Plant nematode pests of banana in East Africa with particular reference to Tanzania

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Abstract

Plant nematodes exists as serious pests of bananas in eastern Africa causing considerable yield losses. The most important species are Pratylenchus goodeyi and Radopholus similis. Also present causing root damage are nematodes of lesser importance, in particular Helicotylenchus multicinctus, Meloidogyne spp. and Hoplolaimus spp. Although some of these nematodes and other factors are special to the region, they are not entirely unique to eastern Africa. Nematodes are considered to be the major root pests of the crop in most banana-growing countries.

An understanding of the role nematodes play in banana cultivation is essential to produce the required solutions. It is important in this analysis of their role that we do not treat nematodes, or other pests and diseases, in isolation from the many other, often interrelated, constraining influences on banana production.

Before we can formulate the research, cultural strategies and priorities to give practical and long term control measures for the farmers, we have to first give clear answer to the many unsolved questions posed by the presence of the nematodes.

1. Has the severity of nematode damage on highland bananas in East Africa increased in recent years ?
2. Are nematodes being rapidly disseminated into areas previously free of the pests ?
3. What is the main factor causing yield loss by nematodes ?
4. Do climatic or environmental conditions affect the nematode pests ?
5. Are there clear interrelationships between nematodes and other organisms ?

In order to solve the problem, the following points should be considered :

1. Resistance to plant nematodes.
2. Control of nematodes in banana material : Use of clean planting material.
3. Chemical control in field soil.
4. Non-chemical or cultural means of reducing nematodes in field soil.

It is hoped that all the points raised above can be discussed in relation to the overall objectives of INIBAP.

History

The recognition of plant parasitic nematodes as serious pests of banana in parts of East Africa has only occured in the past two decades and many questions are still left unanswered concerning their distribution and role in declining banana yields particularly of highland bananas. In 1959, it was reported that roots of banana plants in East Africa were commonly attacked by nematodes from the genera, *Pratylenchus, Meloidogyne* and *Hoplolaimus* (Whitehead, 1959), but there is no suggestion from research in the region that nematodes were causing yield losses until later. The burrowing nematode, *Radopholus similis*, was found as a pest of bananas in Somalia and by 1966 attemps were being made at its control (Beccari & Scavazzon, 1966). Bananas in Uganda were first found to be infested with *Radopholus similis* in 1968 (Bock *et al*, 1969; Anon., 1972) and more recently *Pratylenchus goodeyi* has been isolated from banana root material from Uganda (Machon & Hunt, 1985). In Kenya during 1971, *Radopholus similis* and *Pratylenchus* sp. were recovered from banana root lesions, and large population of *Helicotylenchus* and *Meloidogyne* were found associated with bananas (Taylor *et al*, 1972 ; Ngundo & Taylor, 1973). A later survey in Kenya showed that *Radopholus similis* was localised whereas the other species, identified as *Pratylenchus goodeyi*, was widely distributed on bananas (Gichure & Ondieki, 1977).

In Tanzania, nematodes causing damage to bananas were first observed in 1969 when *Radopholus similis* was isolated from diseased material (Ngundo & Taylor, 1973). The authors in this paper give the first apparent reference to the finding of *Radopholus similis* infesting local highland bananas in northwestern Tanzania in 1972. An obvious decline in yields of highland bananas had been noticed since around 1970 in the Bukoba district of Tanzania. It was suggested in 1974 that this decline was due "to heavy infestation by *Cynodon* spp. ; severe nematode attack (*Meloidogyne* sp., and *Radopholus similis* being the most prevalent and destructive species) ; and banana weevil (*Cosmopolites sordidus*) invasion" (Ngundo *et al.*, 1974). The local banana cultures found to be infested with either *Radopholus similis* or *Pratylenchus* sp. were Kiguruwe, Mbwairuma, Nkonjwa, Entukula, Ifanaiya, Kitarasa and Ngudemu.

A detailed nematode survey of highland bananas in Tanzania was undertaken in 1983 as described below.

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Nematode Survey of Highland Bananas in Tanzania

The survey of nematodes on highland bananas was done as part of a team survey to appraise the role of pests in the decline of banana yields in the Kagera region of Tanzania (Walker *et al.*, 1984). The team consisted of an entomologist, agricultural economist and myself, as a nematologist. The Kagera region is bordered by Rwanda to the west, Uganda to the north and Lake Victoria to the east. It lies at an altitude of 1200-1800 m and a latitude between 1 00' and 2 15' south.

A total of 53 different farms were sampled in the Kagera region to assess the crop damage caused by nematodes and determine the identification and distribution of nematode genera and species present. Nematodes were extracted from roots and soils, and comparisons made between population levels. The root damage associated with the different nematodes was assessed by the simple technique of determining the amount of cortical root tissues necrosed as a percentage of total root tissues. This was done at sampling in the farms by digging out roots from one part of the banana mat and splitting root pieces longitudinally so that the amount of necrosis could be observed in fresh tissues. The degree of root damage was assessed as follows :

Root damage	**Amount of root necrosis**
Slight	< 25 % of total root cortex with necrosis
Moderate	25-50 % of total root cortex with necrosis
Severe	51-75 % of total root cortex with necrosis
Very Severe	> 75 % of total root cortex with necrosis

In all sampling sites the populations and species of nematodes extracted were correlated with root damage and above-ground symptoms on the bananas.

Many different plant parasitic nematode species were found on or around banana roots in the survey (Table 1). Those occuring as endoparasites in root tissues were *Pratylenchus goodeyi*, *Radopholus similis*, *Helicotylenchus* spp. (mainly *Helicotylenchus multicinctus*), *Hoplolaimus pararobustus* and *Meloidogyne incognita* (Table 1). These nematodes occurred singly or in mixed populations in roots (Table 2). Both *Pratylenchus goodeyi* and *Radopholus similis* caused very similar necrosis of root cortical tissues consisting of yellow, purple or brown lesions in discrete patches or spreading throughout the length of the root and extending to the central stele of the root. Necrosis caused by *Helicotylenchus multicinctus* was confined to the outer cortex. The root-knot nematode *Meloidogyne incognita* caused swellings or galls most easily seen at the root-tips.

Table 1 : Plant parasitic nematode species from roots and soil of Highland bananas in Tanzania

ROOTS
Pratylenchus goodeyi Sher & Allen, 1953
Radopholus similis (Cobb, 1893) Thorne, 1949
Helicotylenchus multicinctus (Cobb, 1893) Golden, 1956
Meloidogyne incognita (Kofoid & White, 1919) Chitwood, 1949
Hoplolaimus pararobustus (Sch. Stek. & Teun., 1938) Sher, 1963
SOIL
Criconemella goodeyi (de Guiran, 1963) de Grisse & Loof, 1963
Helicotylenchus dihystera (Cobb, 1893) sher, 1961
H. microcephalus Sher, 1966
H. multicinctus
H. pseudorobustus (steiner, 1914) Golden, 1956
Meloidogyne incognita
Paratrichodorus minor (Colbran, 1956) Siddiqi, 1974
Pratylenchus goodeyi
Radopholus similis
Scutellonema sp.

The above-ground symptoms directly associated with root damage and presence of large nematode populations in the roots were toppling, stunted growth, small bunches, chlorosis, weak or reduced numbers of followers, and poor cover of bananas in the farms. Toppling or uprooting typical of nematode damage was very common caused by breakage of roots around the areas of necrotic tissues. The stunted, severely infested, bananas with small bunches often had less tendency to topple than the equally severely infested taller plants with larger bunches. The most serious examples of stunted and chlorotic bananas occurred in farms with poor soil fertility. Bananas infested with nematodes growing in the better soils tended to be taller with better foliage although bunch size was visually reduced in comparison to healthy plants.

The most important parasitic nematode responsible for severe root damage and yield loss of bananas in the Kagera region was *Pratylenchus goodeyi*. It occured in all Districts in 94.5 % of the farms samples and was directly associated with toppling and other symptoms of damage to the bananas in 84 % of these farms. *Pratylenchus goodeyi* was present as the only important root nematode parasite in 39.5 % of the farms but was also often found in concomitant populations with *Helicotylenchus multicinctus* and *Radopholus similis* (Table 2).

Table 2 : Extent of damage associated with nematodes of highland bananas in Tanzania

Root nematodes	% Farms with Root Necrosis and Toppling of Bananas			
	Slight (< 25 % root necrosis)	Moderate-Severe (25-75 % root necrosis)	Very Severe (> 75 % root necrosis)	TOTAL
1. *Pratylenchus goodeyi* Alone	5.5 %	24.5 %	9.5 %	39.5 %
2. *Radopholus similis* Alone	0	0	0	0
3. *Heliocotylenchus multicinctus* Alone	0	2 %	0	2 %
4. *P. goodeyi* *H. multicinctus* Mixed populations	3.5 %	34 %	0	37.5 %
5. *R. similis* *H. multicinctus* Mixed populations	2 %	0	2 %	4 %
6. *P. goodeyi* *H. multicinctus* *R. similis* Mixed populations	0	7.5 %	9.5 %	17 %

Radopholus similis, although present, was less important and had a restricted distribution occuring in only 21 % of the farms sampled. It did not occur in the farms in the higher altitude and cooler district of Karagwe. *Radopholus similis*, although present, was less important and had a restricted distribution occuring in only 21 % of the farms sampled. It did not occur in the farms in the higher altitude and cooler district of Karagwe. *Radopholus similis* was seen to be the main cause of toppling and root necrosis in only one farm, and root populations of *Radopholus similis* exceeded those of *Pratylenchus goodeyi* in only three farms.

Helicotylenchus spp. (mainly *Helicotylenchus multicinctus*) were widespread in 62,5 % of the farms sampled. They occured normally in mixed root populations with both *Pratylenchus goodeyi* and *Radopholus similis* and were a contributory, but not a major factor in root damage and yield decline.

The only other two plant parasitic species present in banana roots, *Hoplolaimus pararobustus* and the root-knot nematode, *Meloidogyne incognita*, were present in comparatively low populations in 9.5 % and 24.5 % of the farms respectively and were not serious pests in the farms sampled. In addition to the above species, the other parasitic nematodes found in soils were *Helicotylenchus dihystera*, *Helicotylenchus microcephalus*, *Helicotylenchus pseudorobustus*, *Criconemella goodeyi*, *Paratrichodorus minor* and *Scutellonema* sp. (Table 1). Large numbers of non-plant parasitic nematodes occured in rotting banana roots but these were secondary fungal and bacterial feeding species not involved in crop damage.

Banana weevils (*Cosmopolites sordidus*) were also serious pests of the highland bananas in Kagera and details of their distribution and the damage caused can be found in the 1984 report (Walker *et al.*, 1984). Nematodes and banana weevils occured together in the farms and on the same plants but there was no apparent direct relationship between the two pests ; both caused different types independent of each other. However, the combined effect of the two pests did contribute to increased falldowns of some plants as a result of both root breakage, due to nematodes, and corm breakage above the soil surface, due to weevils. Root breakage resulting in uprooting occured in 85 % of the farms sampled, corm breakage in 56.5 % of farms, and uprooting and corm breakage combined was observed in 39.5 % of the farms.

Nematodes on bananas in Burundi

Banana root and soil samples collected from Burundi in late 1987 were found to contain some of the important plant parasitic nematodes that occur in other countries of East Africa although, at this time, they were not associated with obvious yield reductions in the few plants sampled. At Cibitoke, *Radopholus similis* and *Helicotylenchus multicinctus* were extracted from necrotic tissues of banana cv. Pisang Awak ; *Radopholus similis*, *Helicotylenchus multicinctus*, *Scutellonema cavenessi* and *Rotylenchulus reniformis* were found in soil around roots. In another area, Bukeye, at a higher altitude of over 2000 m only *Pratylenchus goodeyi* was found in low populations in roots of banana cv. Igitsiri ; nematodes found in soil around roots were *Pratylenchus goodeyi*, *Rotylenchulus reniformis*, *Rotylenchulus unisexus*, *Helicotylenchus dihystera*, *Ogma decalineata* and *Criconema (Paracriconema)* sp.

The unanswered questions

An understanding of role plant parasitic nematodes play in highland banana cultivation in relation to other pest and disease organisms, environmental constraints, and cropping systems is essential if we are to produce the required solutions. Before we can formulate priorities for the research needed and for the cultural and control strategies that will give practical and long term benefits for the farmers and countries concerned, we have to first give clear answers to the many unsolved questions that have been raised by the results of the above and earlier work. The questions which I consider to be most important with some speculative answers can be summarised as follows :

A. Explaining the nematode problem

1. Has the severity of nematode damage on highland bananas in East Africa increased in recent years ?

— is a simple explanation that the problem has always been present but has only been investigated recently ?

— alternatively, if the severity has actually increased, could this be due to changes in cultivation techniques and local conditions, such as decrease in soil fertility, increased land pressure, climatic changes, introduction of new cultivars, etc.?

2. Are nematodes being rapidly disseminated into areas previously free of the pests ?

— we know that nematodes are easily spread on infested banana planting material and this spread is certainly occuring within areas or countries, but a more important question is why is this being allowed to occur particularly between countries ?

3. What is the main factor causing yield loss by nematodes ?

— the nematodes are root parasites causing severe cortical necrosis and root death. This damage leads to reduce growth and/or toppling of the plants. Are both these symptoms of damage equally important in relation to yield loss, or is it possible that by reducing toppling alone we can solve much of the problem ?

4. Do climatic or environmental conditions affect the nematode pests ?

— are bananas grown in particular soil types more prone to nematode attack ?

— are nematodes limited by certain temperature and moisture requirements within normal banana growing parameters ?

5. Are there clear interrelationships between nematodes and other organisms ?

— the obvious interrelationship which could occur is with *Cosmopolites* as they frequently are found together ; but is the effect simply additive ?

— fungi and other disease organisms are the other contenders for interrelationships with nematodes ; does this always occur and, if so, how important is it in relation to controlling the pests and improving yields ?

B. Solving the problem

1. Resistance to plant nematodes.

— resistance in acceptable cultivars is the most beneficial and practical means of controlling nematodes on most crops.

— some cultivars and *Musa* spp. are known or suspected to escape damage by certain nematode species. But is this tolerance rather than resistance ? The mechanisms of resistance or tolerance that may exist in local bananas are largely unknown. In most cases they are possibly forms of mechanical, rather than physiological, resistance which can be explained by different growth habits, different root systems (greater root production of greater depth or growth), and different requirements of the cultivar.

— banana nematodes are generally non-specific in their feeding habits and behaviour. This fact, together with the difficulties of working with the crop itself, does suggest that breeding for resistance is a difficult proposition.

— however, if resistance/tolerance to nematodes does exist in bananas, eastern Africa, being an apparent centre of banana genetic diversity, holds out far more promise of selecting suitable cultivars than other growing areas based on a single clone commercial cultivars.

— in the selection process, it may be possible to identify a number of genetic characters which are associated with resistance or reduced nematode damage. In addition to the host status of the cultivars, selection could also be for dwarf strains of local cultivars which may have greater resistance to toppling and stem breakage.

2. Control of nematodes in banana material : Use of clean planting material.

— it is essential to stop the spread of nematodes and this is achieved by the use of clean planting material. But, do we have an inexpensive, practical, reliable and safe method that can be recommended in different circumstances for producing nematode-free planting material ? The present choices are between, or a combination of, hot water treatment, chemical dips, and paring or manual removal of diseased tissues.

3. Chemical control in field soil.

— it can be argued that blanket use of nematicides for the long term control of nematodes is an unacceptable, impractical and economically unsound means of controlling nematodes in most of the farming systems in eastern Africa. However, is it possible to recommend a judicious use of nematicides in certain circumstances, such as planting or as spot treatments ?

4. Non-chemical or cultural means of reducing nematodes in field soil.

— organic or inorganic fertilisers can be an effective way of compensating for presence of nematodes and increasing yields. This requires more detailed investigation in local cropping systems.

— retention of moisture by mulching can also increase yields when nematodes are present.

— propping bananas can greatly increase yields by reducing toppling and stem breakage.

— these above methods are ways of living with nematodes, but is this sufficient ?

It would be presumptive to imply that this is a full list of the questions on highland banana nematodes that need to be tackled, but answers to the above will go a long way to solving the nematode problems. It is hoped that the thoughts and research programmes of nematologists and other scientists dealing with these pests in East Africa can be directed along these lines.

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