# NEMATODE REPRODUCTION AND DAMAGE TO *MUSA* SWORD SUCKERS AND SWORD SUCKER DERIVED PLANTS

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## ABSTRACT

P. R. Speijer, E. Boonen, D. Vuylsteke, R. L. Swennen, and D. De Waele. 1999. Nematode reproduction and damage to *Musa* sword suckers and sword sucker derived plants. Nematropica 29:193-203.

The susceptibility and sensitivity to *Radopholus similis* and *Helicotylenchus multicinctus* of 2-month-old plants derived from sword suckers (early screening) and of sword suckers of established 18-month-old mats belonging to 12 *Musa* genotypes was investigated and compared. Differences in nematode population densities and root damage (number of functional roots, percentage of dead roots and necrosis) were observed between the two evaluation trials which suggests a different host plant response to nematode attack of young root systems compared to older root systems. Therefore, for early screening, it is proposed that sword sucker derived plants be grown in nematode-free soil for at least 8-10 weeks to enable the plants to develop mature root systems, comparable to those of sword suckers from established mats.

*Key-words:* Banana, *Helicotylenchus multicinctus*, *Musa*, necrosis, plantain, population densities, *Radopholus similis*, root damage, screening.

## RESUMEN

P. R. Speijer, E. Boonen, D. Vuylsteke, R. L. Sweennen y D. De Waele. 1999. Respuesta de los vástagos certificados de *Musa* y de las plantas derivadas de vástagos, a la reproducción y daño de nematodos. Nematrópica 29:193-203.

La susceptibilidad y sensibilidad a *Radopholus similis* y *Helicotylenchus multicinctus* de plantas de 2 meses de edad derivadas de vástagos certificados, previamente seleccionados y de vástagos certificados de plantíos establecidos por 18 meses, pertenecientes a 12 genotipos de *Musa*, fueron investigadas y comparadas. Diferencias en cuanto a las densidades poblacionales de los nematodos y al daño de la raíz (número de raíces funcionales, porciento de raíces muertas y necrosis) fueron observadas entre los dos ensayos evaluativos, lo que sugiere que la planta hospedante, responde de manera diferente al ataque por nematodos del sistema radical joven, en comparación al sistema radical viejo. Por lo que se propone, que para la selección temprana, las plantas derivadas de vástagos certificados, se crezcan en suelo libre de nematodos por al menos 8-10 semanas, para permitir que las mismas desarrollen un sistema radical maduro, comparable al producido por los vástagos certificados provenientes de plantíos establecidos.

*Palabras claves:* banana, daño a la raíz, densidad poblacional, *Helicotylenchus multicinctus*, *Musa*, necrosis, plátano, *Radopholus similis*, selección.

## INTRODUCTION

The East African highland banana (*Musa* spp., AAA group) is the most extensively grown food crop and a source of income for millions of people in Uganda, Burundi, Rwanda, the Kivu region of the Democratic Republic of Congo, Tanzania, and western Kenya. The majority of the bananas are cultivated either for preparing "matooke," a cooked starch-rich puree, or "mbidde," a beer (Karamura and Karamura, 1994). Uganda produces about 9 million tons of banana annually, representing about 11% of the total world production (FAO, 1994). In Uganda, bananas are cultivated by more than 75% of farmers on 1.5 million hectares, equivalent to almost 40% of the arable land (Karamura, 1993). As elsewhere in East Africa, bananas are primarily produced by smallholders in home gardens and consumed locally.

Banana production in East Africa is declining. In Uganda, banana production has fallen by more than 25% from more than 8 ton/ha in the 1970s to less than 6 ton/ha in the 1990s (Karamura, 1993). Root nematodes, the banana weevil (*Cosmopolites sordidus*), black sigatoka leaf spot disease (*Mycosphaerella fijiensis*), banana streak disease caused by the banana streak virus (BSV) and reduced soil fertility are considered the major constraints to banana production (Gold *et al.*, 1993; Sebasigari and Stover, 1988; Speijer *et al.*, 1994; Tushemereirwe *et al.*, 1996).

Plant-parasitic nematode species identified on bananas in East Africa include the lesion-inducing nematodes *Radopholus similis* (Cobb) Thorne, *Helicotylenchus multicinctus* (Cobb) Golden, *Pratylenchus goodeyi* Sher & Allen, and several root-knot nematodes, *Meloidogyne* spp. (Bridge, 1988; Gichure and Ondieki, 1977; Kashaija *et al.*, 1994; Sikora *et al.*, 1989; Speijer and Bosch, 1996). Lesion-inducing nematodes feed and multiply inside the banana roots and corm, cause root necrosis and suppress root growth. In addition, the weakened root system affects plant anchorage resulting in plant toppling, especially at bunch filling and when strong winds prevail (Gowen and Quénéhervé, 1990). *Radopholus similis* and *H. multicinctus* dominate in the lower elevations of Uganda, ranging from 1 000 to 1 350 m above sea level (Kashaija *et al.*, 1994). Production loss in East African highland bananas caused by these species varies in Uganda from 30% to 50% (Speijer and Kajumba, 1996).

The use of *Musa* cultivars with resistance or tolerance to nematodes is an appropriate strategy to reduce yield losses caused by this pest. In order to identify such cultivars, the susceptibility to nematode reproduction and the sensitivity to nematode damage of selected cultivars have to be investigated. Following the terminology of Bos and Parlevliet (1995), resistance/susceptibility on the one hand and tolerance/sensitivity on the other hand are defined as independent, relative qualities of a host plant based on comparison between genotypes. A host plant may either suppress (resistance) or allow (susceptibility) nematode development and reproduction; it may suffer either little injury (tolerance), even when infected with relatively large numbers of nematodes, or much injury (sensitivity), even when infected with few nematodes. The comparison between genotypes results in such indications as completely, highly, and partially resistant genotypes describing, respectively, genotypes supporting no, little or an intermediate level of nematode reproduction.

In *Musa*, a flowering plant or a plant bearing a bunch (mother plant) is surrounded by many small plants or suckers in different stages of development (daughter plants or followers). Such a cluster is referred to as a mat and is usually several years old. The susceptibility and sensitivity to nematodes of a *Musa* genotype is often evaluated early in the first crop cycle (the time between planting and the first harvest), either in containers in the greenhouse or in the field, using 2-to- 3-month-old plants grown from sword suckers (see for instance Fogain, 1996; Price, 1994). A sword sucker is a 50 to 150 cm high sucker with lanceolate leaves of which the growth is inhibited by the mother plant. Sword suckers are considered the best conventional planting material (Swennen, 1990). To be relevant, the so-called early screening of sword sucker derived plants should be comparable with the host response in the field of sword suckers of established mats belonging to the same genotype.

In this study, the susceptibility and sensitivity for *Radopholus similis* and *Helicotylenchus multicinctus* of 2-month-old sword sucker derived plants (early screening) and of sword suckers of established 18-month-old mats belonging to 12 *Musa* genotypes was investigated and compared.

## MATERIALS AND METHODS

Two evaluations were carried out at the Eastern and Southern Africa Regional Center (ESARC) of the International Institute of Tropical Agriculture (IITA) in Sendusu, Uganda. Sendusu is located at 1 200 m above sea level, has an average annual rainfall of approximately 1 100 mm and an average annual temperature of 22°C, with an average monthly minimum of 16°C and an average monthly maximum of 28°C. Sendusu has a dark reddish brown sandy loam soil with a pH ranging from 5.5 to 6.2 (IITA, 1992).

Twelve *Musa* genotypes belonging to six genomic groups were included in the evaluations: three diploids (*Musa* AA and AB), two dessert bananas (*Musa* AAA) and two East African Highland bananas (*Musa* AAA), one plantain (*Musa* AAB), two cooking and brewing bananas (*Musa* ABB) and two *Musa* hybrids (Table 1). These genotypes represent cultivars commonly grown in Uganda ('Sukali Ndizi', 'Gros Michel', 'Entundu', 'Mbwazirume', 'Pisang Awak'), parents used in the *Musa* breeding program of IITA ('Calcutta 4', 'Pisang Lilin', 'Obino l'Ewai'), improved hybrids ('TMPx 582-4', 'TMBx 612-74'), a cultivar with interesting agronomic characteristics ('Cardaba') and a susceptible reference genotype ('Valery').

*Evaluation of sword suckers of established mats*: Ten mats per genotype were planted (at 2 m distance within a row, 3 m between rows) in field plots in September 1993. Non-infected planting material was obtained by using tissue-cultured plants for the AA diploids, 'Valery', 'Obino l'Ewai', 'Cardaba' and the hybrids. Pared and hot water treated (Colbran, 1967) suckers of uniform size were used for 'Sukali Ndizi', 'Gros Michel', the East African highland bananas and 'Pisang Awak'. At planting, half of the plants were inoculated using 100 g of root segments from the cultivar Mbwazirume infected with a mixture of approximately 18 000 *R. similis*, 23 500 *H. multicinctus* and 3 200 *P. goodeyi* collected in farmer fields. The plants were mulched, but no fertilizers were applied during the trial. Two treatments (nematode-infected and non-infected) were compared using a completely randomized design.

Starting from February 1995 sword suckers were detached from harvested mats and assessed for nematode density and damage. In most mats more than one sword sucker developed. For most genotypes this resulted in more observations than mats planted (Table 1).

*Evaluation of 2-month-old sword sucker derived plants (early screening)*: The trial was established in June 1996. The planting material consisted per genotype of pared and hot water-treated (Colbran, 1967) sword suckers of uniform size. Two treatments (nematode-infected and non-infected) were compared using a completely randomized design. The nematode-infested plot was obtained by planting and growing suckers (a mixture of susceptible East African highland cultivars) heavily infected with *R. similis* and *H. multicinctus* in a 1 m × 1 m spacing during six months prior to the initiation of the trial.

Table 1. *Musa* genotypes tested for nematode resistance and tolerance at Sendusu, Uganda (1995-1997).

| | | | Number of observations | | | |
|---|---|---|---|---|---|---|
| | | | Established mat trial | | Early screening trial | |
| Genotype | Genome | Subgroup/Type | Non-infested | Infested | Non-infested | Infested |
| Calcutta 4 | AA | Wild diploid | 12 | 10 | 6 | 6 |
| Pisang Lilin | AA | Edible diploid | 17 | 12 | 7 | 6 |
| Sukali Ndizi | AB | Edible diploid | 12 | 16 | 15 | 6 |
| Gros Michel | AAA | Gros Michel | 19 | 12 | 13 | 10 |
| Valery | AAA | Cavendish | 10 | 10 | 6 | 6 |
| Entundu | AAA | Mbidde | 20 | 18 | 7 | 6 |
| Mbwazirume | AAA | Matooke | 19 | 36 | 12 | 6 |
| Obino l'Ewai | AAB | French Plantain | 26 | 22 | 6 | 6 |
| Pisang Awak | ABB | Pisang Awak | 8 | 19 | 8 | 7 |
| Cardaba | ABB | Bluggoe | 13 | 11 | 11 | 5 |
| TMPx 582-4 | Bobby Tannap × Calcutta 4 | 4× Plantain Hybrid | 25 | 16 | 9 | 8 |
| TMBx 612-74[z] | Bluggoe × Calcutta 4 | 4× Banana Hybrid | 21 | 21 | 9 | 3 |

[z]Off-type.

These infected suckers were removed at the time of planting of the trial. The plants were mulched, but no fertilizers were applied during the trial.

In August 1996, 2 months after planting, the plants derived from the sword suckers were removed from the soil and assessed for nematode density and root damage. For each genotype, the survival rate of the plants was recorded and expressed as the percentage of the plants alive at time of assessment out of the sword suckers of that genotype planted.

*Root damage and nematode density assessment*: Root sampling, root damage and nematode density assessment were done according to the procedures described by Speijer and Gold (1996) and Speijer and De Waele (1997). Root damage observations included: number of functional primary roots (= functional roots), percentage of non-functional primary roots (= dead roots), and percentage of root necrosis. Estimation of the percentage root necrosis was based on the scoring of five 10-cm-long longitudinally sliced functional primary roots. Nematodes were extracted from a macerated 5 g sub-sample of the five roots previously scored for necrosis using a modified Baermann funnel technique (Hooper, 1990). Extraction time was 16-20 hours at room temperature of approximately 24°C. Nematodes in three 2-ml aliquots (taken from a 25 ml suspension) per sample were then counted and are presented as number of nematodes per 100 g fresh root weight (FRW). *Radopholus similis* and *H. multicinctus* numbers consist of females, males and juveniles.

*Statistical analysis*: Data on number of functional roots, percentage dead roots, percentage root necrosis and nematode densities of the 2-month-old sword sucker derived plants and of the sword suckers of the established mats were compared by Student's *t*-test. Differences in number of functional roots, percentage dead roots, percentage root necrosis and nematode densities between genotypes in each evaluation trial were subjected to General Linear Models procedure and means were separated using the Least Square Means procedure available in the SAS software (SAS, 1992). Percentage root necrosis and nematode numbers were ln(x + 1) transformed, while percentage dead roots was arcsin transformed prior to analysis. Number of functional roots was not transformed before analysis. Ranking of genotypes based on nematode densities or damage was compared using Spearmann's Rank Order Correlation (Statistica, 1993).

## RESULTS

*Survival of planting material*: In the early screening trial (evaluation of 2-month-old sword sucker derived plants), plant death was a major constraint. For all genotypes combined, the survival was lower (*t*-test, $P < 0.05$) in the infested plots compared to the non-infested plots. Plant death was highest for 'Sukali Ndizi', 'Mbwazirume', 'Pisang Awak' and 'TMBx 612-74', for which survival in the nematode infested plots was 40 to 60% lower compared to the noninfested plots. For 'Calcutta 4' and 'Valery,' plant death was generally high; only 55-60% of the plants survived, in both the non-infested and the infested plots, for the period of the trial.

*Nematode densities*: *Radopholus similis* and *H. multicinctus* were the most abundant species in both evaluation trials. *Meloidogyne* spp. were observed in low numbers, while *P. goodeyi* was rarely found in the roots. In the established mat trial, 'Valery' supported the highest density of *R. similis* (33 653 per 100 g FRW; Table 2). Other genotypes with high densities of *R. similis* were 'Calcutta 4', 'Pisang Lilin', 'Entundu', 'TMPx 582-4' and 'TMBx 612-74'. The genotype with the lowest density was 'Gros Michel', with only 340 *R. similis* per 100 g FRW. In the early screening trial, no significant differences in average densities of *R. similis* were observed among genotypes (Table 2). 'Obino l'Ewai' supported the highest density of *R. similis* (38 528 per 100 g FRW). 'Calcutta 4' and 'Pisang Lilin' supported the lowest densities of *R. similis* (1 144 and 2 706 per 100 g FRW, respectively). *Radopholus similis* densities were higher ($P < 0.05$) in the established mat trial compared to the early screening trial for 'Calcutta 4', 'Valery' and 'Entundu'. Ranking of genotypes for *R. similis* densities supported differed ($R_{spearman} = 0.020$, $P = 0.948$) between the two evaluation trials. Although 'Gros Michel' supported the lowest density of *R. similis* in the established mat trial, it ranked only fourth lowest in the early screening trial, after 'Calcutta 4', 'Pisang Lilin' and 'TMBx 612-74'. 'Pisang Lilin' supported a high density of *R. similis* in the established mat trial, but supported a low density in the early screening trial.

In the established mat trial, 'TMPx 582-4' supported the highest density of *H. multicinctus* (31 529 per 100 g FRW; Table 2). Other genotypes with high densities of *H. multicinctus* were 'Sukali Ndizi', 'Obino l'Ewai' and 'Cardaba'. 'Calcutta 4' and 'Pisang Awak' supported the lowest densities of *H. multicinctus* (1 366 and 1 378 per 100 g FRW, respectively). In the early screening trial, 'Cardaba' supported the highest density of *H. multicinctus* (8 418 per 100 g FRW; Table 2), while 'Calcutta 4' supported only 15 *H. multicinctus* per 100 g FRW. For all genotypes except 'Pisang

Table 2. Number[y] of *Radopholus similis* and *Helicotylenchus multicinctus* per 100 g fresh root weight extracted from sword suckers of 18-month-old mats (established mat trial) and from 2-month-old sword sucker derived plants (early screening trial) of 12 *Musa* genotypes grown in nematode-infested plots, Sendusu, Uganda.

| | *Radopholus similis* | | *Helicotylenchus multicinctus* | |
|---|---|---|---|---|
| Genotype | Established mat trial | Early screening trial | Established mat trial | Early screening trial |
| Calcutta 4 | 18,784 ef[z] | 1,114 a | 1,366 ab | 15 a |
| Pisang Lilin | 27,676 Cdef | 2,706 a | 4,818 bcd | 1,607 bcd |
| Sukali Ndizi | 5,232 Ab | 8,678 a | 10,246 bcde | 1,063 bcd |
| Gros Michel | 340 A | 5,904 a | 3,631 abcd | 748 bc |
| Valery | 33,653 F | 10,958 a | 8,755 de | 1,194 bcd |
| Entundu | 23,824 Ef | 10,019 a | 4,970 bcde | 1,136 ab |
| Mbwazirume | 9,478 A | 12,444 a | 6,731 a | 1,708 abc |
| Obino l'Ewai | 11,056 Bcde | 38,528 a | 20,560 e | 3,750 bcd |
| Cardaba | 15,621 Abcd | 20,732 a | 13,280 de | 8,418 cd |
| Pisang Awak | 2,734 Abc | 8,516 a | 1,378 abc | 4,602 |
| TMPx 582-4 | 28,754 Def | 14,212 a | 31,529 cde | 3,878 d |
| TMBx 612-74 | 26,803 Def | 4,639 a | 9,758 bcde | 6,500 abc |

[y]Data were ln(x + 1) transformed prior to statistical analysis.
[z]Means in columns followed by the same letter are not significantly different ($P < 0.05$) according to Least Square Means test.

Awak', the densities of *H. multicinctus* were higher in the established mat trial compared to the early screening trial. These differences were only significant ($P < 0.05$) for 'Calcutta 4' and 'Valery'. The two trials differed ($R_{spearman} = 0.503$, $P = 0.095$) in ranking for the *H. multicinctus* densities by genotype. The difference in ranking was most evident for 'Pisang Awak' which supported the lowest density of *H. multicinctus* in the established mat trial but the second highest in the early screening trial.

*Number of functional roots*: The number of functional roots was influenced by nematode attack, genotype and method used. In the non-infested field of the established mat trial, the average number of functional roots varied from 16 to 30 per sword sucker (Table 3). 'Valery' had the highest and 'TMBx 612-74' had the lowest number of functional roots in the established mat trial. In the non-infested field of the early screening trial the average number of functional roots varied from 6 to 25 per sword sucker derived plant. 'Gros Michel' had the highest and 'Calcutta 4' and 'Pisang Awak' the lowest number of functional roots in the early screening trial. For the majority of the genotypes the average number of functional roots in the non-infested field was higher in the established mat trial compared to the early screening trial. These differences were significant ($P < 0.05$) for 'Calcutta 4', 'Pisang Lilin', 'Pisang Awak' and 'TMPx 582-4'. Genotype rankings for number of functional roots in non-infested plots for the established mat trial and the early screening trial were correlated ($R_{spearman} = 0.679$, $P = 0.015$).

Table 3. Number of functional roots of sword suckers of 18-month-old mats (established mat trial) and of 2-month-old sword sucker derived plants (early screening trial) of 12 *Musa* genotypes grown in nematode-infested and non-infested plots, Sendusu, Uganda.

| Genotype | Non-infested field: Established mat trial | Non-infested field: Early screening trial | Infested field: Established mat trial | Infested field: Early screening trial |
|---|---|---|---|---|
| Calcutta 4 | 19 ab[z] | 6 ab | 27 de | 3 a |
| Pisang Lilin | 17 a | 8 abc | 21 bcd | 16 a |
| Sukali Ndizi | 21 abc | 23 de | 22 cd | 17 a |
| Gros Michel | 24 abc | 25 e | 33 e | 12 a |
| Valery | 30 c | 21 de | 15 abc | 10 a |
| Entundu | 27 bc | 22 de | 16 ab | 14 a |
| Mbwazirume | 27 bc | 23 de | 19 bc | 20 a |
| Obino l'Ewai | 21 ab | 18 bcde | 15 ab | 17 a |
| Cardaba | 26 abc | 22 de | 27 d | 18 a |
| Pisang Awak | 19 ab | 6 a | 15 ab | 8 a |
| TMPx 582-4 | 23 abc | 18 cde | 13 a | 12 a |
| TMBx 612-74 | 16 a | 16 bcd | 15 ab | 16 a |

[z]Means in columns followed by the same letter are not significantly different according to the Least Square Means test ($P < 0.05$).

In the infested field of the established mat trial, the average number of functional roots varied from 13 to 33 per sword sucker (Table 3). 'Gros Michel' had the highest and 'TMPx 582-4' the lowest number of functional roots in the established mat trial. In the infested field of the early screening trial, the average number of functional roots varied from 3 to 20 per sword sucker derived plant. 'Mbwazirume' had the highest and 'Calcutta 4' the lowest number of functional roots in the early screening trial. For the majority of the genotypes the average number of functional roots in the infested field was higher in the established mat trial compared to the early screening trial. These differences were significant ($P < 0.05$) for 'Calcutta 4', 'Gros Michel', 'Valery' and 'Cardaba'. Genotype rankings for number of functional roots in the infested plots were not correlated ($R_{spearman} = 0.143$, $P = 0.656$) for the established mat trial and the early screening trial.

*Root damage*: The percentage dead roots and the percentage root necrosis were influenced by nematode attack, genotype and method used. In the established mat trial, the percentage dead roots varied from 12% in 'Gros Michel' to 41% in 'Obino l'Ewai' (Table 4), while 'Sukali Ndizi', 'Gros Michel', 'Pisang Awak' and 'TMBx 612-74' had less than 20% dead roots. In the early screening trial, the percentage dead roots varied from 4% in 'TMBx 612-74' to 34% in 'Entundu' (Table 4), while 'Pisang Lilin', 'Sukali Ndizi', 'Obino l'Ewai' and 'TMBx 612-74' had less than 20% dead roots. 'Pisang lilin' and Obino l'Ewai scored higher ($P < 0.05$)

Table 4. Percentage of dead roots and percentage of root necrosis in sword suckers of 18-month-old mats (established mat trial) and in 2-month-old sword sucker derived plants (early screening trial) of 12 *Musa* genotypes grown in nematode-infested plots, Sendusu, Uganda.

| | % Dead roots[x] | | % Root necrosis[y] | |
|---|---|---|---|---|
| Genotype | Established mat trial | Early screening trial | Established mat trial | Early screening trial |
| Calcutta 4 | 21 abcd[z] | 28 a | 32 d | 2 a |
| Pisang Lilin | 33 cd | 7 a | 31 d | 2 ab |
| Sukali Ndizi | 17 abc | 15 a | 11 ab | 16 abc |
| Gros Michel | 12 a | 30 a | 6 a | 7 abc |
| Valery | 31 bcd | 32 a | 37 d | 16 cd |
| Entundu | 30 bcd | 34 a | 30 d | 23 abc |
| Mbwazirume | 26 abcd | 25 a | 16 a | 15 bcd |
| Obino l'Ewai | 41 d | 12 a | 28 cd | 43 d |
| Cardaba | 21 ab | 27 a | 26 cd | 12 abc |
| Pisang Awak | 15 ab | 31 a | 17 abc | 6 abc |
| TMPx 582-4 | 31 cd | 26 a | 25 d | 21 cd |
| TMBx 612-74 | 15 ab | 4 a | 22 bcd | 4 abc |

[x]Data were arcsin transformed prior to statistical analysis.
[y]Data were ln(x + 1) transformed prior to statistical analysis.
[z]Means in columns followed by the same letter are not significantly different ($P < 0.05$) according to the Least Square Means.

for percentage dead roots in the established mat trial compared to the early screening trial. In 'Gros Michel' and 'Pisang Awak' the percentage dead roots was twice as high in the early screening trial compared to the established mat trial, but the difference was not significant. In nematode-infested plots, genotype rankings for percentage dead roots in the established mat trial and the early screening trial were not correlated ($R_{spearman} = -0.151$, $P = 0.639$).

In the established mat trial, the percentage root necrosis varied from 6% in 'Gros Michel' to 37% in 'Valery' (Table 4). The genotypes with less than 20% root necrosis were 'Sukali Ndizi', 'Gros Michel', 'Mbwazirume' and 'Pisang Awak'. In the early screening trial, the percentage root necrosis varied from 2% in 'Calcutta 4' and 'Pisang Lilin' to 43% in 'Obino l'Ewai' (Table 4). 'Calcutta 4', 'Pisang Lilin', 'Gros Michel', 'Pisang Awak' and 'TMBx 612-74' scored less than 10% for root necrosis. In the majority of the genotypes, the percentage root necrosis was higher in the established mat trial than in the early screening trial. The differences between the established mat trial and the early screening trial were significant ($P < 0.05$) for 'Calcutta 4', 'Pisang Lilin' and 'Valery'. Genotype rankings for root necrosis in nematode infested plots were not correlated ($R_{spearman} = -0.055$, $P = 0.956$) between the established mat trial and the early screening trial.

## DISCUSSION

The nematode species composition in both evaluation trials were similar to that common in the lower altitude regions of Uganda (Kashaija *et al.*, 1994). The high population densities of *R. similis* recovered from 2-month-old sword sucker derived plants of 'Obino l'Ewai' and 'Cardaba' demonstrate the ability of this species to build up high population densities in a short period of time.

The host response to nematode attack of most of the genotypes studied is unknown with the exception of 'Gros Michel' and 'Valery'. Our study confirms the resistance to *R. similis* of established mats of 'Gros Michel' as observed in Cameroon by Price (1995) but not the poor host status of 2-month-old plants derived from tissue-cultured plants as reported by Mateille (1992). In both evaluation trials, 'Valery' was highly susceptible and sensitive to *R. similis* which is in agreement with Pinochet (1990).

Genotype ranking for resistance and tolerance to *R. similis* and *H. multicinctus*, using density and damage parameters, differed significantly between the evaluation trials. It is unlikely that these differences were caused by age-related differences between the sword sucker derived plants and the sword suckers. Rather, it is suggested that these were the result of temporary differences in root emergence, compensatory root growth (Speijer *et al.*, 1998) and, possibly, morphology. Differences in root emergence and compensatory root growth will result in differences in the size of the root system, which in turn will lead to differences in nematode population densities in the roots under similar levels of nematode inoculum. Other factors that may have affected the host response of the genotypes include environmental differences (the sword suckers of the established mats were evaluated in 1995, the sword sucker derived plants of the early screening trial in 1996) and differences in the species composition of the inoculum.

The number of functional roots in the non-infested field can be regarded as the potential number of roots that can emerge. In the established mat trial, few differences were observed between the genotypes in the number of functional roots in the non-infested field. Therefore, the differences observed among the genotypes in the infested field were likely due to nematode infection. The genotypes 'Valery', 'TMPx 582-4' and 'Entundu' for which the greatest reduction of functional roots in the infested field compared to the non-infested field was observed, were the most sensitive to nematode infection. In the early screening trial, however, considerable differences were observed among the genotypes in the number of functional roots in the non-infested field. In this trial, the differences observed among the genotypes in the infested field might be the result of temporary differences in root emergence, compensatory root growth, root morphology and not necessarily related to nematode sensitivity. Thus 'Gros Michel', which is sensitive according to the early screening trial is tolerant according to the established mat trial. Flushes of root emergence have been observed in banana and plantain beginning 7 weeks after planting (Beugnon and Champion, 1966; Swennen *et al.*, 1988), suggesting that sword sucker derived plants should grow at least 7 weeks before root growth is similar to the root growth of sword suckers of established mats.

The differences observed between the established mat trial and the early screening trial in percentage dead roots and percentage root necrosis, and in the ranking of the genotypes using these damage indices, suggest that many of the young root systems examined in the early screening trial have a different host response to nematode attack compared to the established root systems sampled in the established mat trial. Therefore, it is proposed for early screening to grow pared and hot water-treated sword suckers in nematode-free soil for at least 8 to 10 weeks to enable the plants to develop a root system that is comparable to the root systems of sword suckers of established mats.

## ACKNOWLEDGMENTS

The authors wish to acknowledge the Flemish Agency for Development Cooperation and Technical Assistance (VVOB) and the Belgian Administration for Development Cooperation (BADC) for financial support.

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*Received:* 27.V.1999

*Recibido:*

*Accepted for publication:* 30.VII.1999

*Aceptado para publicación:*