The mission of the **International Network for the Improvement of Banana and Plantain** is to increase the productivity and stability of banana and plantain grown on smallholdings for domestic consumption and for local and export markets.
INIBAP has four specific objectives:
- to organize and coordinate a global research effort on banana and plantain, aimed at the development, evaluation and dissemination of improved cultivars and at the conservation and use of *Musa* diversity;
- to promote and strengthen regional efforts to address region-specific problems and to assist national programmes within the regions to contribute towards, and benefit from, the global research effort;
- to strengthen the ability of NARS to conduct research on bananas and plantains;
- to coordinate, facilitate and support the production, collection and exchange of information and documentation related to banana and plantain.

In May 1994, INIBAP was brought under the governance and administration of the International Plant Genetic Resources Institute (IPGRI) to enhance opportunities for serving the interest of small-scale banana and plantain producers.

The International Plant Genetic Resources Institute is an autonomous international scientific organization operating under the aegis of the Consultative Group on International Agricultural Research (CGIAR). The international status of IPGRI is conferred under an Establishment Agreement which, by December 1995, had been signed by the Governments of Australia, Belgium, Benin, Bolivia, Burkina Faso, Cameroon, China, Chile, Congo, Costa Rica, Côte d'Ivoire, Cyprus, Czech Republic, Denmark, Ecuador, Egypt, Greece, Guinea, Hungary, India, Iran, Israel, Italy, Jordan, Kenya, Mauritania, Morocco, Pakistan, Panama, Peru, Poland, Portugal, Romania, Russia, Senegal, Slovak Republic, Sudan, Switzerland, Syria, Tunisia, Turkey, Ukraine and Uganda. IPGRI's mandate is to advance the conservation and use of plant genetic resources for the benefit of present and future generations. IPGRI works in partnership with other organizations, undertaking research, training and the provision of scientific and technical advice and information, and has a particularly strong programme link with the Food and Agriculture Organization of the United Nations. Financial support for the agreed research agenda of IPGRI is provided by the Governments of Australia, Austria, Belgium, Canada, China, Denmark, France, Germany, India, Italy, Japan, the Republic of Korea, Mexico, the Netherlands, Norway, Spain, Sweden, Switzerland, the UK and the USA, and by the Asian Development Bank, IDRC, UNDP and the World Bank.

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New Frontiers in Resistance Breeding for Nematode, Fusarium and Sigatoka

Proceedings of the workshop held in Kuala Lumpur, Malaysia 2-5 October 1995

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Screenhouse Evaluation of *Musa* for Susceptibility to *Radopholus similis*: Evaluation of Plantains AAB and Diploid AA, AB and BB

R. Fogain

Introduction

Nematodes are serious constraints of banana and plantain production worldwide (Perclay and De Langhe 1987; Gowen and Quénéhervé 1990). Many workers have reported a significant improvement in yield with the use of nematicides (Roman *et al.* 1977; Sarah 1989; Gowen and Quénéhervé 1990; Fogain *et al.*, in press). Damage on the root systems of susceptible cultivars during the first cycle can be more than 50%, while less than 5% damage occurs on resistant cultivars (Fogain and Gowen 1995).

Chemical control with nematicides is currently the most used method to control nematodes. However, although this is feasible in large-scale dessert banana plantations, it is not recommended in peasant farms. Providing farmers with resistant or tolerant cultivars is probably the best form of nematode management. We started the first screening for nematode resistance in Cameroon in 1989 with the aim of determining the reaction of most of the parental materials used in banana breeding programmes in the world, new hybrids released by these programmes and assessing the susceptibility of plantain and diploid clones.

This paper discusses the susceptibility of plantains (*Musa* AAB) and diploids to *Radopholus similis*.

Materials and methods

Planting materials and substrate

Suckers of 17 AAB cultivars and 28 diploids (AAw, AAcv, AAhy, AB and BBw) of approximately the same size were obtained from the *Musa* germplasm of CRBP. Cultivars or accessions were selected based on their importance to

CRBP/IRA, Douala, Cameroon

farmers and breeding programmes. After the suckers were collected, their corms were peeled to remove necrosis and they were sterilized using hot water at 50-55°C for 15-20 min (Melin and Vilardebo 1973). They were planted immediately after disinfection in 10-L pots previously filled with a sterilized mixture of soil of volcanic origin and coffee husk in equal proportions. They were allowed to grow for 2 weeks before inoculation in order to allow the root system to establish.

Inoculum and inoculation

Stock cultures of *R. similis* from a population from Njombe (Cameroon) were reared on carrot disc using the technique described by Huettel (1990). Each plant was inoculated with 1000 *R. similis*. The nematode suspension was pipetted and poured rapidly and uniformly in drenches made around the base of the plant.

The potted plants were arranged in the greenhouse in a completely randomized design with five replicates. Three known control cultivars were provided for comparison (Muller 1991): Yangambi Km5 and Pisang Jari Buaya were used as the resistant controls and French Sombre as the susceptible control (Table 1). In the second experiment only French Sombre was used.

Observations

Plants were harvested 2 and 4 months after inoculation, for experiment one and two respectively. The following observations were made:

1. **Root damage**: the percentage of infected roots (PNIR) was calculated as the ratio of the number of lesioned roots (lesion at any stage of development) and the total number of roots produced by the plant. The root lesion index (RLI) is a percentage of the cortical parenchyma necrosed of the total root length measured on one side of each of 10 longitudinally split root pieces of about 10 cm lengthtaken at random from the sample using a ruler ('ruler method'). The corm lesion index (CLI) is a measure of the rhizome surface tissue with lesions and is expressed on an arbitrary grading from 0 to 4 (Pinochet 1988). Grade 0 (clean); grade 1 (1-3 lesions not more than 1 cm diameter); grade 2 (3-6 small to medium-size lesions not more than 2 cm diameter); grade 3 (1-15% of the rhizome with lesions); grade 4 (>25% of the rhizome surface with lesions that coalesce).
2. **Nematode count**: after estimating root damage, the 10 root pieces were cut into small pieces of about 1-2 cm and 25 g were sampled for nematode extraction using the direct sieving method (Vilardebo and Guerout 1974).

Table 1. Control plants used at CRBP for screening for resistance to *R. similis*

Cultivars	Susceptibility level	Reference
French Sombre and Grande Naine	s	Price 1994; Fogain and Gowen 1995
Pisang Jari Buaya	r	Wehunt *et al.* 1978; Pinochet and Rowe 1979
Yangambi Km5	r	Sarah *et al.* 1992; Price 1994; Fogain and Gowen 1995

Statistical analysis and interpretation

Nematode populations were log-transformed before analysis. The square root transformation was used for PNIR and RLI. Analysis of variance was performed using SYSTAT 5.02 statistical package. Mean separation was carried out using LSD (Least Significant Difference) when significant differences were found. Groups can be determined as follows:

- *group I = resistant*: cultivars or accessions in the same homogeneous group as the resistant control,
- *group II = susceptible*: cultivars or accessions in the same group as the susceptible control,
- *group III = moderately susceptible*: cultivars or accessions showing intermediate level of susceptibility between the two control cultivars,
- *group IV = highly susceptible*: cultivars or accessions with susceptibility level higher than that of the susceptible control.

Because most of the *Musa* spp. are invaded by *R. similis*, no cultivars have yet been classified as immune.

Results and discussion

Experiment one: Evaluation of susceptibility of 17 *Musa* AAB to *R. similis*

Nematode population densities from roots

Populations of *R. similis* recovered from plants are presented in Table 2. None of the plants were immune. Significant differences were observed between cultivars in the population levels of nematodes recovered 2 months after inoculation ($p<0.05$). Although distinct groups were separated, many cultivars showed comparable levels of susceptibility. The cultivar Popoulou had the highest level of *R. similis* 8 weeks after inoculation. Most of the cultivars from the plantain subgroup were at least comparable to the susceptible control

French Sombre in their susceptibility, indicating a higher susceptibility in this subgroup. Cultivars Foconah, Pisang Ceylan and Pisang Kelat were the least susceptible.

Root damage

About 60% of the accessions were more damaged than the control cultivar French Sombre. Differences observed between cultivars in their PNIR, RLI and CLI were significant ($p<0.05$) (Table 2).

Cultivar Popoulou CMR showed the highest root length damaged by *R. similis*; this high damage level on Popoulou may be related to the high rate of multiplication of *R. similis* on that cultivar.

Table 2. Susceptibility of 17 *Musa* AAB cultivars 2 months after inoculation with 1000 *R. similis* per plant, measured by the final population of *R. similis*, the percentage of infected roots (PNIR), the root lesion index (RLI) and the corm lesion index (CLI)

		Parameters				
Cultivars	**Subgroups**	***R. similis*/ 100 g of roots**		**PNIR (%)**	**RLI (%)**	**CLI**
Popoulou	Popoulou	19200	(4.28)	34.8	33.8	2.3
Orishele	Plantain	9400	(3.97)	39.9	26.4	1.8
Laknau	Laknau	8200	(3.91)	33.8	26.6	1.7
One Hand Planty	Plantain	7100	(3.85)	20.1	23.5	1.4
Kelong Mekintu	Plantain	6900	(3.83)	39.3	30.8	1.2
Big Ebanga	Plantain	6100	(3.78)	20.2	17.1	1.4
Batard	Plantain	5700	(3.75)	30.2	29.1	1.3
Igihobe	Plantain	4200	(3.62)	32.7	22.7	1.6
Amou	Plantain	3900	(3.59)	28.6	16.5	1.1
French Sombre*	Plantain	3700	(3.56)	23.4	26.5	1.6
Maritu	Inarana	2715	(3.43)	36.3	16.7	2.8
Ntie	Plantain	1914	(3.28)	31.3	20.7	1.8
Mbeta 2	Plantain	1713	(3.23)	13.9	10.8	1.7
Poingo	Popoulou	1238	(3.08)	48.1	18.1	0.4
Pisang Kelat	Pisang Kelat	955	(2.98)	21.8	24.3	0.8
Foconah	Pome/Prata	125	(2.09)	22.1	15.6	0.9
Pisang Celan	Mysore	31	(0.75)	21.1	18.9	0.9
SED (N=5)		0.69		8.56	4.72	0.54
p		0.007		0.006	0.001	0.002

Data in parentheses are log *R. similis*/100 g roots.
* = susceptible control.
SED = standard error of difference (log transformed).

Experiment two: Evaluation of the susceptibility of diploid *Musa* to *R. similis*

Nematode populations

All the accessions were infected by *R. similis* (Table 3). Highly significant differences in level of susceptibility were observed among cultivars ($p<0.05$). The susceptible cultivar French Sombre (control) showed the highest level of infection. Accessions were grouped in three homogeneous groups based on their level of susceptibility. The susceptibility level of the diploid cultivar Akondro Mainty (AA) was equivalent to that of French Sombre.

Thirty percent of the accessions showed a level of resistance comparable to that of Yangambi Km5. Susceptible and resistant accessions were found within genomic groups and even within subgroups. For instance, within the subgroup *M. acuminata microcarpa*, cv. Pisang Jari Buaya IDN was resistant to *R. similis* while Kirun and Pisang Mas were intermediate in their susceptibility. In a large diploid screening carried out in Honduras, most of the accessions of the Pisang Jari Buaya (PJB) group were found resistant to *R. similis* (Wehunt *et al.* 1978). The PJB used in this study was assessed for the first time and was found resistant to *R. similis*. All the accessions from the subgroup *M. acuminata banksii* (Galeo, Guyod, Bie Yeng, Heva and Yirnamayik) were susceptible to *R. similis*. In contrast, the three diploids from the wild *M. balbisiana* (BBw) group were not significantly different from Yangambi Km5 in their degree of susceptibility to *R. similis*.

Root damage

All the susceptible cultivars and accessions showed severe root damage (Table 3). For instance, cultivars Akondro Mainty, Kirun, Tuu Gia and French Sombre had more than 20% of their root length attacked by nematodes while most of the resistant accessions had less than 5%.

Conclusions

This study shows that clones from the plantain subgroups are severely damaged by *R. similis*. Most of the clones were at least equal to the control French Sombre in their susceptibility to *R. similis*. Many workers have reported that French Sombre was more susceptible to *R. similis* than most of the Cavendish bananas (Price 1994; Fogain, in press; Fogain and Gowen 1995). A variability in susceptibility level was found within the AAB genomic group but not within the plantain subgroup. This could be due to the limited size of the sample. For instance, out of the 120 plantain cultivars available in the CRBP germplasm, only 10 were assessed. Further studies should involve a larger number of cultivars.

In the diploid experiment, all the *M. acuminata banksii* cultivars were very susceptible to *R. similis*. Wehunt *et al.* (1978) also showed that accessions

Table 3. Difference in susceptibility levels of diploid *Musa* clones 4 months after inoculation, measured by the final population of *R. similis* and the root lesion index (RLI)

		Parameters		
Cultivars	**Subgroups**	***R. similis*/ 100 g of roots**		**RLI (%)**
French Sombre*	Plantain AAB	106600	(5.02)	20
Akondro Mainty	AAcv ?	93800	(4.97)	38
Guyod	AAcv Banksii	41800	(4.62)	30
Kirun	AAcv Microcarpa	32400	(4.51)	62
Tuu Gia	AAcv ?	26000	(4.41)	25
Bie Yeng	AAcv Banksii	22000	(4.34)	12
M53	AA hybrid	22000	(4.34)	8
Heva	AAcv Banksii	15300	(4.18)	14
Pisang cici alas	AAw Microcarpa	14250	(4.15)	3
Galeo	AAcv Banksii	14000	(4.14)	6
Pisang Mas	AAcv Microcarpa	12400	(4.09)	2
AB Hybrid No 6	ABcv ?	12200	(4.08)	2
Pa Rayong	AAw Siamea	10000	(4.00)	10
Pisang Tongat	AAcv Errans	9100	(3.95)	5
IDN 110	AAcv ?	8400	(3.92)	3
Nirnama Yik	AAcv Banksii	6800	(3.83)	3
Pa Pathalong	AAcv ?	3600	(3.55)	2
M. *acuminata* Pahang	AAw Malaccensis	2600	(3.41)	4
Pisang Berlin	AAcv ?	2400	(3.38)	5
Safet Velchy	ABcv Ney Poovan	2300	(3.36)	1
Pallen Berry	AAcv ?	1500	(3.17)	2
Calcutta 4	AAw Burmanicoides	1400	(3.14)	1
M. *acuminata* microcarpa	AAw Microcarpa	800	(2.91)	1
Pisang Oli	AAcv Malaccensis	600	(2.78)	0.3
Truncata	AAw Microcarpa	500	(2.69)	2
M. *balbisiana* Cameroon	BBw No 2	400	(2.61)	2
Yangambi Km5**	AAA Ibota	100	(2.00)	1
Pisang Jari Buya IDN**	AAcv Microcarpa	100	(2.00)	0
M. *balbisiana* Tani	BBw No 4	100	(2.00)	0.3
M. *balbisiana* Honduras	BBw No 1	80	(1.91)	0.2
SED (N=5)			(092)	
p			0.001	

SED = standard error of difference (log transformed).
*= susceptible control.
** = resistant controls; w= wild; cv= cultivar; ?=unknown.

from this subgroup or *M. acuminata banksii* derivatives (e.g. Guyod) were equivalent to Cavendish cultivars in their susceptibility to *R. similis*.

Although accessions with moderate susceptibility to *R. similis* were found within the wild diploids AA (AAw), it can be said that most of the AAw and BBw tend to have a higher level of resistance than the diploid cultivars (AAcv and ABcv) and hybrids (AAhy).

Results from phylogenetic studies have shown a possible relationship between *M. acuminata banksii* and plantain subgroup (Horry and Jay 1990; Tézenas du Montcel 1990; Charrier 1993; Carreel 1995). According to Carreel (1995), the A genomes of plantains are very close to *M. acuminata banksii*. In these studies, we have shown that both subgroups are highly susceptible to *R. similis*. It can therefore be hypothesized that the high susceptibility of plantains to *R. similis* may be related to the presence of the A component from *M. acuminata banksii* in their genome.

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