Population of nematodes in soils under banana, cv. Poyo, in the Ivory Coast. 4. Seasonal dynamics of populations in organic soil

Patrick QUÉNÉHERVÉ

Laboratoire de Nématologie, Centre ORSTOM, B.P. V 51, Abidjan, Côte-d'Ivoire.

SUMMARY

The dynamics of nematode populations of bananas have been monitored during two vegetatives cycles on two sites located on " organic soil " (clay soil and peat soil) in the banana producing area of the Ivory Coast. On this soil type the main endoparasitic nematode which occurred at a high level in the soil and in the roots is the spiral nematode, *Helicotylenchus multicinctus.* In these optimal conditions of soil type for *H. multicinctus,* the rainfall in respect to soil moisture appears as the only factor involved in the dynamics of *H. multicinctus;* whereas for *Radopholus similis,* the competition with the other nematodes species seems the most important factor involved in its dynamic beside the other factors observed on mineral soil such as the renovation of the root system and the rainfall.

RÉSUMÉ

Populations de nématodes associés à la culture du bananier cv. Poyo en Côte-d'Ivoire. 4. Dynamiques de populations saisonnières sur sols organiques

Les dynamiques de populations de nématodes associés au bananier ont été suivies sur deux sites en sols organiques (sol argileux et sol tourbeux) de culture bananière en Côte-d'Ivoire. Sur ce type de sol, le principal nematode endoparasite présent en très grand nombre aussi bien dans le sol que les racines est *Helicotylenchus multicinctus.* Dans ces conditions optimales de sol pour *H. multicinctus,* la pluviosité, en relation avec la teneur en eau du sol, apparaît comme le seul facteur agissant sur les dynamiques de population. Par contre, la compétition avec les autres espèces de nématodes semble être le facteur dominant dans la dynamique de population de *Radopholus similis,* avant les autres facteurs observés sur sol minéral comme la nature du système racinaire et la pluviosité.

Important results on the seasonal fluctuation of nematode populations on bananas were obtained on mineral soil in the Ivory Coast, with a diverse range of behaviours for each nematode species encountered (Quénéhervé, 1988). This previous study has also confirmed that the root infestation by *R. similis* is first in relation with the successive root emergence on each sucker, making the burrowing nematode the primary root invader. On the other hand, *R. similis* populations build up during the dry season and decrease with increasing rainfall whereas *H. multicinctus, H. pararobustus* and *C. emarginatus* show the reverse trend.

As outlined by Fargette and Quénéhervé (1988), in the Ivory Coast, bananas are grown on different soil type, but there is a very peculiar region, the lagoon valley of Nieky and its surroundings (2 850 ha) where soils are classified as " organic soil " for their very high organic matter content (Stover & Simmonds, 1987). In this region, formerly a primary forest, soil type ranged from pure clay soil to pure peaty soil, without any mineral particles, in the layer of soil explored by the banana root system.

As described for mineral soil type, the objective of this study was to obtain a better evaluation of the seasonal fluctuation of nematode populations on bananas by using a new sampling method which gives a more accurate quantitative relationship between the nematode population and the different parts of the root system than a blind random sampling of roots. This study was conducted in order to optimize the pest management strategy, taking into account the type of soil, the structure of the nematode communities encountered, the physiological stage of the plant, and the climatic season.

Material and methods

Commercial irrigated banana plantations were located on two sites in the lagoon valley of Nieky, one in " Agbo " plantations on a pure clay soil (site 1), and the other in " Yace " plantations on a pure peaty soil (site 2). Chemical and granulometric characteristics of the two soils are given in Table 1. The trials were monitored during two vegetative cycles. Bananas, cv. Poyo, were planted with bullheads in April 25th, 1981 on site 1 and in April 7th, 1982 on site 2. Fluctuations of nematode populations were followed monthly (sampling every 28-32 days) in untreated plots. Roots and corms of

Table 1

Granulometric and chemical characteristics of soil of the two sites studied

	Site 1 (Agbo)	*Site 2 (Yace)*
% Clay 0-2 μm	61.2	0
% Silt 2-20 μm	20.3	0
% Silt 20-50 μm	0.2	0
% Sand 50-200 μm	0.2	0
% Sand 200-2 000μm	0.2	0
% H_2O	3.0	*
% Org. Matter	14.2	*
pH H_2O	4.0	3.4
pH KCl	3.0	*
‰ C	109.5	397.3
‰ C	5.5	15.5
C/N	20.1	25.6

(*) Missing data.

banana rhizomes were sampled and analysed according to the method described by Quénéhervé and Cadet (1986) with six replicates per sampling date. Standardized extraction techniques were used for soil (Seinhorst, 1962) and roots (Seinhorst, 1950).

Results of infestation are expressed as nematode densities per dm³ of soil and per gram of root or corm, belonging to the mother plant or bullhead (RPM, EPM), of the first principal sucker (R1Y, E1Y), of the second principal sucker (R2Y, E2Y), of the pruned suckers (R2YO, E2YO), etc. In order to have the level of infestation corresponding to the whole plant for each sampling, a « global root infestation » was calculated as a mean of the partial infestations on the different parts of the root system.

Rainfall records were collected daily on each site. A canopy level irrigation occurred in the dry season (about 24 mm per irrigation and per week). Three months after planting, the number of days of rainfall and the total rainfall (irrigation included) in a two, three, four, five, six-week period ending zero, one or two weeks before the monthly sampling dates were correlated with the nematode densities occuring in the soil and for the global root infestation for each species encountered. Correlations were calculated respectively on eighteen and nineteen sampling dates for sites 1 and 2.

Results

Seasonal fluctuation of nematodes on site 1 (Agbo)

On site 1 (pure clay soil) four main nematode species were found associated with bananas : three endoparasitic species, *Helicotylenchus multicinctus* (Cobb, 1893) Golden, 1956, *Radopholus similis* (Cobb, 1893) Thorne, 1949 and *Hoplolaimus pararobustus* (Sch. Stek. & Teun., 1938) Sher, 1963; one ectoparasitic species : *Cephalenchus emarginatus* (Cobb, 1893) Geraert, 1968.

H. pararobustus was encountered very sporadically in soil and root samples, so for the sake of clarity the dynamics are not illustrated in the figures.

Monthly amount of irrigation in dry seasons are illustrated on the same figure as the rainfall records.

Helicotylenchus multicinctus

H. multicinctus was the main endoparasitic nematode to occur on site 1 and fluctuation in numbers of nematodes from soil showed two different parts; the first vegetative cycle with a soil infestation below 5 000 nematodes per dm³ of soil, and the second vegetative cycle with a soil infestation which had built up to 61 600 in Aug. 82. In these conditions several major peaks were observed, coinciding for some of them with heavy rainfall periods (Fig. 1, A & B).

In the roots (Fig. 2, A-D), high levels of infestation by the spiral nematode occurred very rapidly either from pruned or unpruned suckers. For example, in the roots of the first sucker (Fig. 2, B), fluctuations showed two peaks (Nov. 81 and Apr. 82) which coincided with heavy rainfall periods. One can observe that the peaks of infestation by the spiral nematode occurred at the same period for the first vegetative cycle whatever the sucker, but infestation seemed more erratic for the second vegetative cycle.

The global root infestation reflecting the level of infestation of the whole root system of the banana plant (Fig. 1, D), showed four peaks, two in rainy seasons (Oct. 81 and Apr. 82) and two in dry season (Aug. 82 and Dec. 82).

One can observe (Fig. 3, A-D) that *H. multicinctus* have colonized the cortical part of the corm after infestation by *R. similis* whatever the suckers. *R. similis* and *H. multicinctus* were the only species constantly found in the corms. As the infestation level of *H. multicinctus* in the corm was increasing, simultaneous infestation by *R. similis* decreased.

There was no correlation between root infestation by *H. multicinctus* and soil population or the number of days of rainfall or total rainfall.

Radopholus similis

The population of *R. similis* in the soil (Fig. 1, C) remained at a very low level, below 800 nematodes per dm³ of soil during the two vegetative cycles. The fluctuations did not show any noticeable peak.

In the roots (Fig. 2, A-D), infestation reached small peaks just after the emergence of roots on unpruned and pruned suckers. The global root infestation by *R. similis* (Fig. 1, D) show clearly three small peaks of infestation occurring in dry seasons (Dec. 81, Aug. and Dec. 82), which also coincided with the flowering of the main sucker.

If the infestation of the roots by *R. similis* remained very low by comparison with that which occurred with *H. multicinctus*, it is important to note the high level of infestation of the cortical part of the corm by *R. similis* rapidly after the sucker emergence, with increasing levels on each successive sucker whatever the season, till 395 nematodes per gram of corm in the sucker of third generation (Fig. 3, A-D). There was no correlation between root infestation by *R. similis* and soil population or the number of days of rainfall or total rainfall.

Cephalenchus emarginatus

Soil infestation by *C. emarginatus* showed only one noticeable peak in Jul. 82 (Fig. 1, C). There were significant positive correlations found between population level of *C. emarginatus* and *i)* the total rainfall in a three week period before sampling ($P = 0.001$; $r = 0.711$), and *ii)* the number of days of rainfall in a four week period before sampling ($p = 0.001$; $r = 0.719$).

SEASONAL FLUCTUATION OF NEMATODE ON SITE 2 (YACE)

On site 2 (pure peaty soil) the same four nematode species were found associated with bananas as on site 1 : three endoparasitic species *(H. multicinctus, R. similis, H. pararobustus)* and one ectoparasitic species *(C. emarginatus).*

Helicotylenchus multicinctus

Fluctuations in number of *H. multicinctus* from soil showed several peaks and seemed very erratic (Fig. 4, C).

The infestation of the roots occurred very early, as soon as the root emergence (Fig. 5, A-D). This infestation was very important in number, with an average of 350 nematodes per gram of roots on the main sucker. The root infestation level was the same in all suckers, except on the third pruned sucker which exhibited a higher peak of infestation in Jun. and Jul. 83 than the unpruned sucker.

The global root infestation (Fig. 4, D), showed that *H. multicinctus* was the main endoparasitic nematode with an average of 300 nematodes per gramme of roots and that several peaks were coinciding with the rainy seasons.

There was no correlation between soil population and root infestation. There was a significant positive correlation between population levels of *H. multicinctus* in the soil and the number of days of rainfall in the three weeks before sampling ($p = 0.002$; $r = 0.425$) and no significant correlation between population levels of *H. multicinctus* in the roots and the number of days of rainfall or total rainfall.

Radopholus similis

The population of *R. similis* in the soil (Fig. 4, C) remained at a very low level during the two vegetative cycles in comparison with *H. multicinctus.* The fluctuation in the soil showed only two small peaks, in Jan. and Sept. 83.

In the roots (Fig. 5, A-D), the infestation by the burrowing nematode reached small peaks just after the emergence of roots on unpruned and pruned suckers, except for the first sucker where the peak of infestation was delayed for four months occurring in Aug. 82.

The global root infestation (Fig.4, D) showed a decreasing level of infestation by *R. similis* from the first to the second vegetative cycle; the two peaks of infestation were occuring in relative dry seasons (Aug. 82 and Jan. 83) during the first vegetative cycle.

There was no correlation between root infestation by *R. similis* and soil population or the number of days of rainfall or total rainfall.

Hoplolaimus pararobustus

H. pararobustus was scarcely present in the soil during the first vegetative cycle, and more frequently for the second vegetative cycle, but infestation level remained very low by comparison with the other species encountered, except *R. similis* (Fig. 4, C).

In the roots (Fig. 5, A-D), an average of only ten nematodes per gram was observed in all suckers, pruned or unpruned. The global root infestation did not show any noticeable peak.

There was no correlation between root infestation by *H. pararobustus* and soil population or the number of days of rainfall or total rainfall.

Cephalenchus emarginatus

Soil infestation by *C. emarginatus* was very important (an average of 3 000 nematodes per dm^3 of soil) and seemed very erratic with successive peaks (Fig. 4, C).

There was no correlation between population levels of *C. emarginatus* in the soil and the number of days of rainfall or total rainfall.

Discussion

The climate in the south of the Ivory Coast where bananas are grown is defined as humid tropical with two rainy seasons and the industrial plantations of bananas need additional supplies of water in the dry season by irrigation (most of them are made by canqpy level irrigation).

Without taking again the discussion on the biology of the different nematodes species previously outlined, it is necessary to summarize the results obtained on mineral soil (Quénéhervé, 1989) to compare them to those observed on organic soil.

Radopholus similis

Dynamics of *R. similis* observed on mineral soil have shown that the burrowing nematode is the primary root

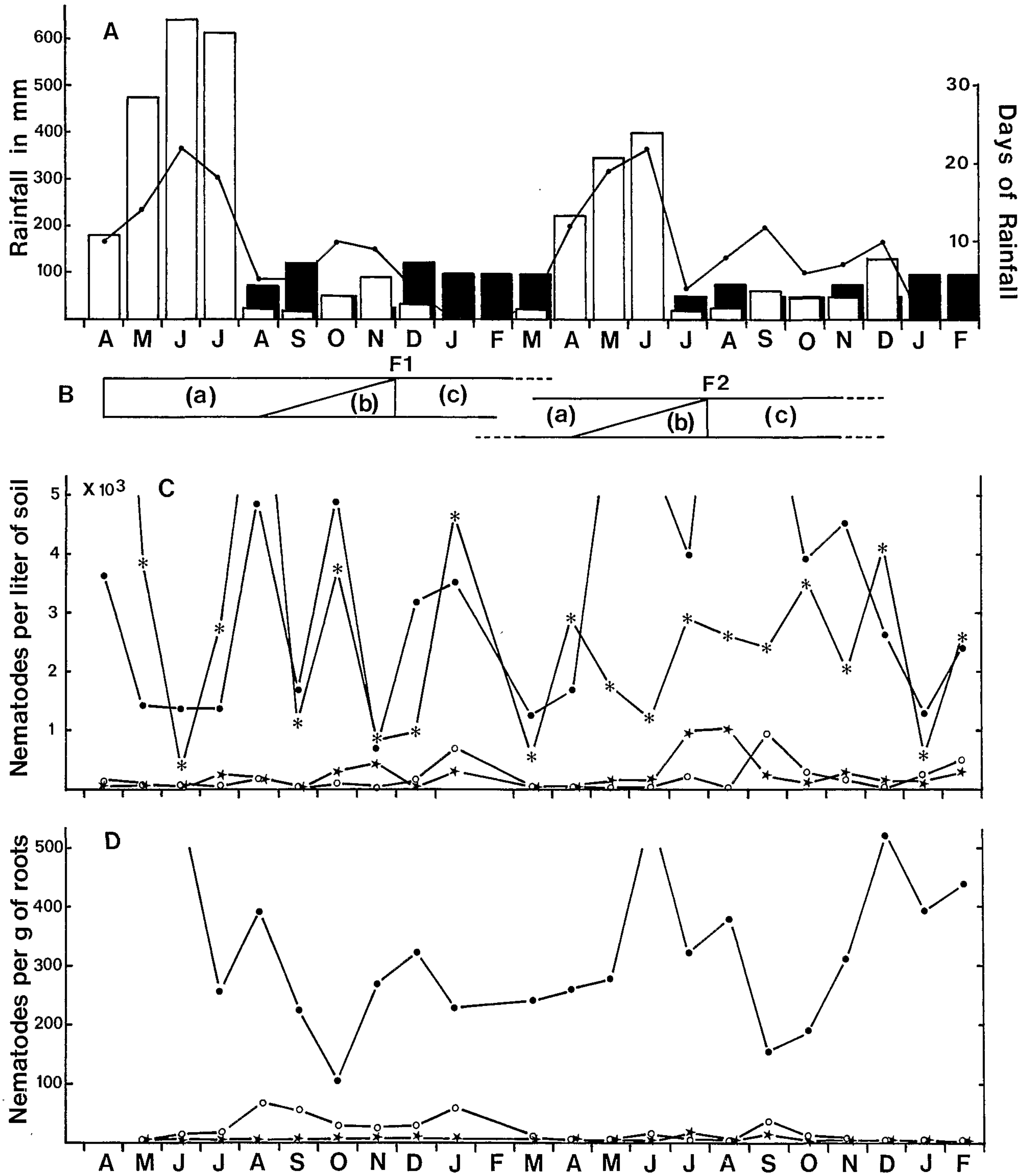

Fig. 1. Nematode population dynamics on site 1 (Agbo). A : Rainfall and irrigation (white bar : monthly rainfall; black bar : monthly irrigation; black circles and plain line : number of days of rainfall per month). B : Schematic representation of physiological stages of banana plant : (a) vegetative phase; (b) fruiting phase; (c) ripening phase; F 1, shot fruit of the plant crop; F 2, shot fruit of the first ratoon. C : Seasonal fluctuation in the soil. D : Seasonal fluctuation of the global root infestation [o : *Radopholus similis;* ● : *Helicotylenchus multicinctus;* * : *Cephalenchus emarginatus;* ★ : *Hoplolaimus pararobutus*].

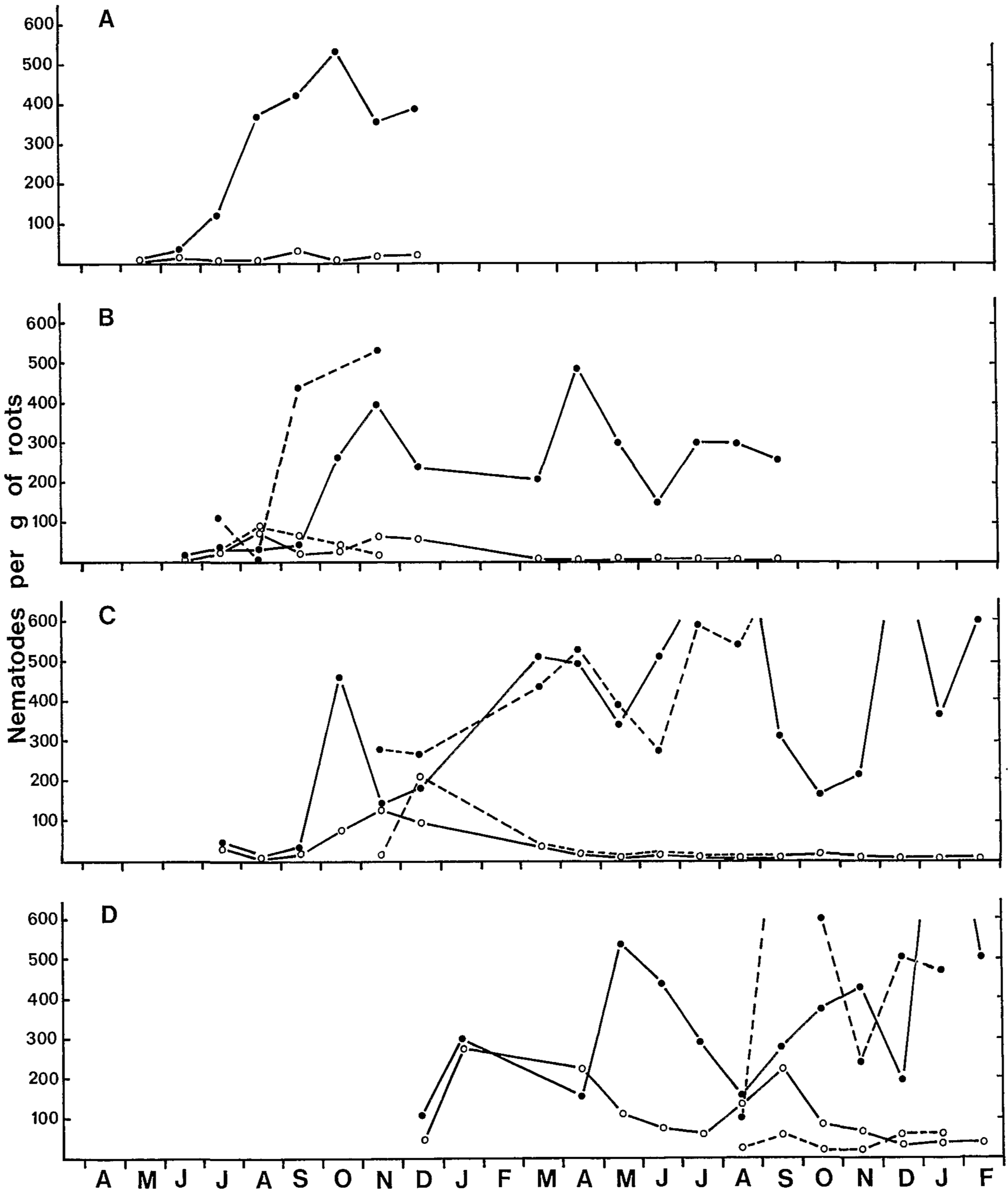

Fig. 2. Nematode population dynamics in the roots on site 1 (Agbo). A : Seasonal fluctuation in the roots of the mother plant. B : Seasonal fluctuation in the roots of the first suckers. C : Seasonal fluctuation in the roots of the second suckers (first ratoon). D : Seasonal fluctuation in the roots of the third suckers (second ratoon) [○ : *Radopholus similis;* ● : *Helicotylenchus multicinctus;* plain lines : main suckers; dotted lines : pruned suckers].

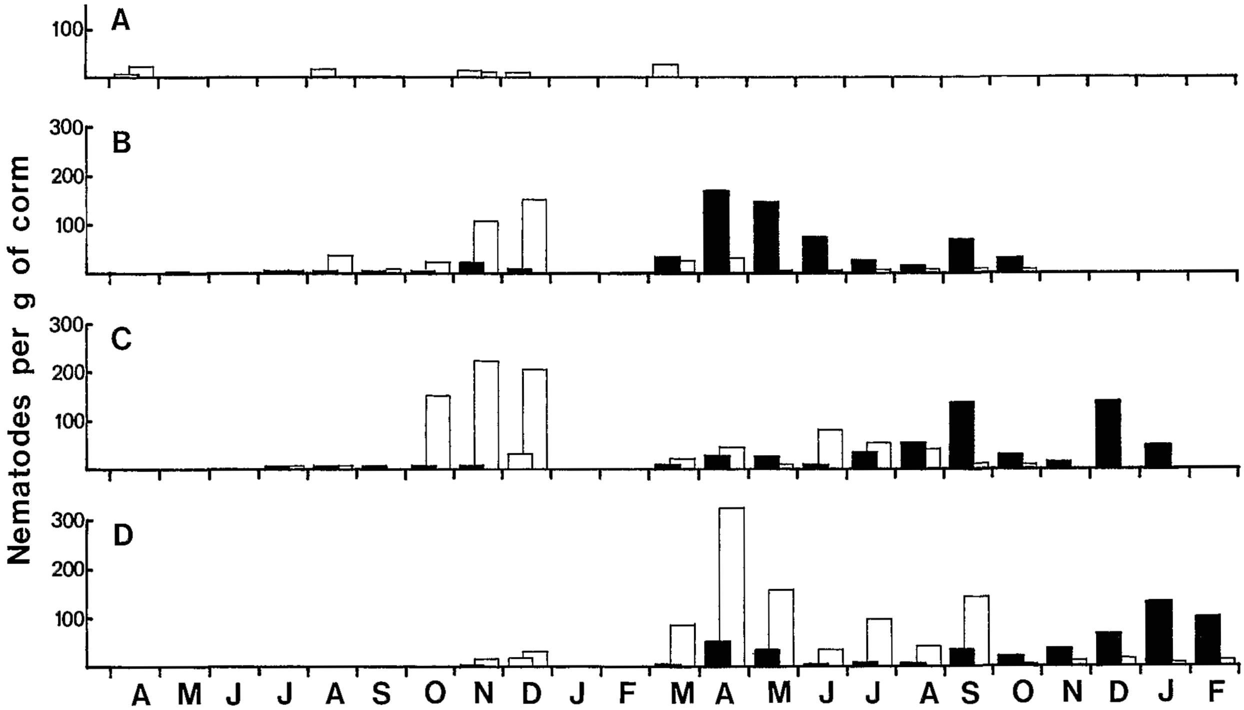

Fig. 3. Nematode population dynamics in the corm on site 1 (Agbo). A : Seasonal fluctuation in the corm of the mother plant. B : Seasonal fluctuation in the corm of the first suckers. C : Seasonal fluctuation in the corm on the second suckers (first ratoon). D : Seasonal fluctuation in the corm of the third suckers (second ratoon) [white bar : *Radopholus similis;* black bar : *Helicotylenchus multicinctus*].

invader : *i)* more closely related to the successive root emergence on each sucker than to the physiological stage of banana tree; *ii)* with respect to the healthy tissue, and *iii)* with respect to the soil moisture. On this type of soil, it is always the first parasite of the new roots and levels of infestation decrease as the root system ages or decays and when there is increasing rainfall.

In this study on organic soil, infestation levels of *R. similis* are always lower than those of the other nematodes encountered and the only peaks of infestation in the soil and in the roots occurred in the dry seasons. In the superficial part of the corm, the level of infestation by *R. similis* is very important and increases on each successive sucker.

In this type of soil the pressure of the other nematode species is so high, the complex of parasites speeds up superficial root decay, which restricts the avalaibility of healthy tissue to the over-particular parasite such as *R. similis.* In fact, the corm appears to be a location where the population of *R. similis* finds a refuge as a mean of survival in bad environmental conditions of competition and soil moisture.

As outlined in the previous study (Quénéhervé, 1988), the literature deals with information on the relationships between population of *R. similis* and the physiological stage of the banana plant or climatic factors as temperature and rainfall (Jiménez, 1972; Melin & Vilardebó, 1973; Jaramillo & Figueroa, 1974; Shafiee & Mendez, 1975; McSorley & Parrado, 1981; Hugon, Ganry & Berthe, 1984; Hunt, in Ambrose, 1984). In this study we have not found correlation between root infestation by *R. similis* and soil population or the number of days of rainfall or total rainfall.

In conclusion, on organic soil, the competition with the other nematode species appears to be the most important factor involved in the dynamics of *R. similis.*

Helicotylenchus multicinctus

Dynamics of *H. multicinctus* observed on mineral soil have shown that the root infestation generally took place after infestation by *R. similis* whatever the suckers and showed maximum population in the rainy season.

It is obvious that on organic soil the dynamics are very different. The main difference being the number of *H. multicinctus* expressed as percentage of the global population of plant parasitic nematodes. In the soil and in the roots the spiral nematode occurs for respectively 82.9 et 87.6 % on site 1 and for 53.1 and 92.1 % on site 2 during the time of the experiment (Quénéhervé, 1989). The population level in the soil (specially on clay soil) is so high that all the roots are infested very early after their emergence either from pruned or unpruned suckers and more in the rainy season.

If the literature deals with information on the relationship between densities of *H. multicinctus* and rainfall (Hutton, 1978; McSorley & Parrado, 1981; Badra & Caveness, 1982; Hunt, in Ambrose, 1984), the conflicting results depend of the local condition of soil type and rainfall (McSorley & Parrado, 1986). In this study we have only found on site 2 a significant positive correlation between population levels of *H. multicinctus* in the soil and the number of days of rainfall in the three weeks before sampling. In the Ivory Coast, the soil type seems to be one of the most important environmental factors related to the frequency and the abundance of *H. multicinctus.*

In conclusion, fluctuations of *H. multicinctus* are a result of various factors, but in optimal conditions of soil type, like on clay soil with a high organic matter content, the soil moisture appears the only factor involved in the dynamics of *H. multicinctus.*

Hoplolaimus pararobustus

H. pararobustus was observed for the first time in 1956 on banana in the Ivory Coast (Luc & Vilardebó, 1961). Though it occurs in high densities mainly on sandy soil (Fargette & Quénéhervé, 1987; Quénéhervé, 1987), *H. pararobustus* is now widespread in the banana growing areas.

In organic soil, soil and root infestations are always very low and we can assume that in these soils, conditions are not optimal for the development of high population, but allow a kind of survival of *H. pararobustus.* In fact the whole area where these trials have been conducted were sometimes accidentally flooded and the plantations completely destroyed (the last in 1976 during a very rainy season). In order to replant, the planting material (bullheads, sword suckers) was collected from other plantations, located on mineral soil (Azaguié), where *H. pararobustus* occurred more consistenly and was disseminated with this planting material from this area.

Cephalenchus emarginatus

It was the only ectoparasitic species constantly observed in every sample like on mineral soil. The densities in the soil were very important on both sites. There is no information on the host-parasite relationship of *C. emarginatus* and banana in the literature. In this study on organic soil, seasonal fluctuations of *C. emarginatus* showed several peaks generally coinciding with period of heavy rainfall. In fact there is a significant positive correlation between population densities in the soil and the rainfall in the previous weeks before sampling.

Conclusion

This study on the seasonal dynamics of populations on bananas growing on organic soil in Ivory Coast has shown that root infestations are closely related to the soil infestation levels by nematodes. In this area with very high soil infestation of *H. multicinctus,* the new roots which are free of nematode when they emerge from the rhizome (Quénéhervé & Cadet, 1986), are highly infested by *H. multicinctus* as soon as they grow through the soil. Maybe for the over-particular host parasite relationship of *R. similis* with the healthy tissue previously discussed (Quénéhervé, 1989), and in respect to the soil moisture in these particular edaphic conditions, the dynamics of *R. similis* are very restricted and the main part of the endoparasitic populations are located in the cortical part of the corm, as if waiting more favourable environmental conditions to build up its population.

On this soil type, population of both *H. multicinctus* and *C. emarginatus* build up during the rainy season, whereas *R. similis* shows the reverse trend.

Like for the previous study these results on the nematode population dynamics and the related interdependent factors should increase basic nematological knowledge to have an overall view on the nematological problem on bananas in order : *i)* to determine the optimal time to control nematode populations or *ii)* to find any correlation between the population levels of nematodes in soil as well as in the roots with environmental and edaphic factors.

Indeed with respect to environmental and edaphic factors, to the structure of the nematode community, to the cultivar used, to the dynamics of population, the damage function (Oostenbrink, 1966) should be investigated to determine local economic threshold levels (Ferris, 1978, 1980) and to assess the nematode control on bananas in the Ivory Coast for a global pest management strategy.

ACKNOWLEDGEMENTS

The author thanks COFRUITEL (Ivory Coast) for its support of this investigation and gratefully acknowledges the grower M. H. Manuelle, for his technical assistance in the field trials. The author is also indebted to Dr. P. Cadet, and MM. T. Mateille, A. Adiko, P. Topart and all the technical staff of the Laboratory of Nematology, ORSTOM, Ivory Coast, for their helpful advices and technical assistance.

REFERENCES

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

BADRA, T. & CAVENESS, F. E. (1983). Effects of dosage sequence on the efficacy of nonfumigant nematicides on plantain yields, and nematode seasonal fluctuations as influenced by rainfall. *J. Nematol.,* 15 : 496-502.

FARGETTE, M. & QUÉNÉHERVÉ, P. (1988). Populations of nematodes in soils under banana, cv. Poyo, in the Ivory Coast. 1. The nematofauna occuring in the banana producing areas. *Revue Nématol.,* 11 : 239-244.

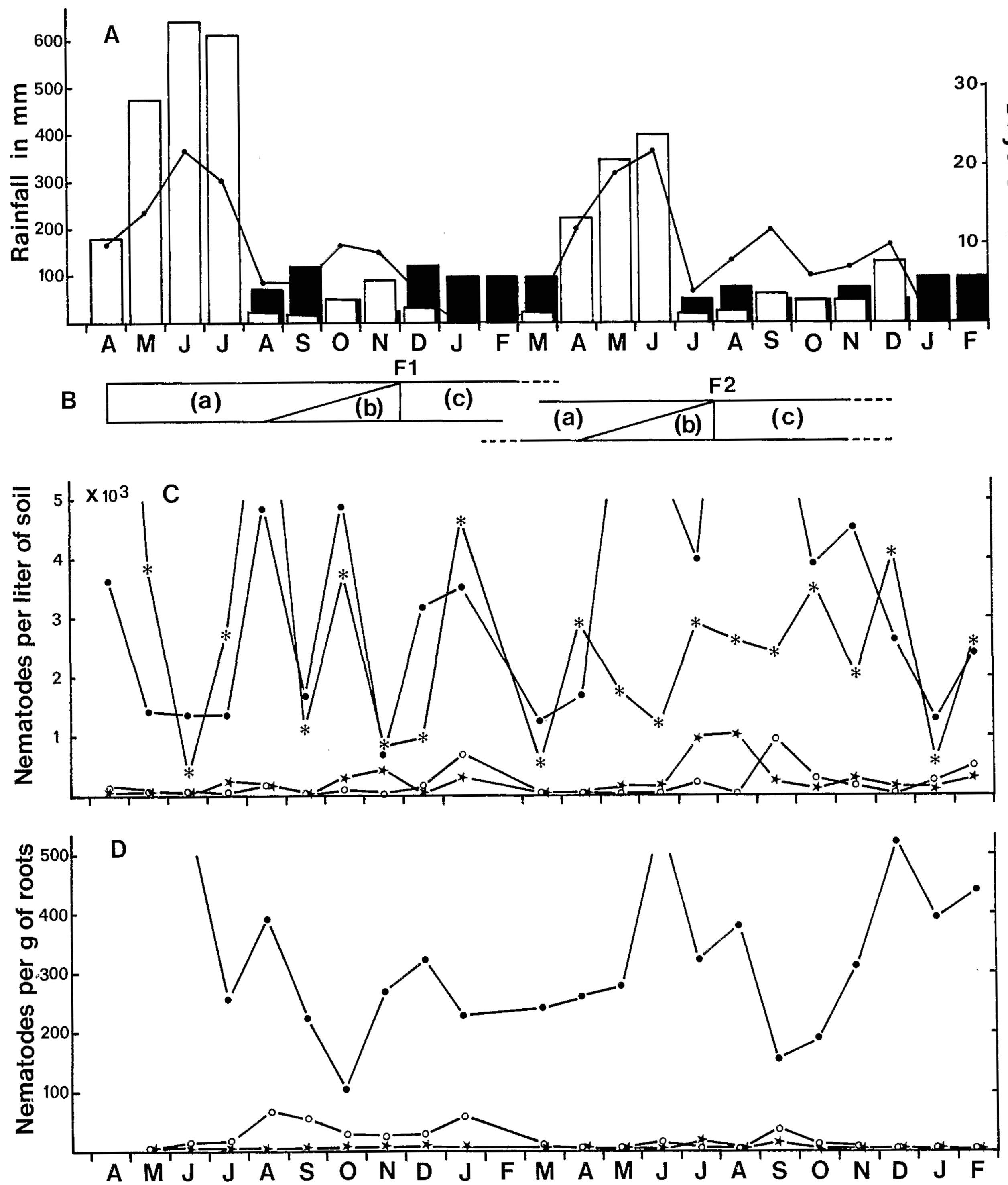

Fig. 4. Nematode population dynamics on site 2 (Yace). A : Rainfall and irrigation (white bar : monthly rainfall; black bar : monthly irrigation; black circles and plain line : number of days of rainfall per month). B : Schematic representation of physiological stages of banana plant : (a) vegetative phase; (b) fruiting phase; (c) ripening phase; F 1, shot fruit of the plant crop; F 2, shot fruit of the first ratoon. C : Seasonal fluctuation in the soil. D : Seasonal fluctuation of the global root infestation [o : *Radopholus similis;* ● : *Helicotylenchus multicinctus;* ★ : *Hoplolaimus pararobustus;* * : *Cephalenchus emarginatus*].

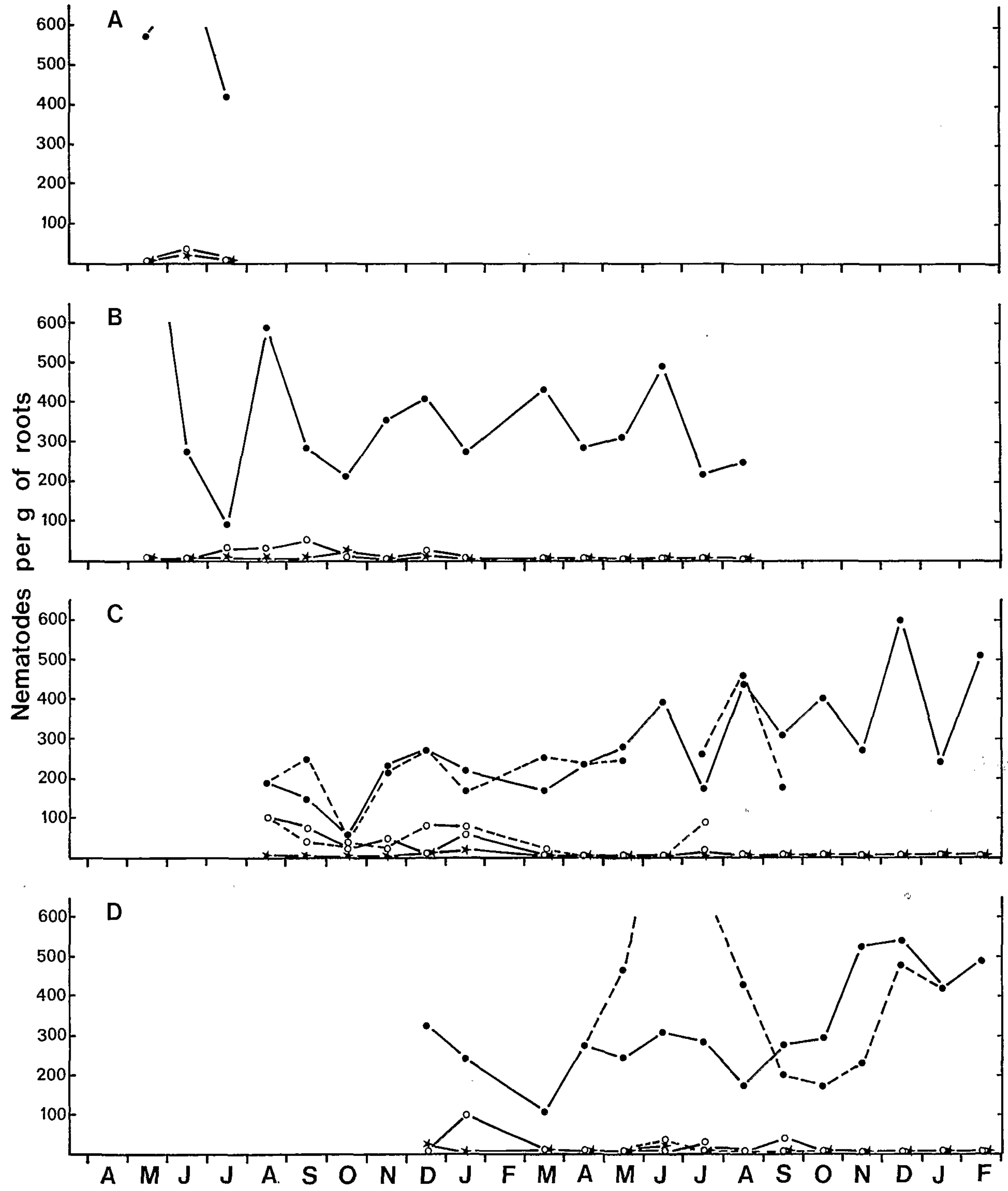

Fig. 5. Nematode population dynamics in the roots on site 2 (Yace). A : Seasonal fluctuation in the roots of the mother plant. B : Seasonal fluctuation in the roots of the first suckers. C : Seasonal fluctuation in the roots of the second suckers (first ratoon). D : Seasonal fluctuation in the roots of the third suckers (second ratoon) [o : *Radopholus similis;* ● : *Helicotylenchus multicinctus;* ★ : *Hoplolaimus pararobustus;* plain lines : main suckers; dotted lines : pruned suckers].

FERRIS, H. (1978). Nematode economic tresholds : derivation, requirements and theoretical considerations. *J. Nematol.*, 10 : 341-350.

FERRIS, H. (1980). Nematology-status and prospects : Practical implementation of quantitative approaches to nematology. *J. Nematol.*, 12 : 164-170.

HUGON, R., GANRY, J. & BERTHE, G. (1984). Dynamique de population du nématode *Radopholus similis* en fonction du stade de développement du bananier et le climat. *Fruits*, 39 : 251-253.

HUTTON, D. G. (1978). Influence of rainfall on some plantain nematodes in Jamaica. *Nematropica*, 8 : 34-39.

JARAMILLO, R. & FIGUEROA, A. (1974). Analisis armònico de la densidad de poblaciòn de *Radopholus similis* (Cobb) Thorne en la zona bananeira de Guàpiles, Costa Rica. *Turrialba*, 24 : 402-407.

JIMENEZ, M. F. (1972). Fluctuaciones anuales de la poblacion de *Radopholus similis* en la zona bananera de Potoci, Costa Rica. *Nematropica*, 2 : 33-40.

LUC, M. & VILARDEBÒ, A. (1961). Les nématodes associés aux bananiers cultivés dans l'Ouest Africain. *Fruits*, 16 : 205-219.

MCSORLEY, R. & PARRADO, J. L. (1981). Population fluctuations of plant-parasitic nematodes on bananas in Florida. *Proc. Fl. State hort. Soc.*, 94 : 321-323.

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

MELIN, P. & VILARDEBÒ, A. (1973). Efficacité de quelques nématicides en bananeraie dans les sols volcaniques de la région du Mungo (Cameroun). *Fruits*, 28 : 3-17.

Accepté pour publication le 16 mai 1988.

OOSTENBRINK, M. (1966). Major characteristics of the relation between nematodes and plants. *Meded. Landbouwhogesch. Wageningen*, 66 : 1-46.

QUÉNÉHERVÉ, P. (1988). Populations of nematodes in soils under banana, cv. Poyo, in the Ivory Coast. 2. Influence of soil texture, pH and organic matter on nematode populations. *Revue Nématol.*, 11 : 245-251.

QUÉNÉHERVÉ, P. (1989). Populations of nematodes in soils under banana, cv. Poyo, in the Ivory Coast. 3. Seasonal dynamics of populations on mineral soil. *Revue Nématol.*, 12 : 149-160.

QUÉNÉHERVÉ, P., CADET, P. (1985). Étude de la dynamique de l'infestation en nématodes transmis par les rhizomes du bananier cv. Poyo en Côte-d'Ivoire. *Revue Nématol.*, 8 : 257-263.

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 stengelaatje (*Ditylenchus dipsaci* (Kühn) Filipjev). *Tijdschr. Pl. Ziekt.*, 56 : 291-349.

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

SHAFIEE, M. F. & MENDEZ, J. M. (1975). Estudios sobre tres poblaciones y fluctuaciones estacionales de *Radopholus similis* en plátano, *Musa* sp. *Ciencias, Univ. Habana, Ser. II, Sanidad veg.* (1975), 12, 12 p.

STOVER, R. H. & SIMMONDS, N. W. (1987). Soils. In : Wrigley G. (Ed.). *Bananas*, 3rd ed., London, Longman : 212-222.