, Longidoridae). *Bull. Mus. natn. Hist. nat.*, Paris, 4e sér., 5, section A, n° 2 : 515-519.

LUC, M. & DE GUIRAN, G. (1960). Les nématodes associés aux plantes de l'Ouest africain. *Agron. trop., Nogent*, 15 : 434-449.

LUC, M. & VILARDEBÓ, A. (1961). Les nématodes associés aux bananiers cultivés dans l'Ouest africain. *Fruits*, 16 : 205-279.

MACSORLEY, R. & PARRADO, J. L. (1986). Nematological review : *Helicotylenchus multicinctus* on bananas : an international problem. *Nematropica*, 16 : 73-91.

QUÉNÉHERVÉ, P. & CADET, P. (1986). Une nouvelle technique d'échantillonnage pour l'étude des nématodes endoparasites du bananier. *Revue Nématol.*, 9 : 95-97.

SEINHORST, J. W. (1950). De Betekenis van de toestand van de grond voor het optreden van aantasting door het stengelaaltje *(Ditylenchus dipsaci* [Kühn] Filipjev). *Tijdschr. Pl. Ziekt*, 56 : 291-349.

SEINHORST, J. W. (1962). Modification of the elutriation method for extracting nematodes from soil. *Nematologica*, 8 : 117-128.

VILARDEBÓ, A. (1984). Problèmes scientifiques posés par *Radopholus similis* et *Cosmopolites sordidus* en cultures bananières des zones francophones de production. *Fruits*, 39 : 227-233.

WEHUNT, E. J. & EDWARDS, D. I. (1968). *Radopholus similis* and other nematode species on banana. In : Smart, Jr., G. C. & Perry, V. G. (Eds). *Tropical nematology.* Gainesville, Univ. Florida Press : 1-19.

WEHUNT, E. J. & HOLDEMAN, Q. L. (1960). Nematode problems on the banana plant. *Proc. Soil & Crop Sci. Soc. Florida*, 19th an. Meet., 1959 : 436-442.