Susceptibility of *Musa* cultivars to nematodes in Kagera Region, Tanzania

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ABSTRACT
Bananas (*Musa* spp) are one of the dominant food crops in the highlands of East Africa. A survey was conducted in the Kagera Region in order to determine production constraints in the banana cropping system. East African Highland cooking bananas (*Musa* AAA, Matooke group) and to a larger extent beer bananas (*Musa* AAA, Mbire group) were observed to be replaced by the cultivars Gros Michel (*Musa* AAA), Pisang Awak (*Musa* ABB) and Kanana (*Musa* AB). The common nematode species in banana roots were *Pratylenchus goodeyi* (with high densities considering the other species), *Helicotylenchus multicinctus* and *Meloidogyne* spp. Densities of *P goodeyi* were consistently higher in the East African Highland cooking and brewing cultivars than in the cultivars Gros Michel, Pisang Awak and Kanana. The East African Highland banana cultivars were expected to be more susceptible to *P goodeyi* than more recently introduced cultivars.

KEYWORDS
Tanzania, *Musa*, varieties, pest resistance, plant nematodes, surveys, *Pratylenchus goodeyi*, *Helicotylenchus multicinctus*, *Meloidogyne*.

Sensibilité aux nématodes de cultivars de bananiers exploités dans la région de Kagera, en Tanzanie.

RÉSUMÉ
La banane (*Musa* spp) constitue l'une des principales productions alimentaires des hautes terres de l'Est africain. Une enquête a été conduite dans la région de Kagera en Tanzanie pour déterminer les contraintes de production liées au système de culture des bananiers. Certains cultivars de bananes à cuire (*Musa* AAA, groupe Matooke) et à bière de ces régions (*Musa* AAA, groupe Mbire) auraient été remplacées par les cultivars Gros Michel (*Musa* AAA), Pisang Awak (*Musa* ABB) et Kanana (*Musa* AB). Les espèces de nématodes observées dans les racines de bananiers ont été *Pratylenchus goodeyi* (en fortes densités par rapport aux deux autres), *Helicotylenchus multicinctus* et *Meloidogyne* spp. *P goodeyi* a été beaucoup plus fréquent chez les cultivars traditionnels de bananes à cuire et à bière des régions étudiées que chez Gros Michel, Pisang Awak and Kanana. La sensibilité à *P goodeyi*, plus forte pour ces anciens cultivars que pour ceux introduits récemment, pourrait expliquer leur remplacement par ces nouveaux cultivars.

MOTS CLÉS
Tanzanie, *Musa*, variété, résistance aux organismes nuisibles, nématode des plantes, enquête, *Pratylenchus goodeyi*, *Helicotylenchus multicinctus*, *Meloidogyne*.

Sensibilidad a los nemátodos de cultivares de bananos explotados en la región de Kagera en Tanzania.

RESUMEN
El banano, (*Musa* spp) constituye una de las principales producciones alimentarias de las alturas del Este africano. En la región de Kagera en Tanzania se efectuó una encuesta para determinar los apremios de producción ligados con el sistema de cultivo de los bananos. Ciertos cultivares de plátano blanco (*Musa* AAA, grupo Matooke) y para cerbeza de estas regiones (*Musa* AAA grupo Mbire), se hubieran sustituido por los cultivares Gros Michel (*Musa* AAA), Pisang Awak (*Musa* ABB) y Kanana (*Musa* AB). Las especies de nemátodos observadas en las raízes de bananos fueron *Pratylenchus goodeyi* (en fuertas densidades comparadas con las otras dos), *Helicotylenchus multicinctus* y *Meloidogyne* spp. *P goodeyi* fué mucho más frecuente en los cultivares tradicionales de plátanos blancos y para cerveza de las regiones estudiadas que en Gros Michel, Pisang Awak y Kanana. La sensibilidad a *P goodeyi*, más fuerte para estos antiguos cultivares que para los más recientes podría explicar su sustitución por estos nuevos cultivares.

PALABRAS CLAVES
Tanzania, *Musa*, variedades, resistencia a las plagas, nemátodos de las plantas, encuestas, *Pratylenchus goodeyi*, *Helicotylenchus multicinctus*, *Meloidogyne*.

introduction

The Lake Victoria Basin countries, viz Uganda, Tanzania and Kenya, produce and consume 18% of the world banana production (FAO, 1991). In Tanzania, major banana production is at higher elevation regions with abundant rainfall, such as the Kagera Region (EVERS, 1992).

In the Kagera Region, the East African Highland banana (*Musa* AAA) forms the dominant group of cultivars (BOSCH et al, 1994). It includes cooking or Matooke cultivars and brewing or Mbire cultivars (BOSCH et al, 1995). In addition to the East African Highland beer banana, the cultivars Gros Michel (*Musa* AAA), Pisang Awak (*Musa* ABB) and Kanana (*Musa* AB) are grown for brewing purposes (table I). None of the ABB and AB cultivars are used for cooking, and the cultivar Gros Michel only rarely. The fruits of the cultivars Gros Michel and Kanana are occasionally consumed as dessert fruits.

Surveys to evaluate pest pressure to *Musa* were carried out in the Kagera Region. They revealed that the dominant nematode species were *Pratylenchus goodeyi* (Sher and Allen) and *Helicotylenchus multicinctus* (Cobb, Golden); *Radopholus similis* (Cobb, Thorne) was observed occasionally (WALKER et al, 1984; BRIDGE, 1988; SIKORA et al, 1989). A more detailed survey was conducted to determine constraints to *Musa* production looking into soil fertility, cultivars, pests, diseases and management practices (BOSCH et al, 1994). This paper presents data on *Musa* cultivars and nematode species.

Table I
Banana cultivars and their distribution in the survey in Kagera Region, Tanzania.

Cultivar Common name	*Genome group*	*Synonym*[1]	*Common use*
Nshakara	AAA (Matooke-EA[2])	Enshakara; Musakala	Cooking
Nshansha	AAA (Matooke-EA)	Kisansa	Cooking
Nyoya	AAA (Matooke-EA)	Njoya	Cooking
Mbire	AAA (Mbire-EA)	Mbidde	Beer
Kijoge	AAA	Gros Michel; Bogoya	Beer / dessert
Kisubi	ABB	Pisang awak; Kayinja	Beer / dessert
Kanana	AB	?Ney poovan; Sukali Ndizi	Beer

Cultivar	*Village*[3]						*Location*[4]
	Bulamula	*Muzinga*	*Kyaitoke*	*Musira*	*Buhekera*	*Ntoija*	
Nshakara	+	+	+	+		+	Close
Nshansha	+	+	+	+	+	+	Close
Nyoya	+	+		+	+	+	Close
Mbire	+	+	+	+			Distant
Gros Michel	+		+	+	+		Distant
Pisang Awak	+	+	+	+	+	+	Distant
Kanana	+	+	+	+	+	+	Distant

[1] (KARAMURA and KARAMURA, 1994); [2] EA: East African Highland banana; [3] +: cultivar present in sample; [4] close: cultivar is generally grown close to the homestead; distant: cultivar is generally grown at a distance from the homestead.

materials and methods

In the Kagera Region, six villages and 20 farm households within each of these villages were selected. A farm household contained several fields. From each household, one field was selected, which included an area close to the house. Such a field is called a Kibanja (BOSCH et al, 1994). Generally within 15 m or more of the house, the soil is more fertile, due to household refuse, than further into the field (BOSCH et al, 1994). In addition, the cooking cultivars are grown in relatively higher numbers than the beer cultivars nearer to the house (BOSCH et al, 1995). In each Kibanja, two cultivars were selected, one grown close to the homestead and another further into the field. For each cultivar, three mats were sampled. A group of banana plants growing from connected rhizomes is defined as a mat. No single cultivar was grown in all the villages. Therefore, the survey team selected commonly grown cultivars, three cooking and four beer (table I). The three East African Highland cooking cultivars selected were consistently identified by farmers and researchers (ROSSEL and MBWANA, 1991; BOSCH et al, 1995). The East African Highland beer cultivars were more difficult to differentiate in the field and were, therefore, grouped as one Mbire cultivar. The other beer cultivars selected were Gros Michel, Pisang Awak and Kanana and are well described (ROSSEL and MBWANA, 1991). They are generally referred to as 'exotic' cultivars as they are considered to be more recently introduced into the region (KARAMURA and KARAMURA, 1994).

Root samples were collected from plants at the early flowering stage (flower emerges - fruits horizontal) in an excavation of 25 cm × 25 cm × 25 cm, at 25 cm from the base of the flowering plant. Roots from each of the three mats selected per cultivar were observed for root necrosis and then combined (BOSCH et al, 1994). Samples were stored at approximately 8 °C for up to one month prior to nematode extraction. Nematodes were extracted from a macerated 5 g subsample, using a modified Bearman funnel technique (HOOPER, 1990). Extraction time was 16 to 20 hours at room temperature, approximately 24 °C. Nematodes were counted three times in 2 ml aliquots from a 25 ml suspension, and densities per 100 g fresh root weight were estimated.

The villages and cultivars within villages were selected randomly. The observed nematode counts for the three dominant species, *P goodeyi*, *H multicinctus* and *Meloidogyne* spp, were transformed using the square root (counts + 0.5) transformation (GOMEZ and GOMEZ, 1984). Pair-wise comparisons of least squares means (LSMEANS) of transformed counts were performed using the general linear models (GLM) procedure and LSMEANS statement in SAS (anon, 1987). Furthermore, genome groups were formed and differences evaluated. Components of variance were also estimated in SAS (VARCOMP procedure).

results and discussion

It was observed that East African Highland cooking cultivars and, to a larger extent, the East African Highland brewing cultivars had been replaced with exotic beer cultivars (anon, 1989; BOSCH et al, 1995). The cultivar Gros Michel is the most common replacement, followed by Kanana and Pisang Awak (MUKANDALA et al, 1994). Currently 65% of all mats in the survey were classified as East African Highland cooking cultivars, 9% as East African Highland brewing cultivars and 26% as exotic brewing cultivar (BOSCH et al, 1995). In the late 1960s, 98% of the mats grown in the Kagera Region were East African Highland cultivars; 70% of these cultivars were cooking and 30% brewing cultivars (FRIEDRICH, 1968; RALD and RALD, 1975), which suggests a 24% overall reduction in East African Highland cultivars. The East African Highland brewing cultivars appear to have been replaced by exotic beer cultivars in excess of 70% during the last 25 years. The replacement may possibly be linked to nematode susceptibility; therefore, the nematode densities were compared for the different cultivar groups.

P goodeyi was the dominant nematode species at all sites and for all cultivars (table II). *H multicinctus* and *Meloidogyne* spp were also commonly observed; however, in consistently lower densities. *R similis* and *P coffeae* were occasionally observed, but always in very low densities of less than 300 nematodes per 100 g fresh root weight

Table II
Nematode densities per 100 g fresh root weight of seven *Musa* cultivars grown in six villages in Kagera Region, Tanzania.

Cultivar	*Genome group*	*n*	*P goodeyi*	*H multicinctus*	*Meloidogyne* spp
Nshakara	AAA (EA[1])	21	23,300	70	250
Nshansha	AAA (EA)	54	14,260	610	20
Nyoya	AAA (EA)	39	9,370	1,890	160
Mbire	AAA (EA)	33	11,090	380	170
Gros Michel	AAA	27	1,950	680	80
Pisang Awak	ABB	24	1,670	590	90
Kanana	AB	30	1,270	130	330
Village	Altitude masl	*n*	*P goodeyi*	*H multicinctus*	*Meloidogyne* spp
Muzinga	1,500-1,600	39	14,490	130	290
Bulamula	1,460-1,500	37	16,990	50	250
Ntoija	1,160-1,300	34	3,840	1,170	100
Musira	1,160-1,235	40	9,650	240	130
Kyaitoke	1,280	37	7,470	740	–
Buhekera	1,220-1,280	41	3,540	1,790	90

n: number of samples; [1] EA: East African Highland banana; *Pratylenchus goodeyi* and *Helicotylenchus multicinctus*: juveniles + females + males; *Meloidogyne* spp: juveniles.

(table III). The nematode species profile observed in the Kagera Region is similar to those observed in Uganda (KASHAIJA et al, 1994; SPEIJER et al, 1994a,b), Kenya (SPEIJER et al, 1993) and Cameroon (SARAH, 1989; BRIDGE et al, 1995) at similar elevations.

Of the mats sampled, 64.5% were classified as East African Highland banana cultivars, 13.2% as Pisang Awak, 11.8% as Gros Michel and 10.5% as Kanana. The *P goodeyi* densities on East African Highland cultivars differed for the villages Bulamula and Buhekera ($P = 0.0421$); however, they did not differ among the Highland cultivars within the villages ($P = 0.2813$). Much of the variation (92.8%) in nematode counts for the Highland cultivars remains unexplained; however, this may be attributed to differences in nematode densities in planting material used, management or plantation age. The cultivar Gros Michel was mainly grown at one location, Buhekera, and was therefore excluded from further analysis. The *P goodeyi* densities on the *Musa* genome groups AAA (East African Highland types), AB and ABB were different between the genome groups ($P = 0.0001$), but not among the villages ($P = 0.1326$). Genome differences explained 19.5%, while village difference accounted for 0% of the variation. The *P goodeyi* densities observed for the AAA genome group were significantly higher ($P \leq 0.0014$), than for the AB and ABB group (table IV). The relatively higher densities of *P goodeyi* suggest that the East African Highland banana cultivars are more susceptible to *P goodeyi* than the exotic *Musa* AB and ABB cultivars. The higher susceptibility of the East African Highland cultivars to *P goodeyi* may be the reason for their gradual replacement by the less susceptible exotic cultivars. The relatively high replacement of Mbire cultivars may be explained by the fact that they were generally grown further away from the homestead than the Matooke cultivars. Therefore, Mbire cultivars received less additional nutrients from household waste and their root system may develop at a

Table III
Occurrence of *Radopholus similis (Rs)* and *Pratylenchus coffeae (Pc)* in *Musa* cultivars in Kagera Region, Tanzania.

Cultivar	*Village*					
	Bulamula	*Muzinga*	*Kyaitoke*	*Musira*	*Buhekera*	*Ntoija*
Nshakara	*Rs*					
Nshansha		*Rs*	*Pc*	*Rs Pc*	Pc	
Nyoya	Pc					
Mbire	*Pc*		*Pc*	Pc		
Gros Michel						
Pisang Awak		Rs				
Kanana						

Table IV
Comparison of *Pratylenchus goodeyi* densities for the *Musa* genome groups AAA (East African Highland type), ABB and AB, using least square means for the transformed nematode densities.

Genome	*P goodeyi density*	*P values for comparison of transformed [1] nematode densities*		
		AAA (EA[2])	*ABB*	*AB*
AAA (EA)	13,542	–	0.0014	0.0002
ABB	1,670		–	0.8164
AB	1,270			–

[1]: Nematode density transformation using square root (counts + 0.5); [2]: EA[2] East African Highland banana.

slower pace, further reducing its tolerance to nematode attack.

In Kenya, SPEIJER and SIKORA (1990) observed results comparable to those observed in the Kagera Region, such as high densities of *P goodeyi* in Nakyetengu of the East African Highland banana group as compared to low densities in Kanana grown on farms. Only limited data are available for comparison of cultivar performance in other regions. In Cameroon, PRICE (1994) observed low *P goodeyi* densities for Banane Cochon of the East African Highland bananas group and high densities for Christine and Pelipita of the *Musa* ABB group. Comparison of host plant response is difficult because the same cultivars were not available in each region. However, the results suggest that a considerable variation in nematode host response to *P goodeyi* may exist for cultivars from the same genome group. In addition, different pathotypes for *P goodeyi* may be expected, as have been observed for *R similis* (SARAH et al, 1993).

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introduction

Récemment, JERRAYA et ZAIDI (1995) ont montré que la mineuse des agrumes, bien que d'introduction récente en Tunisie, provoquait des dégâts sévères sur les pousses estivales de diverses espèces du genre *Citrus*. Les traitements appliqués en cette saison (été), à titre d'essai, n'ont pas pu assurer une protection satisfaisante des organes vulnérables, en raison, sans doute, de la présence conjointe, dans des proportions comparables, de stades jeunes et âgés de l'insecte nuisible, ces derniers stades étant les moins sensibles aux insecticides employés.

Le peu d'efficacité relative de la lutte chimique pourrait aussi être lié au fait que l'insecticide induit un taux de mortalité insuffisant lorsque l'insecte nuisible est présent à de fortes densités ; en effet, en cas d'attaque importante, les parasites survivants, dont l'espèce se reproduit à un rythme rapide, restent à un niveau suffisamment élevé pour reconstituer la population initiale.

De plus, la difficulté des produits à pénétrer la cuticule foliaire peut intervenir pour expliquer, également, le peu de résultats obtenus, car, en freinant la pénétration de l'insecticide dans le système vasculaire, elle favorise, du fait de la croissance continue des feuilles, la dilution de la matière active dans le végétal hôte ; par ailleurs, les nouvelles pousses qui apparaissent après le traitement insecticide restent totalement vulnérables. Ainsi, la lutte conventionnelle, qui est pratiquée pour le contrôle de la mineuse des agrumes, présente de réelles limites. La solution pourrait résider dans la combinaison de plusieurs procédés de lutte (lutte biologique, techniques culturales appropriées, etc).

De telles méthodes n'étant pas encore développées, la lutte chimique pourrait être améliorée par la définition d'une gamme de produits efficaces et peu coûteux, susceptibles d'épargner quelque peu les autres espèces animales utiles. C'est dans cette perspective que s'inscrivent les expérimentations présentées dans ce document.

matériel et méthodes

L'expérimentation a été menée sur le site de Mornag (banlieue-sud de Tunis), dans une jeune plantation de citronniers, de la variété Eureka, âgés de 3 ans et appartenant à un agriculteur privé. Trois produits insecticides, dont l'un utilisé à deux doses, ont été testés par rapport à un lot d'arbres témoins non traités ; l'essai a donc été constitué de quatre traitements et un témoin. Cinquante pieds, dix par traitement, ont été choisis dans le verger expérimenté.

Les produits appliqués ont été les suivants :
– l'Evisect S est un produit présenté sous une formulation de poudre à 50 % de matière active (thiocyclamhydrogen oxalate) ; il agit par contact, ingestion et est doué de propriétés systémiques ; cet insecticide spécifique a peu d'effet sur la faune auxiliaire ; deux doses ont été choisies : 100 et 200 g/hl ;
– le Confidor est un produit commercial qui se présente sous une forme liquide à 20 % de matière active (Imidacloprid) ; il agit par contact, ingestion et par voie systémique ; il a la propriété d'avoir un effet remontant ; cela constitue un avantage tout particulier pour la lutte contre la mineuse, puisque un tel traitement assurerait, pendant une quinzaine de jours environ, une protection des jeunes feuilles, au fur et à mesure de leur apparition ; le produit a été testé à la dose de 60 ml/hl ;
– l'Oleostec est une huile minérale émulsionnable, de masse volumique 0,871 et de viscosité 14,8 (à 40 °C), à base de paraffine ; ce produit permet d'inhiber la ponte de *Phyllocnistis citrella* et de tuer les larves par suffocation, tout en ayant un coût/ha relativement faible, et peu d'effets secondaires sur l'environnement (BEATTIE, 1990a et 1990b). La dose utilisée lors de l'essai a été de 500 ml/hl.

Un premier contrôle, réalisé le 24 janvier 1996, juste avant le traitement, a montré que tous les stades de l'insecte étaient présents dans le verger, y compris le stade nymphe, avec, cependant, une prédominance de jeunes larves (tableau Ia). Le taux d'infestation était alors relativement élevé (tableau Ib : 73 %), avec une moyenne de plus de deux individus vivants par feuille attaquée (tableau Ic), ce qui justifiait de déclencher un traitement chimique.

Les applications d'insecticides ont donc été effectuées ce même jour (24 janvier 1996) ; 2 l de bouillie par arbre, quantité qui était jugée suffisante pour mouiller les organes sensibles de la plante, ont été apportés à l'aide d'un pulvérisateur à dos, de capacité 18 l.