Musa-based cropping systems of the Cameroon highlands: a case study of the West and Northwest provinces of Cameroon, with emphasis on nematodes

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Musa-based cropping systems of the Cameroon highlands: a case study of the West and North West provinces of Cameroon, with emphasis on nematodes.

Abstract — Introduction. In Cameroon, most subsistence farmers apply a mixed cropping system, resulting in a range of possible nematode host plants. Bananas and plantains (*Musa* spp.) are an important component of these cropping systems, both as a source of cash income and as a staple food. In order to program future extension projects, our study analyzed the cropping associations and their constraints in the West and Northwest provinces of Cameroon highlands. As nematodes have been identified as a major constraint to *Musa* production worldwide, we tried to assess the nematode presence. **Materials and methods**. A survey of over 200 households was done throughout the Cameroon highlands to identify the types of crop associations and preferences, management practices and pest awareness of small-scale farmers. In addition, samples were taken to examine the prevalence of *Pratylenchus goodeyi* on bananas and plantains in the home garden and one field of each household visited. **Results and discussion**. Cropping systems were highly variable between households, in so far as they could not easily be typified. Thirty-eight crops were identified planted in association with *Musa* spp. Bananas and plantains ranked as the most important crop for 43% of the farmers, followed by the staple crop maize (19%) and the traditional cash crop coffee (12%). Pest awareness (% awareness) was relatively high with respect to weevils (72%). The major constraints as perceived by the farmers related to leaf necrosis, weevils and nematode damage. Nevertheless, only 15% of them had heard of a nematode before. All root samples revealed nematode presence (over 40% showed more than 10^4 individuals·100 g^{-1} root fresh weight). *P. goodeyi* was the dominant species found.

Cameroon / *Musa* / cropping systems / farm surveys / plant nematodes

Systèmes de production basés sur bananiers, en montagne du Cameroun : étude de cas des provinces ouest et nord-ouest, avec accent sur la présence de nématodes.

Résumé — Introduction. Au Cameroun, la plupart des fermiers pratiquent un système de cultures en mélange, ce qui induit une large gamme de plantes hôtes potentielles pour les nématodes. Les bananes et plantains (*Musa* spp.) sont une composante importante de ces systèmes de production comme source de revenus et comme aliment principal. Afin de programmer de futurs projets d'extension, notre étude a analysé les types d'associations culturales et leurs contraintes dans les provinces de l'ouest et du nord-ouest des montagnes du Cameroun. Comme les nématodes ont été identifiés dans le monde entier comme une contrainte importante à la production du bananier, nous avons essayé d'évaluer leur présence dans des régions prospectées. **Matériel et méthodes**. Une enquête portant sur plus de 200 familles a été faite dans toutes les montagnes du Cameroun pour identifier les types préférés d'associations de cultures, les procédures de gestion et la reconnaissance par les petits exploitants des parasites. En outre, des échantillons ont été prélevés pour étudier la prédominance de *Pratylenchus goodeyi* sur les bananiers et plantains des jardins de case et des champs appartenant à chaque famille visitée. **Résultats et discussion**. Les systèmes de culture se sont révélés fortement variables d'une famille à l'autre, pour autant qu'ils n'ont pas pu facilement être caractérisés. Trente-huit espèces ont été identifiées comme étant plantées en association avec des bananiers et plantains qui ont été classés comme production la plus importante pour 43 % des fermiers, suivie par le maïs exploité en culture principale (19 %) et par le café traditionnellement source de revenus immédiats (12 %). L'identification des parasites (en % de reconnaissance) a été relativement haute pour les charançons (72 %). Les contraintes principales perçues par les fermiers ont été la nécrose des feuilles, la présence de charançons et les dommages dus aux nématodes. Néanmoins, seulement 15 % d'entre eux avaient déjà entendu parler de nématode auparavant. Tous les échantillons de racines ont indiqué la présence de nématodes (plus de 40 % d'entre eux ont montré plus de 10^4 individus·100 g^{-1} de poids frais de racines). *P. goodeyi* a été identifié comme l'espèce dominante.

Cameroun / *Musa* / système de culture / enquête sur exploitations agricoles / nématode des plantes

1. Introduction

Plant-parasitic nematodes are microscopic worms that attack mainly the root system of crops and weeds in a field. Symptoms of attack can be seen as small lesions on the exterior root surface, galls or large necrotic lesions along the cortex of the root system. Although the mode of parasitism can vary from species to species, all plant-parasitic nematodes are characterized by their need to feed on plants in order to survive; in other words, they are obligatory parasites. Due to their small habitus, plant-parasitic nematodes lack the capacity for long-distance and self-directed movement [1].

These characteristics underline the importance of knowledge of the host status of crops and weeds in a field. In essence, crop management, through rotation or association of various plants of mixed host status, can help a farmer to reduce the nematode population densities below the economic threshold level.

In Cameroon, most subsistence farmers apply a mixed cropping system, whereby several crops are interplanted throughout the field. From a nematological point of view, this gives an interesting landscape of possible host plants, each with a specific effect on the nematode community.

Bananas and plantains are an important component of these mixed cropping systems. They provide more than 25% of food-energy requirements for around 70 million people throughout Sub-Saharan Africa. *Musa* spp. also produce fruit all year round, bridging the "hunger-gap" between crop harvests [2]. In Cameroon, bananas and plantains are one of the most important food crops sold regularly by male and female farmers, contributing significantly to the rural household income. Traditionally, plantain is a crop of men and is high-ranking due to its role in social events [3]. The Cameroon highlands represent 6% of the total land area in Cameroon, but accommodate roughly 30% of the total population [4]. In addition, more than 25% of all plantains are produced in the region and more than 30% of all bananas [3].

Although a total of 33 nematode species have been identified on *Musa* root systems in Cameroon, five species are found regularly [5]. Of these five species, *Radopholus similis* (the burrowing nematode) has received the most attention, due to its destructive nature in part, but also due to its presence in export banana plantations. Although the importance of this nematode cannot be underestimated, another species, *Pratylenchus goodeyi* (lesion nematode), is found in high numbers in farmers' fields above 1000 m altitude, where it causes similar symptoms [5, 6]. Research on that nematode is not as well developed as research on *R. similis*, partially due to the fact that it is found primarily in small-scale farmers' fields.

In order to investigate the prevalence of *P. goodeyi* in small-scale farmers' fields in the Cameroon highlands, a collaboration was set up between the *Centre Africain de Recherche sur Bananiers et Plantains* (CARBAP) and the National Agricultural Extension and Research Program (NAERP) of Cameroon. During the months of September 2002 through to April 2003, a total of 216 farmers' households were interviewed to estimate the importance of banana and plantain, the cropping associations most commonly found, management strategies used and pest awareness. This study reports on the findings of the interviews carried out in the West and Northwest provinces of Cameroon and their implications for future extension projects.

2. Methodology

The Cameroon highlands are situated in a mountainous region, above 1000 m altitude. The climate is sub-tropical with low temperatures (average 19.3 °C). The rainy season, which is longer than the dry season, commences in mid-March and lasts until mid-November. Rainfall averages 2000 mm·year^{-1}. Soils are varied, with high plateaus often consisting of rich black or brown soils, derived from basalt, and valley areas consisting of alluvial plains ([3] and Ministry of Information and Press – SOPECAM, 1979). Favorable agricultural conditions partly explain the high population densities (30% of the total population on 6% of the total land surface area). It is estimated that the region has been continuously populated for up to nine millennia [7].

Table I.
Locations and number of localities visited during a survey aiming to study *Musa*-based cropping systems in the Cameroon highlands (September 2002–April 2003).

Regions	Department	Main town	Province	Number of households visited per location
1	Bamboutos	Mbouda	West province	15
2	Haut-Nkam	Bafang	West province	15
3	Hauts-Plateaux	Mifi, Koung-Khi, Bafoussam	West province	19
4	Menoua	Dschang	West province	15
5	Nde	Bangangté	West province	17
6	Noun 1	Foumbot	West province	15
7	Noun 2	Foumban	West province	15
8	Boyo	Fundong	Northwest province	15
9	Bui	Kumbo	Northwest province	15
10	Donga Mantung	Nkambe	Northwest province	15
11	Menchum	Wum	Northwest province	15
12	Mezam	Bamenda	Northwest province	15
13	Momo	Mbengwi	Northwest province	15
14	Ngoketunijia	Ndop	Northwest province	15

2.1. Interviews

The West and Northwest provinces of Cameroon can be divided into a total of fourteen regions of approximately equal size [administrative unit, cf. National Agricultural Extension and Research Program (NAERP), Cameroon], with each province constituting seven regions. In each region, a minimum of 15 farmers were visited (216 households in total) (*table I*).

Questions were asked with regard to the home garden and one field. The home garden was defined as a field next to the living quarters, or an area of a field that received kitchen waste, if no distinct home garden was found adjacent to the property. The farmers were also asked to describe the primary and secondary constraints in their home garden and field, respectively.

During the interviews, care was taken not to bias the answers given by the farmers. The field technicians were instructed to write down the responses literally. The average age of the farmers interviewed was 50.6 years old. Interviews were carried out essentially (86.4%) with the husband of the family although care was taken to discuss equally with the wife (or wives) during the discussions on other crops.

The checklist method was not used. If a question posed caused silence or was obviously not understood by the farmer, the field technicians were instructed to rephrase the question as opposed to suggesting answers. After each interview, a brief report was made of the context or other remarkable information that could not be directly entered into the interview.

2.2. Sampling

Households were selected based on the presence of *Musa* stands in the fields. Field technicians of the National Extension Program were asked to choose farming systems representative of practices found in each region.

Fields and home gardens were sampled using the following methodology:

– A total of 50 roots were taken from all *Musa* spp. present in the field, with an equal amount of roots from each variety. Roots were stored for a maximum of one week, in refrigerated conditions, between sampling and extraction. The roots were washed and chopped into approximately 1-cm-large pieces. From this, a sub-sample of 50 g was taken. Nematodes were extracted from the sub-samples using the "maceration and sieving technique" [8]. Following

Table II.
Crops found associated with *Musa* spp. in home gardens and fields of the Cameroon highlands.

Scientific name	Common names (French / English / Pidgin, local name)
Abelmoschius esculentus	Gombo / okra / okra
Allium cepa	Onion / onion / onion
Allium porrum	Poireaux / leek / leek
Ananas comosus	Ananas / pineapple / pineapple
Arachis hypogea	Arachide / groundnut / groundnut
Brassica oleracea	Choux / cabbage / cabbage
Capsicum annum	Piment doux / sweet pepper / sweet pepper
Capsicum fructescens	Piment / pepper / pepper
Carica papaya	Papaye / papaya / paw paw
Citrus limon	Lemon / lemon / lemon
Citrus sinensis	Orange / orange / orange
Citrullus lanatus	Pastèque / watermelon / watermelon
Coffea arabica/robusta	Café / coffee / coffee
Cola acuminata	Kola / kola / kola
Colocasia esculenta	Taro / taro / ibu coco
Cucurbita maxima	Melon / pistache / egusi, agushi
Dacryodes edulis	Safoutier / African pear / plum, prune
Dioscorea sp.	Igname / yam / yam
Elaeis guineensis	Palmier à huile / oil palm / red oya
Eucalyptus sp.	Eucalyptus / eucalyptus / eucalyptus
Glycine max	Soya / soya / soya beans
Ipomoea batatas	Patate douce / sweet potato / sweet potato
Lycopersicon esculentum	Tomate / tomato / tomato
Magnifera indica	Mangue / mango / mango
Manihot esculenta	Manioc / cassava / cassava
Passiflora edulis	Fruit de passion / passion fruit / garden egg
Persea americana	Avocat / avocado / pear
Phaseolus vulgaris	Haricot / beans / beans
Psidium guajava	Goyave / guava / guava
Raphia sp.	Raffia / raffia / raffia palm
Saccharum officinarum	Canne à sucre / sugar cane / sugar cane
Solanum nigrum	Amarante / black nightshade / njama njama, legumes
Solanum tuberosum	Pomme de terre / potato (Irish) / Irish potato
Theobroma cacao	Cacao / cacao / cacao
Vigna unguiculata	Niébé / cow pea / ibo beans
Xanthosoma sp.	Macabo / cocoyam / cocoyam
Zea mays	Maïs / maize, corn / corn
Zingiber officinale	Gingembre / ginger / ginger

extraction, the nematode suspension was washed through centrifugal flotation.

– From each sample, 3-mL aliquots were examined and the average calculated. Nematodes were identified based on morphological characteristics with the aid of a microscope.

2.3. Analysis

Due to the conceptual and qualitative nature of the data generated during this survey, statistical analysis was restricted to frequency distributions and percentage analyses.

3. Results

The Cameroon highlands are characterized by a large number of small farms (average 0.9 ha). Farmers who planted *Musa* most often had several fields where bananas and / or plantains were present (90.8%). These fields were often situated many kilometers away from each other. Although the distance of the most easily accessible field is often less than 500 m to the nearest road (in 61.4% of cases studied), farmers frequently walk considerably farther before reaching the nearest market, due to the cost of transport.

Mixed cropping was most frequently encountered as the traditional cropping system. Some farmers had established a monocropped field as a demonstration plot in collaboration with the National Extension Program. The type of association can be extremely variable between households. Some fields are well kept and regularly weeded. Other fields resemble a secondary forest, with various fruit trees, food crops and perhaps old coffee plants planted in no particular order. Farmers often lay their field "fallow" for a few months between harvesting (*i.e.*, maize / bean rotations). In such instances the weeds present in the field become more dominant and, from a nematological point of view, possible host plants. A total of 38 different crops were found in association with *Musa*, throughout the highlands (*table II*). In general, the bananas and plantains are grown between the other crops as solitary stands.

In the home gardens of the Cameroon highlands, the crops most commonly encountered in association with bananas and plantains were cocoyam (in 62% of home gardens visited), coffee (49%), corn (41%), taro (31%) and beans (30%). Discussions on the importance *(i.e.*, contributing significantly to the household consumption or income) of the various crops were held with both the male and female members of the household. Corn was ranked as the most important crop by 28% of those interviewed, followed by coffee (25%), cocoyam (16%) and beans (15%). In the West province, the food crops ranked higher than the traditional cash crop coffee, whereas, in the Northwest province, 43% of the farmers identified coffee as the most important crop in the home garden. Bananas and plantains were not ranked in the home gardens.

In the field, *Musa* spp. ranked as the overall most important crop by 43% of those interviewed (both provinces), followed by maize (19%) and coffee (12%). In both provinces *Musa* spp. outranked coffee in importance. In the West province, maize (the traditional staple food crop for the majority of farmers) was deemed more important (42.5%) than *Musa* (29.2%). In the Northwest province, bananas and plantains ranked as the number one crop for the majority of farmers (65.7%). Farmers in this province often cited the dual purpose of bananas and plantains as both a cash crop and food source.

Fallowing practices were different depending on the province. In the West province, only 22.5% had fallowed their fields before planting *Musa*. In the Northwest province, in contrast, 80% had planted in bush fallow or virgin forest. In all other fields, the *Musa* had been planted into an existing field. An estimation of the time the soil had been exposed to possible nematode populations (relevant with regard to population build-up and related damage) revealed that most farmers (75%) had planted *Musa* varieties at least 10 years ago in the field.

The most important constraints cited by the farmers related to nematode damage, weevil damage or leaf necrosis diseases [such as Black Leaf Streak Disease (BLSD)] (*table III*). Constraints were often similar depending on the region. This could be an indication of the actual constraints present in the field or the focus of extension programs in a given region. For instance, in the division of the Noun (West province), many farmers referred to biting ants as a major problem in their field, whereas, in the area around Bafoussam, Mbouda and Dschang, more farmers cited weevils.

Table III.
Primary and secondary *Musa* production constraints as perceived by the farmers according to a survey held in the Cameroon highlands (September 2002–April 2003).

Primary constraints	% of farmers who cited the constraint	Secondary constraints	% of farmers who cited the constraint
Weevils	33.1	Toppling (wind)	25.2
Leaf necrosis	20.3	Financial	10.8
Toppling (wind)	15.3	Leaf necrosis	10.5
Bunch size	11.1	Bunch size	10.2
Plant rot	5.0	Weevils	7.9
Financial	2.5	Labor	7.1
Root necrosis	2.3	Ants	4.5
Fruit damage	2.1	Fruit damage	4.5
Others (less than 2%)	8.2	Soil fertility	2.9
–	–	Animals (goats, etc.)	2.4
–	–	Weed pressure	2.1
–	–	Others (less than 2%)	8.1

Others: theft, highmat, planting materials, marketing difficulties, etc.

An evaluation of pest awareness indicated that of the 216 farmers interviewed, 72% were aware of weevils and could correctly describe the pest and damage caused by it, 9% were able to describe damage caused by weevils but gave an incorrect cause (often ants), and only 19% had never heard of weevils or recognized damage caused by them. Many farmers were aware of the tunneling damage caused by weevil larvae, and many were able to describe the larvae. However, few had ever seen the adult insect.

In contrast, when asked about nematodes, pest awareness was much lower. Only 15% of all farmers correctly described damage caused by nematodes although the actual concept of a nematode (a worm of microscopic size) was unknown or an incorrect cause was given (ants were often referred

Table IV.
Nematodes found during the sampling of 216 home gardens and 216 fields throughout the Cameroon highlands (September 2002–April 2003).

Species	Occurrence (%)	Individuals per 100 g root fresh weight	
		Maximum	Mean
Meloidogyne spp.	97.3	93,400	1759
Pratylenchus goodeyi	91.2	114,134	9225
Hoplolaimus pararobustus	78.4	3,433	362
Helicotylenchus multicinctus	25.7	48,400	481
Radopholus similis	14.9	39,734	655
Helicotylenchus dihystera	14.7	4,266	45
Helicotylenchus variocaudatus[1]	1.7	Not applicable	–

[1] *H. variocaudatus* was found in two samples.

to). Farmers sometimes referred to BLSD-type symptoms as caused by nematodes. Eighty-five percent of the farmers interviewed had never heard of a nematode or were aware of damage caused by them.

Although specific pests and their symptoms were not always recognized as such, most farmers made a distinction between healthy suckers and unhealthy suckers when planning plantation expansion. Most attention was given to bunch size/type, plant vigor, leaf health status and absence of weevil galleries.

More than one in five farmers used some form of treatment before planting their suckers. The most commonly used treatments were ash coating (56%), pesticide (38%) and trimming of roots (24%). Only 6% pared their suckers before planting and 5% used some form of heat treatment, with lukewarm, warm or boiling water.

In combination with the treatment of planting material (or without) most farmers used additional inputs as a management strategy in the field (or home garden). In the West province, 98% of the farmers interviewed used additional inputs in the home garden: 35% used inorganic fertilizers, 20% used pesticides, 50% used manure and 88% used kitchen waste. In the Northwest province, 95% of the farmers used inputs in the home garden: 7% used inorganic fertilizers, 4% used pesticides, 32% used manure and 97% used kitchen waste.

Field management was slightly different with more emphasis on inorganic inputs: 33% used inorganic fertilizers, 18% used pesticides, 19% used manure and 8% used kitchen waste.

Farmers of the West province used inorganic products more often (60% used inorganic fertilizers and/or pesticides) in their fields compared with the farmers of the Northwest province (26%). All farmers used organic inputs (manure, compost or kitchen waste) in at least one of the two field types.

During the interviews it became apparent that the traditional cash crop coffee was losing importance for the income of rural households. Repeated reports of plantain as a substitute for coffee-related incomes were noted. A supplementary inquiry was held to evaluate the importance of *Musa* in more detail and in comparison with coffee. A total of 89% of all farmers interviewed either had coffee in their fields or used to have it in their fields. Nevertheless, 67% of farmers interviewed found this crop to be unprofitable and were consequently switching to other crops as an alternative income source. Eighty-one percent of the farmers ranked *Musa* spp. as more important than coffee in particular.

Data analysis of the roots sampled in small-scale farmers' fields showed all bananas and plantains in both fields and home gardens to be infested with nematodes, ranging from low infestation (less than 500 individuals·100 g^{-1} root fresh weight) to severely infested (over 10^5 individuals·100 g^{-1} root fresh weight). The dominant species found were (in order of importance): *Pratylenchus goodeyi, Meloidogyne* spp., *Radopholus similis, Helicotylenchus multicinctus, Hoplolaimus pararobustus, Helicotylenchus dihystera* and *Helicotylenchus variocaudatus*. The species *P. goodeyi, Meloidogyne* spp. and *H. pararobustus* occurred frequently in the samples examined. *Helicotylenchus variocaudatus* was found in two samples (*table IV*).

4. Discussion

The high ranking of *Musa* spp. as compared with other food crops is not surprising, considering its traditional role in social events and its dual purpose as both a source of food and cash income. It ranks first in the Northwest province and second after the staple crop maize in the West province.

Musa and cash crops are traditionally a man's task in the fields, whereas other food crops are more consistently the women's task. However, all fields visited were set up with a mixed cropping system whereby *Musa* spp., various cash crops and food crops were planted together. So although responsibilities are gender-dependant, the overall management of the fields is often the responsibility of both the husband and the wife of the household.

Due to plummeting coffee prices, many farmers are switching their focus towards food crops as an alternative. Plantain ranks highly in this scenario, owing to its increased market value [4]. The potential for commercialization has, however, not been fully exploited due to inadequate technology transfer and agronomic practices used.

The dominance of the species *P. goodeyi* in the samples is consistent with previous reports on the higher altitude preference of *P. goodeyi* [5, 6, 9]. *R. similis* was encountered at locations of lower altitude. In one field a total of 114 000 individuals·100 g^{-1} root fresh weight of *P. goodeyi* was encountered, indicating that this species is capable of reaching high population densities.

Pest awareness was linked to visibility of the pest. The general lack of knowledge of nematodes is not surprising, considering their microscopic size. However, this lack can have important implications with respect to pest dispersal to uninfected fields and population build-up.

The majority of farmers had not removed their *Musa* stands from the field in the past 10 years. With land availability reducing bit by bit, due to increasing population pressure, there is a need to apply adequate technologies for the remaining "clean" soils left. In addition, technologies should be developed (crop associations) or transferred (such as mulching) that can reduce nematode damage in an already infested field.

Extension projects should take advantage of the relatively high level of organization of farmers in groups (known as common initiative groups). Sixty percent of those interviewed were part of such an organization. However, only 29% had received any form of *Musa* production training, which given the importance of this crop should be increased to meet demands.

5. Conclusion

In order to arrive at a sustainable improvement of mixed cropping systems (with a focus on *Musa*) the following factors must be taken into account:

1. mixed gender responsibilities in the field and the resulting crop associations,
2. perennial and annual crops planted together,
3. land availability restrictions,
4. financial restrictions.

Technologies that can be easily transferred today are:

1. resistant varieties,
2. clean planting methodologies: corm fragment shoots and hot-water treatment,
3. rational/integrated use of pesticides,
4. mulching.

Future research efforts should look into the exact effect of crop associations on nematode population build-up and related damage.

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Sistemas de producción basados en bananos de montaña de Camerún: estudio de casos de las provincias oeste y noroeste, con especial hincapié en la presencia de nematodos.

Resumen — Introducción. En Camerún, la mayoría de los agricultores practica un sistema de cultivos mezclados, esto hace que exista una amplia variedad de plantas hospederas para los nematodos. Los bananos y plátanos (*Musa* spp.) son un componente importante de dichos sistemas de producción como fuente de ingresos y como alimento principal. Con el fin de programar futuros proyectos de extensión, nuestro estudio analizó los tipos de asociaciones de cultivos y sus limitaciones en las provincias del oeste y noroeste de las montañas de Camerún. Puesto que los nematodos son considerados en todo el mundo como un factor limitador importante para la producción del banano, tratamos de evaluar su presencia en las regiones estudiadas. **Material y métodos**. Se realizó una encuesta que englobaba a más de 200 familias de todas las montañas de Camerún para identificar los tipos preferidos de asociación de cultivos y los procedimientos de manejo e identificación de los parásitos por parte de los pequeños agricultores. Además, se tomaron muestras para el estudio del predominio de *Pratylenchus goodeyi* en los bananos y plátanos de las huertas familiares y de los campos de cultivo de cada familia encuestada. **Resultados y discusión**. Los sistemas de cultivo varían mucho entre las distintas familias y su caracterización no fue fácil. Se identificaron treinta ocho especies plantadas en policultivo junto con los bananos, que fueron designados como producción principal por el 43% de los agricultores, seguidos por el maíz plantado como cultivo principal (19%) y por el café que supone, tradicionalmente, una fuente de ingresos inmediata (12%). La identificación de los parásitos (en % de reconocimiento) fue relativamente alta para el picudo (72%). Los principales limitantes percibidos por los agricultores fueron la necrosis foliar, la presencia de picudo y los daños causados por nematodos. Sin embargo, sólo el 15% de ellos habían oído hablar antes de los nematodos. Todas las muestras de raíces revelaron la presencia de nematodos (más del 40% mostraron más de 10^4 individuos·100 g^{-1} de peso fresco de raíces). *P. goodeyi* fue identificado como la especie dominante.

Camerún / *Musa* / sistemas de cultivo / encuestas sobre explotaciones / nematodos de las plantas