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Plant parasitic nematodes of plantain and other crops in Cameroon, West Africa

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Summary – In a nematode survey of plantains mainly from smallholder farms in Cameroon, 33 species of plant parasitic nematodes from eighteen genera were extracted from plantain soils; thirteen species were found as plantain root endoparasites. The most important in relation to root damage and occurrence were *Pratylenchus goodeyi, Radopholus similis* and *Helicotylenchus multicinctus*. *P. coffeae* was also present in a few areas. This is the first record of *P. goodeyi* occurring as a major root pest of plantains in West Africa, and it was present in a large proportion of the plantain farms. The distribution of *P. goodeyi* and *R. similis* was associated with temperature at different altitudes : *P. goodeyi* occurred mainly at or above an altitude of 900 m above sea level, whereas *R. similis* was always found below an altitude of 900 m. On the other crops, *Scutellonema bradys* was found causing dry rot of yam tubers.

Résumé – ***Nématodes parasites du bananier plantain et d'autres cultures au Cameroun, Afrique de l'Ouest*** – Une prospection nématologique du bananier plantain effectuée au Cameroun chez de petits exploitants agricoles a permis de récolter 33 espèces appartenant à dix-huit genres dont treize espèces endoparasites. En termes de dommages et d'extension géographique, les espèces les plus importantes sont *Pratylenchus goodeyi, Radopholus similis* et *Helicotylenchus multicinctus*. *P. coffeae* est également présent dans quelques zones. C'est la première fois que *P. goodevi* est signalé comme parasite majeur des racines du bananier plantain en Afrique de l'Ouest et cela dans une importante proportion des plantations prospectées. La répartition de *P. goodeyi* et de *R. similis* est associée aux températures des différentes altitudes : *P. goodeyi* est principalement trouvé au-dessus de 900 m d'altitude tandis que *R. similis* est toujours trouvé au-dessous de 900 m. Sur les autres cultures, il convient de signaler la présence de *Scutellonema bradys,* agent d'une pourriture sèche des tubercules d'igname.

Key-words : Nematodes, Cameroon, plantain, *Pratylenchus goodeyi.*

Plant parasitic and other nematodes have been identified from a range of crops and habitats in Cameroon (Goodey, 1957; Luc, 1957; Luc & de Guiran, 1960; Seinhorst, 1963; Barat *et al.,* 1969; Samsoen & Geraert, 1975; Ali & Geraert, 1975; Chavez & Geraert, 1977; Geraert & Ali, 1978; Germani, 1978; Samsoen & Ali, 1978; Sakwe & Geraert, 1991, 1992, 1993) including rain forests (Siddiqi & Lal, 1992; Price & Siddiqi, 1994).

Previous studies in Cameroon on nematodes associated with *Musa* species have concentrated almost exclusively on commercial dessert bananas (*Musa* AAA Cavendish Group) grown in plantations (Price, 1960; Luc & Vilardebó, 1961; Vilardebó *et al.,* 1972; Melin & Vilardebó, 1973 *a, b;* Vilardebó & Guérout, 1976 *a, b*) or on plantains (*Musa* AAB) grown in research stations (Melin & Vilardebó, 1976; Melin *et al.,* 1976). Because of this lack of information on nematodes of plantains, a survey of plant parasitic nematodes on this crop, mainly from smallholder farms in Cameroon was initiated in 1989 and continued during 1990, 1991 and 1992. During the survey, samples were also taken from dessert and highland bananas, and from other crops in different provinces of Cameroon. The results from these are also included in this paper.

Plantains are an extremely important staple food crop in West Africa. They are grown by a very large number of farmers mainly inside village compound gardens entirely for local sale and consumption. West Africa produces one-third of the total world output of plantains and they are one of the most important and preferred food energy sources in the area (Swennen, 1990). In Cameroon, although dessert bananas are a major export crop, plantains represent a much greater percentage of the total *Musa* production in the country. It is estimated that this total *Musa* production in Cameroon is over 1.5 million tonnes annually (F.A.O., 1993). Of this, less than 10 % are *Musa* AAA Cavendish bananas for export (116 000 t) and over 57 % are *Musa* AAB plantains for domestic consumption (860 000 t) (F.A.O., 1993).

Materials and methods

MAIN SURVEY

Plantain root and soil samples were collected from 113 sites in over 40 localities throughout the North-West, West, South-West, Littoral and Central Provinces of Cameroon (Fig. 1, Table 3). Observations were

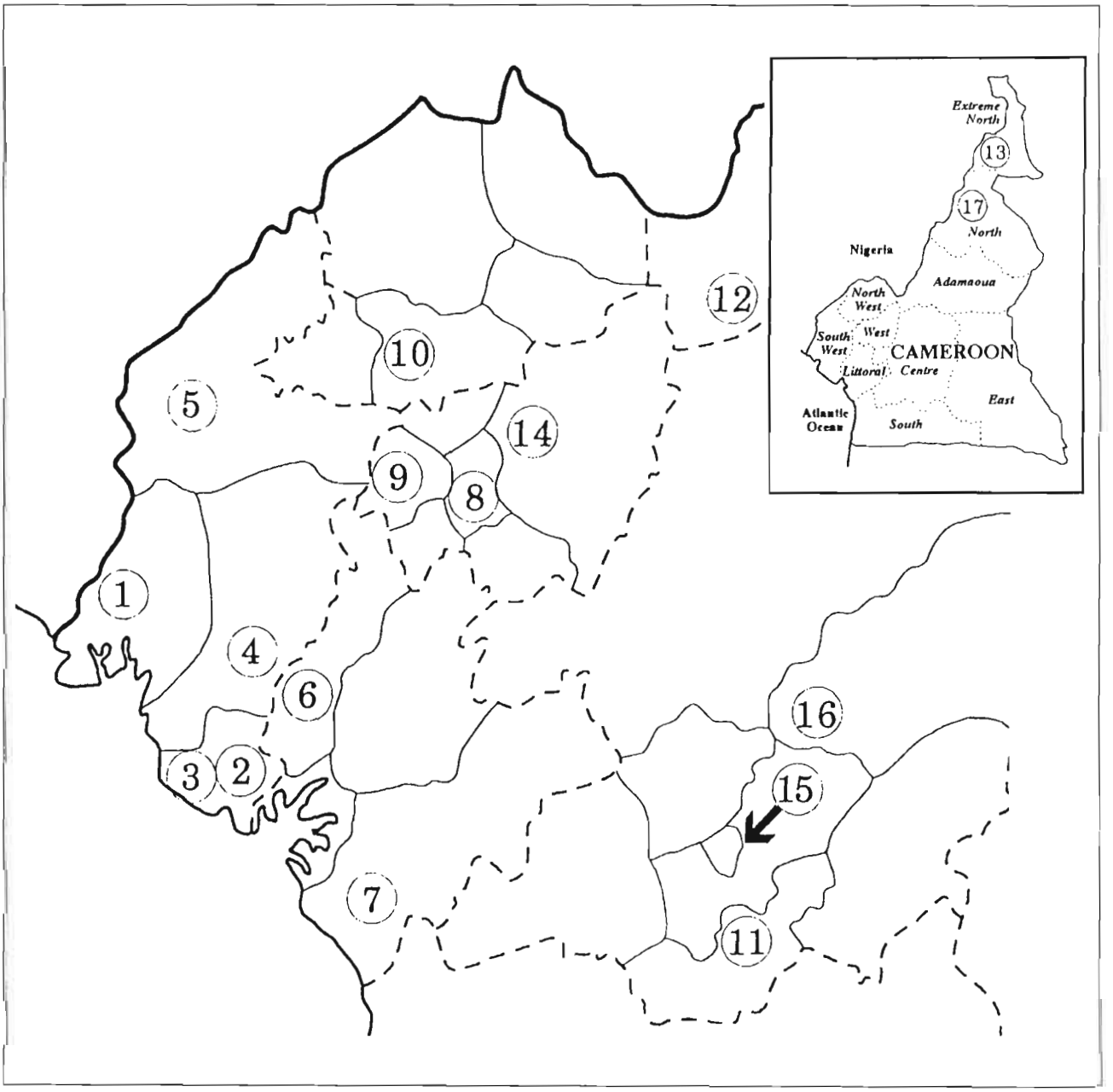

Fig. 1. *Map of Cameroon (inset) and central and south western Provinces showing sampling sites in the main plantain growing region of Cameroon. The circled numbers relate to numbers of sampling localities listed in Table 3.*

made of the degree of cortical root necrosis (Bridge & Gowen, 1993) from each plant and cultivars were identified whenever possible. Nematodes were extracted from soil by a tray modification of the Baermann funnel method (Hooper, 1990), and from plantain roots by maceration and sieving (Pinochet, 1988). Twenty five grams of plantain root material were washed, chopped into 1 cm lengths, macerated and passed through sieves of 250 μm, 50 μm and 32 μm apertures. Material retained on the 250 μm sieve after washing with a jet of water was discarded; material collected on the other screens was made up to 100 ml in volume with water and nematodes in a 1 ml aliquot from each sample were counted. Soil and roots from dessert and highland ba-

nanas were processed as described above. Nematodes in soil from around roots of other crops were also recovered by the tray method and from roots by maceration of 2 to 10 g of roots which were placed on a plastic ring sieve, in a dish of water and left for a minimum of 24 hours.

Nematode identifications in all cases were made or verified by D. J. Hunt, M. R. Siddiqi and J. E. Machon of the International Institute of Parasitology, U. K. Data on temperatures were collected from research stations and other meterological monitoring sites at, or close to, sampling sites. The altitudes of sampling sites were derived from map data, meterological stations and hand-held altimeters.

Monitoring *R. similis* populations at altitude

The influence of altitude on root populations of *R. similis* was determined by transferring infested planting material from a low altitude to a higher altitude. An area of uncultivated land, dominated by elephant grass (*Pennisetum* sp.) was cleared and planted with AAB plantains, variety French Sombre. The site was at Bokwango, Fako Division, South-West Province, at an altitude of 820 m above sea level (ASL) on Mt. Cameroon. At this altitude mean minimum temperatures are estimated to be between 17 to 19 °C (see Table 5). Plantains were obtained from Nyombé, Moungo Division, Littoral Province, at an altitude of 80 m ASL from an area infested with *R. similis*. Plantains were planted " untrimmed " together with some attached roots and adhering soil. Plots consisted of six plants each, spaced at 2 × 2 m, and the trial had five replicate plots. Samples were taken after 12, 24 and 34 months. Roots were collected randomly from three plants per plot and bulked to form five replicated samples. Nematodes were extracted as described above.

Results

Plantains

Out of a total of 42 species of plant parasitic nematodes found in Cameroon (Table 1), 32 species from eighteen genera were extracted from plantain soils. Thirteen species were also found as root endoparasites (Table 2), of which *Helicotylenchus multicinctus, Hoplolaimus pararobustus, Meloidogyne incognita, Pratylenchus goodeyi,* and *Radopholus similis* occurred in more than 30 % of the plantains sampled (Table 4), normally in mixed populations. All other endoparasitic species occurred in 7 % or less of the plants. Three of the most commonly occurring root parasites (*H. multicinctus, P. goodeyi, R. similis*) were found associated with 25 % to greater than 75 % necrosis of the root cortex; *M. incognita* caused slight to moderate galling of the roots. *P. coffeae,* which was found in plantain roots at only three

Table 1. *List of plant parasitic nematode genera and species found in Cameroon.*

Criconemella goodeyi (de Guiran, 1963) De Grisse & Loof, 1965
Criconemella ornata (Raski) Luc & Raski, 1981
Criconemella sphaerocephala (Taylor) Luc & Raski, 1981
Discocriconemella limitanea (Luc, 1959) De Grisse & Loof, 1965
Gracilacus peperpotti Shoemaker, 1963
Helicotylenchus crenacauda Sher, 1966
Helicotylenchus dihystera ((Cobb, 1893) Sher 1961
Helicotylenchus erythrinae (Zimmermann, 1904) Golden, 1956
Helicotylenchus microcephalus Sher, 1966
Helicotylenchus multicinctus (Cobb, 1893) Golden, 1956
Helicotylenchus pseudorobustus (Steiner, 1914) Golden, 1956
Helicotylenchus variocaudatus (Luc, 1960) Fortuner, 1984
Hemicriconemoides cocophillus (Loos, 1949) Chitwood & Birchfield, 1957
Hemicycliophora sp.
Heterodera sacchari Luc & Merny, 1963
Hoplolaimus pararobustus (Schuurmans, Stekhoven & Teunissen, 1938) Sher, 1963
Longidorus laevicapitatus Williams, 1959
Longidorus sp.
Meloidogyne arenaria (Neal, 1889) Chitwood, 1949
Meloidogyne incognita (Kofoid & White, 1919) Chitwood, 1949
Meloidogyne sp.
Paratrichodorus sp.
Paratylenchus sp.
Pratylenchus brachyurus (Godfrey, 1929) Filipjev & Schuurmans Stekhoven, 1941
Pratylenchus coffeae (Zimmerman, 1898) Filipjev & Schuurmans Stekhoven, 1941
Pratylenchus goodeyi Sher & Allen, 1953
Pratylenchus zeae Graham, 1951
Pratylenchus sp.
Radopholus similis (Cobb, 1893) Thorne, 1949
Rotylenchulus reniformis Linford & Oliveira, 1940
Scutellonema bradys (Steiner & LeHew, 1933) Andrassy, 1958
Scutellonema cavenessi Sher, 1964
Scutellonema clathricaudatum Whitehead, 1959
Trichodorus cf. *coomansi* De Waele & Carbonell, 1893
Trophotylenchulus sp.
Tylenchorhynchus annulatus (Cassidy, 1930) Golden, 1971
Tylenchulus semipenetrans Cobb, 1913
Xiphinema cf. *douceti* Luc, 1973
Xiphinema ifacolum Luc, 1961
Xiphinema longicaudatum Luc, 1961
Xiphinema setariae Luc, 1958
Xiphinema vulgare Tarjan, 1964
Xiphinema n.sp.

Table 2. *Plant parasitic nematodes of plantain and other crops in Cameroon.*

Crop	Soil	Roots
PLANTAIN (*Musa* AAB)	*Criconemella goodeyi* *Criconemella sphaerocephala* *Discocriconemella limitanea* *Helicotylenchus crenacauda* *Helicotylenchus dihystera* *Helicotylenchus erythrinae* *Helicotylenchus multicinctus* *Helicotylenchus pseudorobustus* *Helicotylenchus varicaadutus* *Hemicriconemoides cocophillus* Heteroderid sp. *Hoplolaimus pararobustus* *Longidorus laevicapitatus* *Longidorus* sp. *Meloidogyne incognita* *Meloidogyne* sp. *Paratrichodorus* sp. *Paratylenchus* sp. *Pratylenchus coffeae* *Pratylenchus goodeyi* *Pratylenchus* sp. *Radopholus similis* *Rotylenchulus reniformis* *Scutellonema cavenessi* *Scutellonema clathricaudatum* *Trichodorus* cf. *coomansi* *Trophotylenchulus* sp. *Xiphinema* cf. *douceti* *Xiphinema ifacolum* *Xiphinema longicaudatum* *Xiphinema vulgare* *Xiphinema* n.sp.	*Helicotylenchus dihystera* *Helicotylenchus erythrinae* *Helicotylenchus multicinctus* *Helicotylenchus pseudorobustus* *Helicotylenchus variocaudatus* *Hoplolaimus pararobustus* *Meloidogyne incognita* *Pratylenchus coffeae* *Pratylenchus goodeyi* *Radopholus similis* *Rotylenchulus reniformis* *Scutellonema cavenessi* *Trophotylenchulus* sp.
HIGHLAND BANANA (cooking) (*Musa* AAA)	*Helicotylenchus dihystera* *Helicotylenchus pseudorobustus* *Meloidogyne* sp. *Paratrichodorus* sp. *Pratylenchus goodeyi* *Scutellonema cavenessi* *Xiphinema* sp.	*Helicotylenchus dihystera* *Hoplolaimus pararobustus* *Meloidogyne* sp. *Pratylenchus goodeyi*
DESSERT BANANA (*Musa* AAA)	*Criconemella* sp. *Discocriconemella limitanea* *Gracilacus peperpotti* *Helicotylenchus multicinctus* Heteroderid sp. *Hoplolaimus pararobustus* *Meloidogyne* sp. *Radopholus similis* *Rotylenchulus reniformis*	*Helicotylenchus multicinctus* *Hoplolaimus pararobustus* *Meloidogyne incognita* *Pratylenchus goodeyi* *Radopholus similis* *Rotylenchulus reniformis*
CITRUS (*Citrus* spp.)	*Criconemella sphaerocephala* *Helicotylenchus dihystera* *Helicotylenchus multicinctus* *Helicotylenchus pseudorobustus* *Hemicriconemoides* sp. *Heterodera* sp. *Hoplolaimus pararobustus* *Longidorus laevicapitatus* *Meloidogyne* sp. *Pratylenchus brachyurus* *Rotylenchulus reniformis* *Tylenchulus semipenetrans* *Xiphinema ifacolum*	*Pratylenchus brachyurus* *Tylenchulus semipenetrans*
PAPAYA (*Carica papaya*)	*Criconemella* sp. *Helicotylenchus* sp. *Heterodera sacchari* (probably associated with groundcover grasses) *Meloidogyne* sp. *Pratylenchus zeae* *Rotylenchulus reniformis*	*Rotylenchulus reniformis*
MANGO (*Mangifera indica*)	*Helicotylenchus abunaamai* *Helicotylenchus dihystera* *Helicotylenchus* sp. *Hemicriconemoides cocophillus* *Hoplolaimus pararobustus* *Longidorus laevicapitatus* *Rotylenchulus (? reniformis)* *Scutellonema cavenessi* *Tylenchorhynchus annulatus* *Xiphinema setariae* *Xiphinema* sp.	
CUSTARD APPLE (*Annona reticulata*)	*Helicotylenchus cavenessi* *Hoplolaimus pararobustus* *Longidorus laevicapitatus* *Pratylenchus brachyurus*	
COFFEE (*Coffea arabica*)	*Criconemella goodeyi* *Helicotylenchus dihystera* *Hoplolaimus pararobustus* *Longidorus laevicapitatus* *Meloidogyne* sp. *Radopholus similis*	*Helicotylenchus pseudorobustus* *Hoplolaimus pararobustus* *Meloidogyne* sp. *Pratylenchus* sp. *Trophotylenchulus* sp.
SUGARCANE (*Saccharum officinarum*)	*Helicotylenchus microcephalus* *Helicotylenchus pseudorobustus* *Heterodera* sp. *Hoplolaimus pararobustus* *Rotylenchulus reniformis* *Xiphinema* sp.	
CASSAVA (*Manihot esculenta*)	*Hemicycliophora* sp. *Meloidogyne* sp. *Pratylenchus brachyurus*	
POTATO (*Solanum tuberosum*)	*Helicotylenchus* sp. *Hoplolaimus* sp. *Meloidogyne* sp. *Pratylenchus* sp. *Scutellonema bradys*	
BLACK PEPPER (*Piper nigrum*)	*Meloidogyne* sp. *Xiphinema* sp.	*Meloidogyne* sp.
MAIZE (*Zea mays*)	*Helicotylenchus* sp. *Scutellonema bradys* *Scutellonema cavenessi* *Pratylenchus* sp.	
COTTON (*Gossypium* spp.)	*Criconemella ornata* *Scutellonema cavenessi*	
COCOYAM (*Xanthosoma* spp.)	*Meloidogyne arenaria* *Meloidogyne incognita*	*Meloidogyne arenaria* *Meloidogyne incognita*
SOYABEAN (*Glycine max*)	*Helicotylenchus* sp. *Meloidogyne* sp. *Pratylenchus* sp.	
LOCAL BEAN (*Phaseous vulgaris*)	*Criconemella* sp. *Hoplolaimus pararobustus* *Longidorus laevicapitatus* *Pratylenchus goodeyi*	
YAM (*Dioscorea rotundata*)	*Scutellonema bradys* (tubers)	
WILD YAM (*Dioscorea* sp.)	*Scutellonema bradys* (tubers)	

Table 3. *Localities sampled in Cameroon by Division/Department and Province with altitudes.*

Division Département	Province	No. Localities Sampled	Altitude (m above sea level)
PLANTAIN AND BANANA SAMPLES			
1. Ndian	South-West	4	2-80
2. Fako (Mt. Cameroon)	South-West	6	100-950
3. Fako	South-West	12	5-75
4. Meme	South-West	7	55-220
5. Manyu	South-West	1	130
6. Moungo	Littoral	8	40-190
7. Sanaga-Maritime	Littoral	1	25
8. Mifi	West	2	1 300
9. Menoua	West	2	1 500
10. Mezam	North-West	10	1 200-1 600
11. Nyong-et-Soo	Central	1	750
12. Mayo-Banyo	Adamaoua	1	1 200
13. Margui-Wandala	Extreme-North	1	?
SAMPLES FROM OTHER CROPS ONLY			
14. Noun	West	1	1 100
15. Mfoundi	Central	1	750
16. Haute-Sanaga	Central	1	700
17. Benoué	North	2	240

locations in South West Province (Fig. 2), was also associated with obvious cortical root necrosis.

Almost all recordings of *P. goodeyi* were made close to or higher than 900 m ASL. In contrast, *R. similis* was always found below an altitude of 900 m ASL (Fig. 2). Occasionally the two species occurred together at altitudes of 800 to 900 m ASL. The annual mean minimum and maximum air temperatures at different altitudes in the regions sampled are presented in Table 5. Temperatures above 900 m ASL drop to a mean minimum of 16 °C and reach a maximum of 27 °C, at the lower altitudes mean temperatures do not drop below 20 °C and reach a maximum of 31 °C.

Root damage caused by *P. goodeyi* and *R. similis* was indistinguishable and, in both cases, was related to root breakage and plant toppling in a proportion of the farms sampled. *H. pararobustus* was very occasionally observed associated with minor cortical necrosis, but no associated root damage was observed with other endoparasitic and soil nematode species. *H. pararobustus* was the most frequently found species in plantain roots, but mean root populations per 100 g of root were low (1542) compared to mean populations of *R. similis* (23 782), *P. goodeyi* (15 375), *H. multicinctus* (14 182) and *P. coffeae* (9400) (Table 4). Other species found in plantain roots were *Helicotylenchus dihystera, H. erythrinae, H. pseudorobustus, H. variocaudatus, Rotylenchulus reniformis, Scutellonema cavenessi* and *Trophotylenchulus* sp. In the soil

Table 4. *Occurrence and populations of endoparasitic nematodes in roots of plantains in Cameroon.*

Nematode	% Occurrence	Maximum (and mean) populations/ 100 g roots
Radopholus similis	39	184,000 (23,782)
Pratylenchus coffeae	4.5	22,000 (9,400)
Pratylenchus goodeyi	33	56,000 (15,375)
Hoplolaimus pararobustus	43.5	6,000 (1,542)
Meloidogyne incognita	35.5	14,800 (3,420)
Helicotylenchus multicinctus	38	56,800 (14,182)
Helicotylenchus dihystera	5.5	–
Helicotylenchus erythrinae	7	–
Helicotylenchus pseudorobustus	3.5	–
Helicotylenchus variocaudatus	2.5	–
Rotylenchulus reniformis	< 1	–
Scutellonema cavenessi	3.5	–
Trophotylenchulus sp.	< 1	–

around plantain roots, additional plant parasitic nematode species belonging to the genera *Criconemella, Discocriconemella, Hemicriconemoides, Longidorus, Paratrichodorus, Paratylenchus, Trichodorus* and *Xiphinema* were found. Five species of *Xiphinema* were identified including a new species (Hunt, pers. comm.).

The local names of plantain varieties sampled during the surveys are listed in Table 7. All varieties were susceptible to *R. similis, P. goodeyi* or *P. coffeae* where these nematodes occurred. However, the False Horn variety " Big Ebanga " showed few root symptoms even though *R. similis* was recovered from the roots.

BANANAS

Highland bananas (*Musa* AAA) of the Lujugira group including types similar to the " Intutu " types characteristic of East Africa, were identified growing at high altitude in South-West, North-West and West Provinces of Cameroon during this survey. The nematode associated with root damage to the crop was *P. goodeyi,* although *Hoplolaimus pararobustus, Helicotylenchus dihystera* and *Meloidogyne* sp. were also found in the roots. *R. similis* was absent from all the highland banana samples.

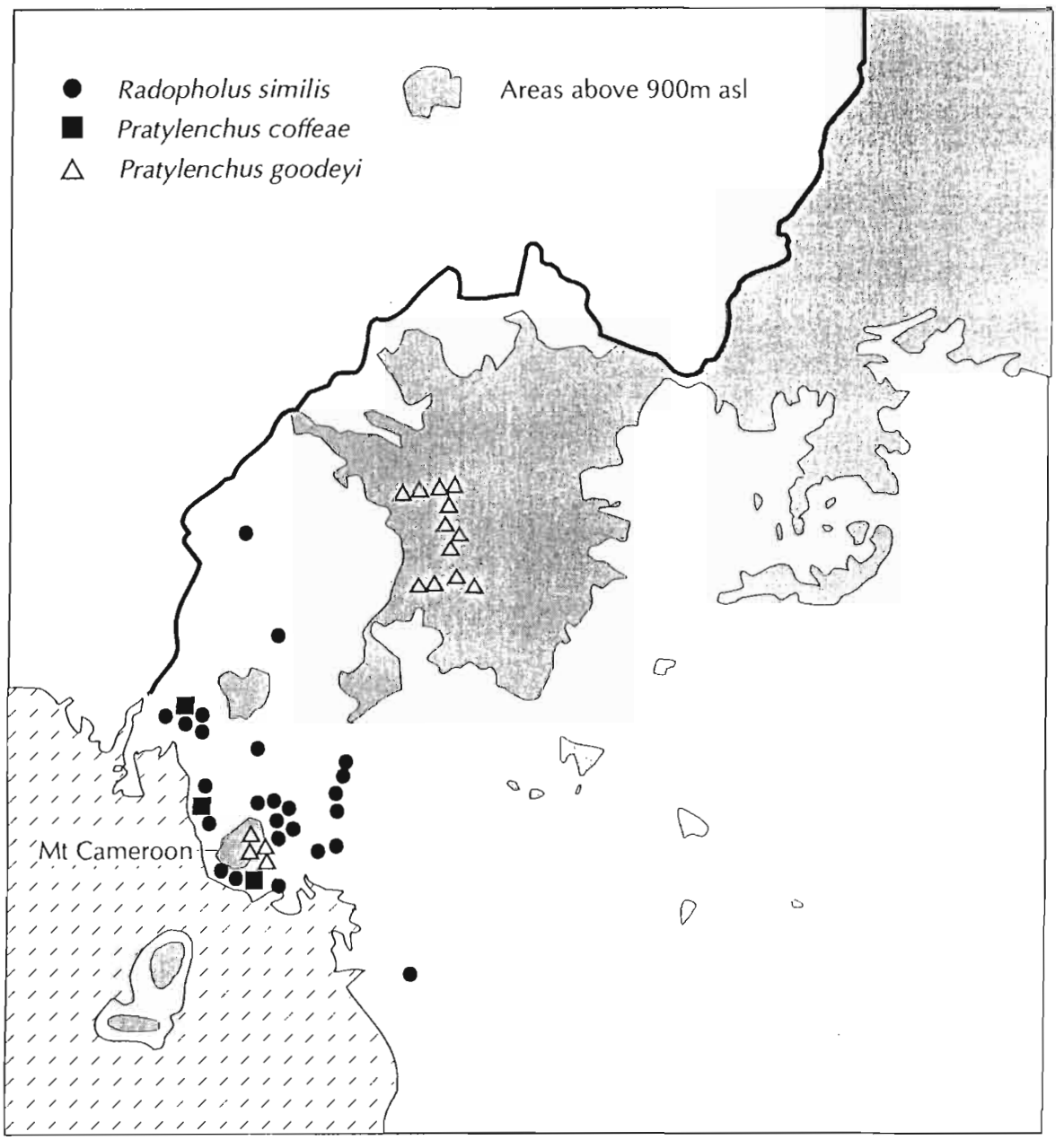

Fig. 2. *Distribution of* Radopholus similis, Pratylenchus coffeae *and* P. goodeyi *in the plantain growing regions of south western Cameroon.*

Dessert bananas sampled from farmers' fields, mainly cv. Gros Michel, were infested by both *P. goodeyi* and *R. similis* with their distribution being again linked to altitude. Other species extracted from dessert banana roots were *H. multicinctus, H. pararobustus,* and *R. reniformis.*

OTHER CROPS

Tylenchulus semipenetrans was present in large numbers on different citrus rootstocks (*Citrus* spp.) at the IRA Fombout Research Station, West Province. Low numbers of *P. brachyurus* were also found in citrus roots at the same locality. Species from nine other genera were found in soil around citrus (Table 2).

The yam nematode, *Scutellonema bradys,* was found to be the cause of severe dry rot disease of yam tubers *(Dioscorea rotundata)* stored in a yam barn at IRA Nyombé Research Station, Littoral Province. *S. bradys* was also found causing dry rot disease of wild yam (*Dioscorea* sp.) tubers growing at the forest edge in Edéa, Littoral

Table 5. *Altitudes and annual mean maximum and minimum air temperatures at selected meteorological stations from the main plantain growing areas of Cameroon.*

Meteorological station	Altitude (m above sea level)	Air temperatures (°C)	
		Mean maximum	Mean minimum
A. Tiko, Fako Division South-West Province	50	30.1	22.4
B. Njombé, Moungo Department Littoral Province	80	31.1	21.4
C. Mamfé, Manyu Division South-West Province	130	31.1	21.8
D. Ekona, Fako Division South-West Province	400	27.6	19.7
G. Yaoundé, Mfoundi Department Central Province	700	28.0	19.4
H. Buea, Fako Division South-West Province	950	25.0	16.7
I. N'Koundja, Mifi Department West Province	1 210	27.1	16.0
J. Dschang, Menoua Department West Province	1 410	25.4	15.5
K. Bamenda, Mezam Division North-West Province	1 610	23.8	15.4

Table 6. *Numbers of* Radopholus similis *juveniles and adult females per 100 g root fresh weight on AAB plantain var. French Sombre grown at Bokwango, 820 m above sea level.*

	Months after planting		
	12	24	34
Radopholus similis per 100 g root *	6 437	2 390	22

Figures de-transformed from the ($\log_e$ n + 1) mean. ANOVA for ($\log_e$ n + 1) values significant at $P = 0.017$. * Means of 5 replicates.

Table 7. *Occurrence of* Radopholus similis, Pratylenchus goodeyi *and* P. coffeae *in roots of different cultivars of plantains sampled in the Cameroon.*

Cultivar	*R. similis*	*P. goodeyi*	*P. coffeae*
Big Ebanga	+		
Bobby Tannup		+	
Brocaca	+		
Ebanga	+	+	+
Enyale	+	+	
Enyale-Liko		+	
French Claire	+	+	+
French Rouge	+		
French Sombre	+		
Giant French		+	
Kamaliko		+	
Kedong			
Mekitu		+	
Kundong-Mufi		+	
Lifongo		+	
Mweni-Liko		+	
Naningo		+	
Neni	+		
Ngomba	+		+
Ntie		+	
Ovang	+		+
Twin Plantain	+		
Two-Hand Planty		+	

Province. *S. bradys* also occurred in soils collected from around *Solanum* potato and maize *(Zea mays)* (Table 2).

The root knot nematode species, *M. arenaria* and *M. incognita,* caused marked root galling of cocoyam (*Xanthosoma* sp.) growing in Mezam District, N. W. Province. Juveniles of *Meloidogyne* spp. were found in soil around many crops including papaya *(Carica papaya),* soyabean *(Glycine max),* cassava *(Manihot esculenta),* potato *(Solanum tuberosum)* and black pepper *(Piper nigrum),* but were not associated with any observable root galling of these crops.

R. reniformis was the only species of *Rotylenchulus* identified from soil samples around roots of citrus and sugarcane *(Saccharum officinarum),* and in large numbers around papaya. Juveniles of *Heterodera* or related genera occurred in soils around citrus and sugarcane without cysts being detected. *H. sacchari* was identified from soil around papaya but was probably parasitic on roots of surrounding groundcover grasses.

MONITORING *R. SIMILIS* AT ALTITUDE

Populations of *R. similis* (juveniles and adult females) in roots of plantain are given in Table 6. Twelve months after planting, *R. similis* numbers at Bokwango were 6437 per 100 g root fresh weight, nearly identical to the 6633 *R. similis* per 100 g root found in a trial at Nyombé, close to the source of the infested material (Price, 1994 *a*). A year later, numbers of *R. similis* had fallen by over 95 % and at the final sampling, 34 months after planting, *R. similis* numbers had declined to insignificant levels.

Discussion

Many more nematode species were found as root parasites of plantain in Cameroon than have previously been recorded elsewhere. The most important in relation to root damage and widespread occurrence were *P. goodeyi, R. similis* and *H. multicinctus*. The root-knot nematode, *M. incognita,* was very common, in most cases associated with relatively minor galling of root tips but in some instances with severe galling. *H. pararobustus* was commonly found in roots but root necrosis, although present, was comparatively limited. *P. coffeae* was present only in a few areas but the root damage associated with this species was equal to that caused by *P. goodeyi* or *R. similis*. *R. reniformis* was present in less than 1 % of the root samples examined in contrast to results from Ivory Coast where *R. reniformis* occurred in approximately 10 % of the samples in large numbers (Adiko, 1988). Three *Helicotylenchus* spp., *H. dihystera, H. erythrinae* and *H. pseudorobustus,* were present in 7 % or less of the root samples and are probably of minor economic importance. *S. cavenessi* was the only species of *Scutellonema* found in the roots.

Two unusual root parasites of plantain were *Helicotylenchus variocaudatus,* a species originally identified from black pepper roots in Ivory Coast (Luc, 1960), and juveniles of *Trophotylenchulus* sp. which could be the species *T. obscurus* found by Samsoen and Ali (1978) on grass roots in Cameroon.

Pratylenchus goodeyi was identified for the first time as a pest of plantains in Cameroon and West Africa during this survey which is surprising as it was the major root nematode pest in a large proportion of the plantain farms. It has previously been considered a species indigenous to E. Africa, where it is recognised as an important pest of highland bananas in Uganda, Tanzania, Kenya, Rwanda and Burundi, and of *Ensete* in Ethiopia (Gichure & Ondieki, 1977; Bridge, 1988; Sarah, 1989; Peregrine & Bridge, 1992). It is also the main nematode pest of bananas in Canary Islands (de Guiran & Vilardebó, 1962) and has been found in Egypt (Oteifa, 1962) and in Crete (Machon & Hunt, 1985) but not elsewhere in the world (Bridge, 1994). The distribution of *P. goodeyi* was very closely linked to altitude and, presumably, temperature as it was found almost exclusively in upland areas of Cameroon. Two samples at low altitude (both in South West Province, at Ekona Research Station and an Agricultural Training College) in which *P. goodeyi* was found could represent recent introductions from *P. goodeyi* infected areas and which were unlikely to survive.

The mean minimum temperatures at the higher altitudes where *P. goodeyi* was present and *R. similis* absent were less than 19 °C (Table 4). Conversely, mean maximum temperatures at the lower altitudes where *R. similis* only was present were greater than 27 °C. The distribution of these two nematodes is almost certainly affected by day-degree accumulations over a period of time and not simply minimum and maximum temperatures. This was indicated by results of the monitoring of *R. similis* at altitude which showed that when *R. similis* was moved to a border-line altitude/temperature between the two species it did not disappear immediately at the cooler temperatures but did decline to insignificant levels over a period of 34 months. During the survey it was observed that at one site close to Dschang, West Province, at an altitude of approximately 1300 m ASL, AAA Cavendish bananas originally obtained from Nyombé Research Centre three years previously, and thus almost certainly originally infested with *R. similis,* were free of *R. similis* but infested with *P. goodeyi.* Sarah (1989) made a similar observation in Rwanda with plants imported from Nyombé Research Station where *R. similis* had been displaced by *P. goodeyi* in the roots because, he suggested, *R. similis* could not adapt to the cooler climate. *P. goodeyi* has only previously been found in the tropics at high altitudes in East Africa or in the warm temperate climates of Canary Islands, Egypt and Crete. The finding in West Africa is further evidence that *P. goodeyi* is a pest of bananas and plantains growing in cooler climates outside the tropical lowlands in which the majority of commercial bananas are grown, and has a lower temperature preference than *R. similis*. In Cameroon, *P. goodeyi* represents a pest exclusively of small holder cultivation and is absent from the commercial banana plantations of the lowland areas. This similarly applies to its presence in East Africa and would explain why the species has not been disseminated worldwide, as *R. similis* has, on commercial bananas. However, *P. goodeyi* has the potential to become an important pest of bananas where they are grown in cooler climatic zones such as in the Mediterranean and Middle East countries. As in other areas of the world, including other African countries, *R. similis* has almost certainly been introduced with planting material used to establish commercial plantations, originally the AAA variety Gros Michel and subsequently with the AAA Cavendish types in use today. The species has spread to the already present banana and plantain varieties and continues to spread with the use and distribution of *R. similis* infected material. Older farms are often *R. similis* free, where *H. multicinctus* is common, whereas newly established farms, commonly planted with pur-

chased (and infested) planting material, are frequently infested with *R. similis*. Such a situation may be expected to continue with the expansion in plantain growing as a response to high urban demand and present economic circumstances (Temple *et al.*, 1984). Many lowland areas of Cameroon are still relatively free of *R. similis*, for example, in the Mamfé region only one out of six farms sampled was found to be infested. It was also interesting to note that *R. similis* was absent from plantains and bananas in a recent nematode survey of farms in the southwestern and middle belt states of Nigeria (Fademi & Bayero, 1993). This illustrates the potential benefit for programmes to restrict the spread of *R. similis* in this region of West Africa, for example by promoting the use of nematode free planting material.

There was no clear evidence of resistance to *R. similis* or *Pratylenchus* among any of the plantain varieties sampled during the survey. This was also true of field trial screening for resistance (Price, 1994 *a, b*). The variety " Big Ebanga ", however, may warrant further study as in both the survey and field trials its appeared to be less susceptible to both *R. similis* and *P. goodeyi.*

Many different nematode genera and species were found associated with crops other than bananas and plantains in Cameroon (Table 1). The most important of these were *S. bradys* on yams, *T. semipenetrans* on citrus, and *Meloidogyne* spp. on various crops. The yam nematode, *S. bradys,* was found for the first time in Cameroon during this survey although it has previously been found to be a serious pest of yams in the neighbouring country of Nigeria and in other West African countries, Gambia, Ivory Coast, Senegal and Togo (Bridge, 1982). The dry rot disease symptoms of *D. rotundata* tubers were characteristic of those found on yam tubers elsewhere in West Africa. The finding of *S. bradys* causing dry rot in tubers of wild yam from forest soils indicates that the nematode is indigenous to Cameroon.

The citrus nematode, *T. semipenetrans,* is present in Cameroon and population estimates from root and soil extracts indicate that it is causing damage. It was not present in all citrus orchards sampled, only at the IRA Fombout Research Station on various rootstocks. As infestation is normally caused by the movement of infected plants, preventing the spread of the nematode by using certified planting material which is nematode free could be realistically achieved.

Both *M. incognita* and *M. arenaria* were found causing root galling of cocoyam, *Xanthosoma* spp. Root-knot nematodes are known to occur on *Xanthosoma* worldwide including Nigeria. Many reports suggest that *Xanthosoma* spp. are generally tolerant of *Meloidogyne,* but both *M. incognita* and *M. arenaria* can cause corm damage and there is the suggestion that *M. incognita* could be involved in a root rot disease of the crop (Jatala & Bridge, 1990).

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