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The mission of the International Network for the Improvement of Banana and Plantain is to sustainably increase the productivity of banana and plantain grown on smallholdings for domestic consumption and for local and export markets.

The Programme 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 collaboration and partnerships in banana-related research activities at the national, regional and global levels
- To strengthen the ability of NARS to conduct research and development activities on bananas and plantains
- To coordinate, facilitate and support the production, collection and exchange of information and documentation related to banana and plantain.

Since May 1994, INIBAP is a programme of the International Plant Genetic Resources Institute (IPGRI).
Bottlenecks in the generation and maintenance of morphogenic banana cell suspensions and plant regeneration via somatic embryogenesis therefrom


Banana and plantain (henceforth called banana) are a staple food for at least 400 million people. About 10% of the more than 80 million tons annually produced (Sharrock and Frison 1998, FAO 1999) is exported and serves as dessert for many more millions of people. A number of developing countries relies upon the banana export to generate their foreign exchange. Despite this and the fact that banana ranks fourth (after rice, milk and wheat) as a world food crop, it is the least researched of the major food sources. This can be partially explained by the biology of the banana plant itself. Most edible landraces are sterile triploids with a life cycle of 1-3 years. This hampers strongly the elaboration of successful hybridisation programmes. The outbreak of fungal and viral diseases like Fusarium wilt, black Sigatoka, banana bunchy top virus (BBTV) and banana streak virus (BSV), with a devastating effect on banana production and germplasm exchange, sparked the renewed interest in banana research. The rapid evolution in molecular techniques to isolate resistance genes from the own or a foreign gene pool and to bring these into the genome of susceptible landraces, brings us closer to the generation of disease resistant/tolerant plants. For cooking bananas like ‘Buggoe’ (ABB), a high number of explants can be easily obtained on the standard proliferation medium (p5 medium with 10 µM BA). For other types like AAA dessert and highland bananas, multiple subsequent cultures on a medium enriched in cytokinin content (p4 medium with 100 µM BA) are required to obtain the same quality of starting material (Schoofs et al. 1998). The minimum cycle number on p4 medium needed to break the in vitro apical dominance was found to be correlated with the percentage of B chromosome sets in the genome i.e. the more B in the genome the higher the initial in vitro proliferation rate (Figure 1).

Part of the in vitro meristem cultures was found to contain bacteria. Because the material preparation phase for scalps already takes so long, it is advisable to screen cultures, from the start onwards and on a regular basis, for the presence of internal contamination. Isolates were identified as Gram-positive endospore forming Bacillus sp. and slow growing...
Low and variable embryogenic responses

Whereas the necessity for an often-extensive explant preparation phase refers only to the scalp methodology, all problems and inconveniences discussed below apply to all available methods. Banana is a highly recalcitrant crop for embryogenesis with most often extreme low responses (<1%). Even when flowers were collected in the right season, the embryogenic response for Grande Naine male flowers never exceeded 5% (Escalant, 1994). For other landraces and under non-optimal conditions responses are often below 1%. From scalps, embryogenic responses of over 30% (of the explants) could be obtained for some plantain types and cooking bananas (Schoofs, 1997). The response from Cavendish types and highland bananas, though, is highly variable and usually lower than 1%. Not only is the embryogenic response genotype and cultivar dependent, also different clones can behave in a completely different way and even a lot of variability exists between experiments.

Embryogenic complexes thus produced are often very heterogeneous. As such, only a very small fraction of it is suitable for transfer to liquid medium. Only early-stage somatic embryos and non-organised embryogenic cell clusters will result in the establishment of an embryogenic cell suspension. These are to be found in friable yellow-whitish complexes (Schoofs et al., 1998). An ideal complex can quickly loose its quality and turn into a heterogeneous or compact complex via a rapid evolution of the somatic embryos at the periphery of the complex. The complexes that are formed therefore require close and frequent observation. Depending on the landrace, embryogenic complexes in general are produced after an incubation period of three to eight months.

Often the formed complexes are too small (<0.5 cm in diameter) for transfer to liquid medium. Transfer of such a complex to a fresh semi-solid induction medium can stimulate proliferation of the embryogenic tissues but their further reaction is most often unpredictable and complexes can seldom be maintained for longer than 6 months.

Few calluses/complexes result in a good cell suspension

Not every good complex will lead to a good embryogenic cell suspension. One out of three to one out of five good male flower-derived calluses results in a useful suspension (Côte, personal communication). The success rate for scalp-derived complexes is one out of two to one out of five. Engler (personal communication, 1998) states that only one out of a thousand initial flower explants gives rise to a cell suspension that can be used in a genetic transformation programme.

Due to the extreme low amount of good embryogenic material available and a high variability in response, it is difficult to optimise the culture conditions and the medium composition. It is generally accepted that young banana suspensions require a very high initial inoculum density and frequent refreshment of the maintenance medium (every three to seven days) during the first few months.

The maintenance of embryogenic cell suspensions

Single cells released from embryogenic cell aggregates and nodular calluses quickly differentiate, followed by cell degeneration and oxidation. They should be removed as far as possible upon each subculture since such cells tend to induce a general cell and tissue differentiation. Also very big aggregates and more developed somatic embryos should be removed, as they tend to accumulate starch in their outer cells. Such aborted embryos then start producing high amounts of polyphenols.

In general, three months after their transfer to liquid medium, embryogenic aggregates start to grow and multiply in the suspension (Schoofs, Côte, unpublished results). Until then, the quality and the aspect of the suspension are highly variable. The correct manipulation of these young suspensions is essential to obtain a homogeneous embryogenic suspension; but thus far, this seems to rely upon the researcher’s “Finger spitzengefühl”. After about six months, good embryogenic cell suspensions, though still heterogeneous in aspect, will consist mainly of embryogenic cell clusters. At that stage, the regeneration capacity of the suspension can be tested.

Time aspects and labour

As discussed earlier, an extensive material preparation phase is required for some landraces when using scalps as explants. This time period can be as long as one year. Embryogenic complexes/calluses are produced on both types of explants (scalps and immature (fe) male flowers) after an incubation period of three to eight months.

**Figure 1.** Number of cycles on medium p4, needed for suitable proliferation, versus in vitro apical dominance per group. Groups were defined according to the percentage of B chromosome sets in the genome.

Data are given as frequencies.

<table>
<thead>
<tr>
<th>Group</th>
<th>Percentage B</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group 1</td>
<td>≥ 66 %</td>
</tr>
<tr>
<td>Group 2</td>
<td>50 %</td>
</tr>
<tr>
<td>Group 3</td>
<td>33 %</td>
</tr>
<tr>
<td>Group 4</td>
<td>0 %</td>
</tr>
</tbody>
</table>

L: low, M: moderate and H: high in vitro apical dominance.

Z: frequency

Y: cycles on medium p4

X: in vitro apical dominance

Mycobacterium sp. (Van den houwe et al., 1998, 1999).
After transfer to liquid medium, it takes about another six months before one can get a final idea on the suspension quality. This means that nine to 26 months are needed to establish a suspension. One needs to add another three to nine months before enough cell material is available and the suspension is fine enough for any application.

The initiation of banana suspensions is time consuming and their maintenance very labour intensive. It is difficult to keep a suspension free from bacterial contamination. Many suspensions get contaminated within two years after initiation. Contaminated suspensions are in fact useless for any application like transformation. It is therefore of prime importance to cryopreserve good cell suspensions in an early stage, especially since the chance of somaclonal variation increases with time. Painis et al. (1990, 1992) have worked out a protocol for the safe storage of banana embryogenic cell suspensions, which however fails on suspensions of which the cells are rich in starch and which fails to conserve somatic embryos and other differentiated tissues.

The behaviour of distinct cell lines of the same clone is often different. Even when the content of one erlenmeyer is distributed evenly over two erlenms, each of them can behave differently. These are additional indications for the fact that the initial initiation steps and the maintenance of suspensions are far from being optimised. Growth curves established for banana suspensions initiated at our laboratory, indicated that settled cell volumes (SCVs) of 3 and 5% are superior to initial SCVs of 10%. It was also observed that banana cell suspensions reveal almost no log phase under these conditions and reach their stationary phase after five weeks only. Cell growth follows a linear rather than an exponential curve (Figure 2). This growth is slow compared to that of cereals like rice and their aspect is quite heterogeneous compared to that of the latter. Preliminary results indicate that the sugar content and medium composition of the maintenance medium has an effect on the growth rate of suspensions and later regeneration therefrom (data not shown).

**Plant regeneration and true-to-typeness**

Regeneration from banana cell suspensions is not really an issue when the quality of the suspension is good. Highly regenerable cell suspensions yield $10^2$ to $10^3$ somatic embryos per ml SCV. Moderately regenerable suspensions yield $10^4$ to $10^5$ somatic embryos per ml SCV. Upon initiation the suspension can grow as fast as that of embryogenic ones. At our lab we have a ‘Three Hand Planty’ (AAB, plantain) suspension for more than four years that still has a very high regeneration potential. Flow cytometry (FCM) analysis of its cells revealed a normal ploidy level (Figure 3a). A nine-year-old ‘Bluggoe’ (ABB, cooking banana) suspension, however, was found to be completely aneuploid and most probably is lacking 4-5 chromosomes (Figure 3b). Its regeneration potential has now dropped to nearly zero and before that, only abnormal plants could be regenerated from that suspension. A non-regenerable ‘Grande Naine’ suspension and a low-regenerable ‘Williams’ suspension were both found to be aneuploid to some extent. These plants showed a retarded growth in vitro and ex vitro compared to control plants.

Recently, FCM analysis was applied to leaf material of plants regenerated from a ‘Nakitengwa’ (AAAh, highland banana) suspension. Its regenerants were much taller than the control plants, did not produce the typical rounded and dark green leaves of a highland banana, but instead produced lighter green and narrower leaves. Results proved that suspension-derived plants as well as plants grown from the p4 meristem culture are aneuploid and, based on theoretical calculations, would lack two chromosomes.

Dhed’a (1992) was the first to report on somaclonal variation in suspension-derived plants. He observed 5-10% abnormal somatic embryos recovered from a ‘Bluggoe’ (ABB, cooking banana) suspension derived from scalps. Out of 140 plants tested in the field, only one off-type (0.7%) with retarded growth and distorted leaves was found. Grapin (1995) reports on 16-22% somaclonal variants among plants regenerated from a ‘French Sombre’ (AAB, plantain) male flower-derived suspension, whereas all plants obtained through classical in vitro clonal propagation were normal. Recently, Côte and Folliot (1999) reported that, during the acclimatisation phase, two types of variants were observed among ‘Grande Naine’ (AAA, Cavendish) plants derived form a male flower suspension: plants with ‘variegated’ and plants with “double” leaves (two parts coalescing at the central vein). In the field, however, all 500 tested plants showed later an agronomical behaviour similar to that of plants produced by the conventional in vitro budding method. All 36 scalp-derived ‘Cardaba’ (ABB, cooking banana) suspension plants, produced at our lab and tested for three cycles in CORBANA (Costa Rica), were found to be normal. An extreme high number of off-types (597/600) was however reported for ‘Williams’ (AAA, Cavendish) plants grown from a scalp-derived suspension. Abnormal plants were of the type ‘long narrow leaf’ (LNL) (Khayat, personal communication). ‘Williams’ is one of those clones that requires an extensive material preparation phase. Meristem cultures need to be maintained for at least 7-9 subsequent cultures on the medium p4 with extreme high BA content (100 µM). The same applies to ‘Nakitengwa’ (AAAh, highland banana), which generated nontrue-to-type aneuploid plants from the suspension and from the p4 control. Though to our knowledge no reports exist on cytokinins like BA causing genomic alterations at standard concen-
A rapid method for the diagnosis of Mycosphaerella musicola musicolana Leach and M. fijiensis Morelet, the causal agents of yellow Sigatoka and black Sigatoka

Martha Cecilia Aguirre Gaviria, Jairo Castaño-Zapata and Luis Eduardo Zuluaga Arias

Mycosphaerella musicola musicolana Leach and Mycosphaerella fijiensis Morelet are respectively the causal agents of yellow Sigatoka and black Sigatoka in *Musa* (Fullerton, 1994).

Yellow Sigatoka was named after the Sigatoka valley on Viti Levu island (Fiji), where the disease was described for the first time in 1902. It caused serious losses in the Fiji islands in 1912, especially in the Sigatoka valley. The disease has also caused damage to the banana industry in Australia in 1924, in Central America, the Caribbean and South America and in Africa in the 1930s (Mourchon and Fullerton, 1990). It was subsequently noted in almost all the Musaceae production regions in the world and is considered as one of the most devastating diseases for these crops.

Black Sigatoka was described as a new disease in 1963, also in the Fiji islands (Rhodes 1964, Leach 1964), although it had been mentioned well before in Hawaii and several regions in the Pacific (Stover 1972). In Central America, it was described for the first time in Honduras in 1972 and spread from there to the rest of the zone. In South America, it was mentioned for the first time in Colombia in 1981 and

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Diseases Early diagnosis

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then in Ecuador in 1989, and more recently in Cuba and Venezuela (Mouri-
chon and Fullerton 1990).

Although the symptoms caused by the two pathogens and visible in the field at macroscopic level may be somewhat different, they are not sufficiently clear for it to be possible to make an accurate distinction between the two diseases (Du Pont 1980). Under microscopy, the perithecia of the sexual stage of *M. musicola* and *M. fijiensis* are very similar and are found in the necrotic tissue of lesions; they measure approximately 51-86 x 35-77 µm. At the asexual stage of *M. musicola*, stromata (sporodochia) form on both faces of the leaves, although they are more abundant on the upper face, and the conidia do not have hila at the point of connection with the stromata, whereas at the same stage *M. fijiensis* produces single conidiophores with an equally visible hilum at the base of conidia and on the conidiophores (Castaña-Zapata and Del Río 1994). The conidia of both species are elongated, septate, hyaline and acicular. The two microorganisms differ mainly in the morphological characteristics of their asexual stages and especially in the characteristics of conidiophores and conidia, and specifically in the presence of a scar in the conidiophores and conidia of *M. fijiensis*, a feature absent in *M. musicola* (Fullerton 1994). The abundance of stromata and conidia of *Paracercospora fijiensis* in the lower part of lesions and of *Pseudocercospora musae* in the upper part is also a rapid guide to the identification of these species (Fullerton 1994). Accurate identification of these fungi must therefore be performed in the laboratory.

The main purpose of the work described here was to develop simple methodology for rapid laboratory diagnosis of *M. musicola* and *M. fijiensis*.

**Material and methods**

The method is a modification of the technique used by Lalancette et al. (1994), consisting of using 6 cm² disposable plastic syringes (Precision Glide 21G 1 1/2 or equivalent). The extremity is removed so that they can be used as simple cylinders with an opening of 123.7 mm². The distributors are filled with agar-crystal violet, streptomycin and benomyl (Oxoid bacteriological agar 1.5g, Oxoid streptomycin in discs 10 mg, benomyl 100 ppm, pure 1% crystal violet solution and water 100 ml). The streptomycin, benomyl and crystal violet are added to the liquid medium previously sterilised at 121°C and 15 lbs. pressure for 20 minutes; the liquid is then placed in the syringes. The latter are then kept vertical and refrigerated to 4°C so that the medium solidifies rapidly.

Conidia of *Pseudocercospora musae* or *Paracercospora fijiensis* are collected in the field by pressing the piston of the syringe until 2 mm of medium is exposed to the air (Figure 1a). The moist surface of the agar-crystal violet is gently placed on a necrotic area of the youngest leaf (Figure 1b). The agar-crystal violet disc is then carefully cut with a scalpel leaving a smooth surface (Figure 1c). Two discs are mounted per slide and placed in a box containing moistened absorbent paper to create a moist atmosphere enhancing the rapid spread of the stain through the cells of the conidia sampled and preventing drying (Figure 1d). Each syringe gives 20 to 24 discs; this is sufficient for 10 to 12 double samples.

The researcher uses this method to establish a relation between the number of discs and the number of lesions sampled and between the number of slides and the number of leaves sampled. In the present case there is one slide per item of material assessed. The slides are placed under the microscope immediately for observation of the morphological characteristics of the conidia sampled using a X40 lens.

**Results and discussion**

Absence of crystal violet in the medium makes it difficult to differentiate between conidia of *Pseudocercospora musae* (Figure 2a) and *Paracercospora fijiensis* (Figure 2b). Use of 1% crystal violet enables immediate differentiation between the two species. The conidia are stained more intensely at the scar (hilum) or point of insertion of the conidia in the conidiophores; this feature is present in *P. fijiensis* (Figure 2c) and absent in *P. musae* (Figure 2d).

The addition of streptomycin and benomyl to the medium prevents contamination by bacteria and germination of the conidia, whose germ tubes could interfere with microscope observations. It is sufficient not to add beno-

A similar method to that described above and based on the addition or not of 1.5% lactophenol to the agar was described by Jacome and Schuch (1993) for the study of *M. fijiensis* conidia. As lactophenol is colourless, the colour of the conidia does not change, making identification of the species difficult. Tapia (1993) described a method for the quantification and characterisation of the asexual reproductive structures of *M. musicola* and *M. fijiensis* on the basis of the characteristics of the stomata and conidiophores, but a period of 84 hours is required for treatment of the tissues sampled in the field. It should be noted that Tapia’s thermal treatment (1993) disperses the conidia, making observation difficult.

Easy distinction can also be made between the two *Mycosphaerella* species by means of the characteristics of the colonies in the culture medium, but this 10-day procedure is too long (Du Pont 1980). Likewise, the two species can be distinguished by molecular techniques such as DNA restriction fragment length polymorphism (RFLP) (Carlier et al. 1994) and the polymerase chain reaction (PCR) (Johnson and Jeger 1993), but use of these techniques is costly.
In addition to the fact that it allows rapid, reliable identification of the causal agents of yellow Sigatoka and black Sigatoka, the technique developed here makes it possible to obtain a large quantity of samples at a minimum cost.

Conclusions
An accurate, simple and rapid method has thus been developed to identify M. fijiensis and M. musi-cola at the anamorphic stages Pseudocercospora fijiensis and Paracercospora fijiensis. The technique is particularly economical and a large quantity of samples can be obtained at a small cost and the number of conidia of each species can be estimated. The method is useful not only for the accurate identification of the fungal species causing black and yellow Sigatoka but also for studies of the resistance of M. fijiensis and M. musi-cola to fungicides, a problem frequently encountered in connection with these two pathogens.

Acknowledgements
The author thank the partner institutions of the ICA-CORPOICA-CIRAD-FLHOR convention, which supported this work.

References

E. I. Jonathan, K. R. Barker and T. B. Sutton

Wild peanut (Arachis pentoi L.) is used in some banana plantations in Central America as a cover crop to minimize the nematode menace. The effects of various mulches on nematode populations, however, are unclear and warrant critical evaluation (Gowen 1995). A recent study has shown that Meloidogyne incognita races 1, 2, 3 and 4, M. arenaria races 1 and 2 and M. javanica readily infect banana, whereas M. hapla reproduced poorly on the crop (Jonathan et al. 1999). Hence, we investigated the suitability of wild peanut as host for four major species of root-knot nematode and the reniform nematode.

Materials and methods
Seeds of A. pentoi of uniform size were planted in 15-cm diameter pots filled with steam-sterilized sand and soil mixture (85% sand, 10% silt and 5% clay). Fifteen days later, given plants were inoculated with M. incognita (Kofoid & White) Chitwood, races 1, 2, 3 and 4 of M. arenaria Chitwood, M. javanica (Treub) Chitwood, M. hapla Chitwood, and R. reniformis Linford & Oliveira. The nematode in-
ocula were obtained at North Carolina State University from cultures maintained in glasshouses. With the exception of *M. incognita* race 2, the eggs for inoculum of *Meloidogyne* species or races of *Meloidogyne* were obtained from nematode populations maintained on tomato (*Lycopersicon esculentum*) cv. Rutgers; those of *M. incognita* race 2 were from a population maintained on tobacco (*Nicotiana tabacum*) cv. NC 95. Inoculum of each root-knot species was prepared by the NaOCl method (Hussey and Barker 1973) with an inoculum level of 10,000 eggs/pot. Each nematode (population was inoculated onto five 5000 nematodes/pot. Each nematode 

*Results and discussion*

*Meloidogyne hapla* suppressed the plant growth, as evidenced by shoot weights (Table 1). In contrast, the other *Meloidogyne* species/races and the reniform nematode did not affect plant growth.

The greatest egg mass index (4.4) and gall index (23%) were observed in *M. hapla*-inoculated plants. No egg masses were observed on the roots of other nematode-inoculated plants. The large numbers of eggs extracted per root system (268,332/plant) in *M. hapla*-inoculated plants was reflected by the high reproduction factor (Rf) [Rf = final population/initial population] value of 26.8. The other *Meloidogyne* spp. and *R. reniformis*-inoculated plants showed Rf values < 1 (Table 1). Similar results were obtained from the second run of the experiment (data not shown).

Our results clearly show that of the nematode taxa evaluated, only *M. hapla* readily infects and reproduces in wild peanuts. In contrast, the other nematodes tested viz. *M. incognita* races 1, 2, 3 and 4, *M. arenaria* races 1 and 2, *M. javanica* and *R. reniformis* did not reproduce on this plant. An earlier study on host status of banana for four major species and host races *Meloidogyne*. Nematom. Medit. (in press).


### Table 1. Effects of *Meloidogyne* spp. and *Rotylenchulus reniformis* on plant growth, infection and reproduction on wild peanut.

<table>
<thead>
<tr>
<th>Nematode tested</th>
<th>Race</th>
<th>Shoot weight(g)</th>
<th>Egg mass index*</th>
<th>Gall index*</th>
<th>Eggs/root system</th>
<th>Rf*</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Meloidogyne</em></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>hapla</td>
<td>Race 1</td>
<td>110 A</td>
<td>0 B</td>
<td>1.4 B</td>
<td>0 B</td>
<td>0.00 B</td>
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<tr>
<td><em>M. incognita</em></td>
<td>Race 2</td>
<td>108 A</td>
<td>0 B</td>
<td>&lt;1 B</td>
<td>146 B</td>
<td>0.01 B</td>
</tr>
<tr>
<td><em>M. incognita</em></td>
<td>Race 3</td>
<td>100 AB</td>
<td>0 B</td>
<td>1 B</td>
<td>0 B</td>
<td>0.00 B</td>
</tr>
<tr>
<td><em>M. incognita</em></td>
<td>Race 4</td>
<td>96 AB</td>
<td>0 B</td>
<td>1.4 B</td>
<td>0 B</td>
<td>0.00 B</td>
</tr>
<tr>
<td><em>M. javanica</em></td>
<td>98 AB</td>
<td>0 B</td>
<td>1 B</td>
<td>1 467 B</td>
<td>0.15 B</td>
<td></td>
</tr>
<tr>
<td><em>M. arenaria</em></td>
<td>Race 1</td>
<td>101 AB</td>
<td>0 B</td>
<td>1 B</td>
<td>0 B</td>
<td>0.00 B</td>
</tr>
<tr>
<td><em>M. arenaria</em></td>
<td>Race 2</td>
<td>100 AB</td>
<td>0 B</td>
<td>&lt;1 B</td>
<td>0 B</td>
<td>0.00 B</td>
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<tr>
<td><em>M. hapla</em></td>
<td>64 C</td>
<td>4.4 A</td>
<td>23 A</td>
<td>268 332 A</td>
<td>26.83 A</td>
<td></td>
</tr>
<tr>
<td><em>Rotylenchulus</em></td>
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<td></td>
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</tr>
<tr>
<td>reniformis</td>
<td>99 AB</td>
<td>0 B</td>
<td>&lt;1 B</td>
<td>25 B</td>
<td>0.01 B</td>
<td></td>
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<tr>
<td>Control</td>
<td>105 AB</td>
<td>0 B</td>
<td>1 B</td>
<td>0 B</td>
<td>0.00 B</td>
<td></td>
</tr>
</tbody>
</table>

*Egg mass index (0-5) after Taylor and Sasser 1978; gall index (0-100) on basis of percentage of root galls; Rf (reproductive factor) = final population/initial population (P).*

Means followed by the same letter are not different according to the Waller-Duncan k-ratio t-test (k = 50).

**Acknowledgements**

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**References**


Dissemination and adaptation of a banana clean planting material technology in Uganda

P.R. Speijer, Ch. Kajumba and W.K. Tushemereirwe

Banana is a major part of the Ugandan diet and is consumed as cooked food or as beer (Banana and Rubalhayo 1994). The highest production is in the humid highlands of the Western and Central regions of Uganda (Karamura 1993). Production is typically for local consumption and bananas are grown on small holdings of a few hectares, whereby only the surplus is sold (Mugisha and Ngambeki 1994). Banana growing in Uganda is not mechanized and plantations are on the same piece of land over long periods of time, ranging from four years in Central Uganda to over 30 years in Western Uganda (Gold et al. 1993).

Declining soil fertility, a reduction of good agronomic practices, and the invasion of new pests (Gold et al. 1995, Gold et al. 1998ab) have severely affected the banana production in Central and Western Uganda over the last 15 years (Karamura 1993). In particular nematodes, and the banana weevil are major constraints and contribute to a reduced plantation life span through increased plant toppling (Speijer et al. 1994, 1998ab). The nematodes Radopholus similis, Helicotylenchus multicinctus, and Pratylenchus geinji live, feed, and reproduce in the roots and outer layer of the Musa rhizome (Quénéhervé 1990), spending most of their lifetime in the soil (Quénéhervé and Cadet 1986). Production loss by nematodes can exceed 50% in the first production cycle (Speijer and Kajumba 1996). The banana weevil, Cosmopolites sordidus, lays most of its eggs in the rhizome and the lower parts of the pseudostem (Abera et al. in press). Its larvae grow and feed in the plant tissue, forming long tunnels, which may lead to high losses of up to 60% in the fourth production cycle (Rukazambuga 1996).

The adult weevil can move freely between banana plants. Nematode damage and the banana weevil are highly associated on young banana suckers (Speijer et al. 1993), which may aggra-
plots at a distance of at least 25 m from the existing banana plots, to reduce on reinfection.

To assess the adoption of the clean planting material technologies, a follow-up visit was made to Busukuma County in May 1998. A total of 111 homesteads, which earlier had one or more household members trained and 112 adjacent homesteads with no trained members, were visited.

Results and discussion
All trained farmers had used ‘corm paring’ or ‘corm paring and hot water treatment’ in the establishment of new banana plots. Over 90% of the trained farmers observed a reduction in plant breakage and toppling, and an improvement of plant vigor and food quality, compared to their standard material (Figure 2). A drawback, observed by 23% of the trained farmers, was a higher susceptibility for livestock damage, because of the plants’ relatively shorter pseudostems. Therefore, most farmers planned to use suckers of at least 1.5 m in height for the next planting season. Most farmers considered the level of organization required for hot-water treatment, particularly transportation, a major constraint. Hot-water treatment may be adopted at village level, when a tank is developed or when the tank is available for the farmers who planted their plot. Hot-water treatment may be used at village level, when a more easily transportable material (Meerman and Speijer 1998). Alternatively the hot-water technology could be adopted by governmental or non-governmental organizations for the establishment of village level nurseries with clean material (Ortiz 1998). Village level nurseries could provide planting material of the farmers preferred size.

It was observed that 8% of the newly established plots were planted in or adjacent to existing plantations, which could result in a rapid infestation by nematodes and weevils. In future training, more attention needs to be given to explain the nematode and weevil spread into newly established plots. Also, it could be that due to the high land pressure, no clean land was available for the farmers who planted into existing plots. In the latter case, farmers should be informed of possible methods to use break crops, like sweet potato and cassava, to reduce nematode pressure in their plots (Kashaija et al. in press). Due to land pressure, 61% of the newly established plots were intercropped. Some intercrops, such as sweet potato, can reduce banana production, while others, like beans, do not interfere with plant crop establishment (Englberger et al. 1988). Farmers’ training should address the situation of high land pressure and provide farmers with various management options. Due to the farmers’ lack of knowledge of banana production or illness, 15% of the plots were poorly managed. More or better farmers training may increase farmers’ knowledge. However, the low productivity of farmers as a result of illness may require even more efforts at the national level, than presently made.

These results also show that training of farmers is highly effective in transferring new technology. It is therefore anticipated that a training of additional farmers, for example through Farmers Training Schools, will result in increased banana production in Central Uganda. National Research and Extension and non-governmental organizations could play a very important role in conducting farmers training.

All non-trained farmers were aware of ‘corm paring and hot-water treatment’ through other farmers (98%) and radio (2%). From these farmers, 30% were planning to use one of the technologies in the next season; a quarter of this group had already used corm paring in the present season. Approximately 25% of the non-trained farmers wanted more information about the technologies, while 45% were not likely to adopt any of the technologies due to illness or age (27%), no land or planting material (10%) or no interest (8%). These results suggest that information on new technologies spreads rapidly through the farmers’ community. However, it may take a planting season before non trained farmers adopt the technology. It may be that non trained farmers first prefer to see the results on their neighbour’s fields prior to adoption.

Conclusions
The technology of paring of planting material was readily adopted and is likely to be used by Busukuma farmers in future plantation establishment, as the majority of the farmers had observed a positive impact on highland banana production. Farmers, using the technology are likely to use planting material with pseudostems of at least 1.5 m in height to prevent damage by livestock. Hot-water treatment of pared planting material may be used at village level, when a more easily transportable tank is developed or when the tank is used for other village level or farm activities, like food processing, hot water disinfection of yam planting material or curing of vanilla.

References


Figure 2. Corm paring and hot water treatment of highland banana planting material in Ruguma village, Uganda.
Agronomic performances of six improved IITA Musa germplasm in the agroecological conditions of Mbalmayo (Cameroon)

P. Noupadja and K. Tomekpé

Black Sigatoka disease has become a major constraint to banana and plantain production worldwide resulting in yield losses from 33 to 50% (Stover 1983). All plantain cultivars and some of the banana cultivars of East Africa are susceptible to this fungal disease (Vuylstekte et al. 1993a). The use of fungicides to control the disease is not feasible in the resource-poor smallholdings where the crop is grown mainly for home consumption. Therefore, durable host resistance is generally considered as the most appropriate component of integrated pest management against the pathogen. The plantain and banana breeding programme of the International Institute of Tropical Agriculture (IITA) has registered some 14 improved tropical Musa plantain hybrids with black Sigatoka resistance (Vuylstekte et al. 1993a). Recently, Ortiz (1997) announced some new releases of improved Musa germplasm by IITA and its availability to national research services for their evaluation.
Materials and methods

The trial was established on 24 April 1997 at the IITA’s Humid Forest Station in Mbalmayo (640 m above sea level; 3° 25N, 11° 28E). The rainfall pattern is bimodal (+2 month dry spell: Dec-Jan; Jul-Aug) with a total rainfall of 1,500 mm. year\(^{-1}\). The soil type is an Ultilsoil derived from schist band (De Cauver et al. 1995). The planting material was made up of tissue culture plantlets received from the INIBAP Transit Center (ITC, Leuven, Belgium) and weaned by the CRBP tissue culture laboratory. The experimental plot was situated on a newly cleared field opened at the heart of the forest with no banana plantation at the vicinity.

The experiment was based on nine treatments consisting of six black Sigatoka resistant hybrids compared to three landraces with different degrees of black Sigatoka resistance (Table 1). The borders were planted with susceptible plantain and banana landraces to build up the Sigatoka inoculum. The experimental design was a randomised complete block with two replicates and ten data plants per replication. There were less than ten plants observed for some of the hybrids that have been rogued because they exhibited virus symptoms (TMPx 7002-1, TMPx 1621-1, TMPx 7152-2 and TMBx 5295-1) although tested BSV-negative by Electron Microscopy (INIBAP 1997). The planting density was 1667 plants ha\(^{-1}\) (3 m x 2 m). Normal agronomic management was applied uniformly to all cultivars and there was no fungicide treatment against black Sigatoka.

Morphological differences between cultivars were determined by measurements of plant height from ground level to the neck of the inflorescence at flowering and pseudostem girth at 100 cm above ground level. Leaf emission was recorded counting from the first functional leaf (first leaf with width greater than 10 cm). Black Sigatoka reaction was assessed by recording the youngest leaf spotted (YLS) during the vegetative phase of the plant. Records of yield components included bunch weight, hands per bunch, fingers per bunch and finger length taken on the medium external finger of the second hand. All these parameters recorded during the first crop cycle (plant crop) were statistically analysed by a standard analysis of variance using Newman-Keuls test for means separation.

Results and discussion

All the hybrids exhibited plant height greater than 3 m with the progeny from \textit{balbisiana} (TMBx 1378) exceeding 4 m (Table 2). Vuylstek et al. (1996) reported a plant height of 295 cm for the hybrid TMPx 4479-1 in Onne from preliminary evaluation of 1990-1991 (plant crop). It is recommended that breeders should aim to produce hybrids no taller than 3 m in order to reduce the wind damage which occurs frequently in banana production areas (ones 1994). In this case, although all the hybrids were over 3 m, it should be noted that, apart from TMBx 1378, none of the hybrids were significantly taller than two of the local landraces, Fougamou and French Sombre.

Apart from the hybrid TMBx 1378 which flowered very late (14 months after planting) being an offspring of \textit{balbisiana} and Fougamou, all the other hybrids flowered earlier than the landraces some eight to ten months after planting. This is true with regards to the plantain landrace (French Sombre) and the cooking banana. Grande Naine which is an AAA dessert banana flowered much earlier. In Uganda, Vuylsteke et al. (1996) reported the planting to flowering interval to be around 14 months (416 days) for the hybrid TMPx 1621-1. This could be due to the influence of the highland conditions of East Africa.

Significant differences (\(p < 0.05\)) have been observed among hybrids for bunch weight (Table 2). Although all the hybrids produce bunches weighing less than 20 kg, the banana hybrid TMBx 5295-1 has the highest bunch weight of 19 kg due to its high number.

Table 1. \textit{Musa} germplasm evaluated in Mbalmayo.

<table>
<thead>
<tr>
<th>Hybrids and Landraces</th>
<th>Plant height (cm)</th>
<th>Plant girth (cm)</th>
<th>Total number of leaves</th>
<th>Bunch weight (kg)</th>
<th>Hands per bunch</th>
<th>Fingers per bunch</th>
<th>Finger length (cm)</th>
<th>Days to flowering (days)</th>
<th>Fruit filling time (days)</th>
<th>Days to harvesting (days)</th>
</tr>
</thead>
<tbody>
<tr>
<td>TMPX 1621-1</td>
<td>1205</td>
<td>Obin i’Ewai x Calcutta 4</td>
<td></td>
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<tr>
<td>TMPX 4479-1</td>
<td>1293</td>
<td>Bobby Tannap x Calcutta 4</td>
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<td></td>
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<tr>
<td>TMPX 7002-1</td>
<td>1272</td>
<td>Obin i’Ewai x Calcutta 4</td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TMPX 7152-2</td>
<td>1294</td>
<td>Mb Egome x Calcutta 4</td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TMBx 1378</td>
<td>1296</td>
<td>Fougamou x BSI 63</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>TMBx 5295-1</td>
<td>1297</td>
<td>Laknao x Tjau Lagada</td>
<td></td>
<td></td>
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<tr>
<td>French Sombre (Plantain)</td>
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<tr>
<td>Fougamou (Banana)</td>
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<tr>
<td>Grande Naine (Banana)</td>
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</tbody>
</table>

Editor’s note: These accessions are being re-indexed by INIBAP. The accessions TMPX 1621-1 and TMPX 7152-2 have been found to contain virus particles and are no longer available for distribution.

1 This accession has been found to contain virus particles
2 This accession is no longer available from INIBAP.
of fruits and longer fruits. The plantain hybrids TMPx 1621-1 and TMPx 4479-1 exhibited higher bunch weights in Mbalmayo compared to Onne (Vuylsteke et al. 1993b) and Ghana (Hemeng and Yeboah 1995). Meanwhile, the hybrid TMPx 7002-1 produced heavier bunches (17.5 kg) in Onne (Vuylsteke et al. 1993b), indicating that this hybrid could be well adapted in those ecoclimatic conditions. It has been reported elsewhere that TMPx 7152-2 (PITA-14) has a lax bunch which could allow the development of big fruits (Ortiz 1997). This feature has not been observed on this hybrid which rather showed a compact bunch like the three other plantain hybrids. All these plantain hybrids have shorter finger length (less than 20 cm) that might have been maintained in the hybrids have shorter finger length (less than 20 cm) that might have been inherited from their male parent Calcutta 4. This characteristic is not well appreciated by many consumers who prefer longer fruits.

The fruit-filling time of the hybrids is always longer than that of the landraces with differences of 17 to 31 days (Table 2). A total of 130 days was required to hybrid TMPx 4479-1 for the full maturity of fruits in this trial against 114 days in a trial carried out in Onne (Vuylsteke et al. 1993b). This difference could be explained by the weather prevailing during the maturation of the fruits especially the temperature which might not be the same in both regions.

The response to black Sigatoka was assessed using the method developed by Fouré et al. (1990) by scoring the youngest leaf spotted (YLS) at four times-interval before the flowering of the plants and the number of standing leaves at this phase (data not shown). All the hybrids showed a more or less pronounced partial resistance (PR) to black Sigatoka (Table 3). These results are not always in accordance with those obtained in Onne (Crouch and Ortiz 1996) maybe because of the inoculum pressure or the different methods used for the evaluation.

### Table 3. Response to black Sigatoka as measured by youngest leaf spotted (YLS) in comparison to results obtained in Onne (Crouch and Ortiz 1996).

<table>
<thead>
<tr>
<th>Hybrids and landraces</th>
<th>YLS</th>
<th>Response</th>
<th>Results obtained in Onne (1996)</th>
</tr>
</thead>
<tbody>
<tr>
<td>TMPx 4479-1</td>
<td>9.1</td>
<td>PR-</td>
<td>Less susceptible</td>
</tr>
<tr>
<td>TMPx 7002-1</td>
<td>10.5</td>
<td>PR</td>
<td>Partiallement résistant</td>
</tr>
<tr>
<td>TMPx 7152-2</td>
<td>11.4</td>
<td>PR</td>
<td>Partially resistant</td>
</tr>
<tr>
<td>TMPx 1621-1</td>
<td>12.2</td>
<td>PR</td>
<td>Less susceptible</td>
</tr>
<tr>
<td>French Sombre</td>
<td>6.8</td>
<td>S</td>
<td></td>
</tr>
<tr>
<td>TMBx 5295-1</td>
<td>12.6</td>
<td>PR</td>
<td>Less susceptible</td>
</tr>
<tr>
<td>TMBx 1378</td>
<td>12.8</td>
<td>PR</td>
<td>Highly resistant</td>
</tr>
<tr>
<td>Fougamou</td>
<td>11.3</td>
<td>PR</td>
<td></td>
</tr>
<tr>
<td>Grande Naine</td>
<td>4.6</td>
<td>S</td>
<td></td>
</tr>
</tbody>
</table>

1: as compared to plantain landrace
S: susceptible; PR: partially resistant; PR:- partial resistance less pronounced.

### Conclusion

The performances of IITA hybrids in Mbalmayo differed somewhat to that expected following previous evaluations in other locations. This demonstration of the influence of the environment on hybrid performance serves to reinforce the need for multilocal evaluation of improved **Musa** germplasm in order to assess the influence of various environments on the genotypes and their adaptation to these environments.

**Acknowledgements**

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### References


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### Evaluation of bananas for niche markets in subtropical Florida

Banana has been an important crop in Florida for over a century (Stambaugh 1952). Commercial production has occurred as far north as Jacksonville (30°N), but is now centered to the west of Homestead (25°30’N, 80°30’W). Fruit from the area is valued at ca. US$2.5 million per annum (Degner et al. 1997).

The banana trade in Florida is unable to compete with the export industry in tropical America and, thus, focuses on non-Cavendish cultivars that are popular in the area’s ethnic markets. In 1995, 37 new banana accesses were introduced to South Florida in the hope that useful dessert and cooking clones would be identified (Ploetz and Benschel 1996). The objectives of the studies that are described below were to determine the accesses’ 1) adaptation to local soils and winter conditions; 2) productivity and

### Genetic resources

### Germplasm evaluation
quality of fruit; and 3) resistance to fusarium wilt (Ploetz et al. 1999a, b).

Materials and methods
Thirty-two of the 37 accessions were from the INIBAP Transit Center (ITC) at the Katholieke Universiteit Leuven, Belgium, and five were from the in vitro collection of the Queensland Department of Primary Industry (QDPI) in Maroochy, Australia. All were multiplied via standard meristem tissue culture in the QDPI laboratory in Maroochy. The micropropagated germplasm was shipped, with Australian phytosanitary certification and under Animal and Plant Health Inspection Service (APHIS) permit, from QDPI to the University of Florida's Tropical Research and Education Center (TREC) in Homestead.

Plantlets were grown in polybags to ca. 1 m in height prior to use in the field. Two accessions, ‘Niyarma yik’ AA and ‘Rimina’, a Fe’i banana, were killed during the cold winter of 1995/1996 prior to the initiation of field experiments.

Agronomy, productivity and fruit quality
Thirty-five accessions were planted in a completely randomized design in a field at TREC. Accessions were replicated seven times, and replicates were pairs of plants. Rows were 4.5 m apart, and within rows plants were separated by 2.5 m.

After four months, suckering and height of the accessions were recorded monthly. The number of suckers that were produced in a mat and height at fruiting (distance in meters from the base of the stem to the top of the peduncle) were determined at the end of the first fruiting cycle. Cycling time (the number of days that elapsed between planting and harvest) was also recorded for the first fruiting cycle, and bunch weight (weight in kg of all hands in a bunch minus the raceme) was recorded from 1996 to 1998. Taste panels at TREC and agricultural festivals in Homestead, Florida and West Palm Beach, Florida determined the appearance and organoleptic qualities of fruit from the experiment. Subjective 1 - 4 scales were used for both parameters where: 1 = poor, 2 = fair, 3 = good, and 4 = excellent. Ratings were computed from 743 evaluations by more than 200 individuals.

To determine a clone’s yield potential, a productivity index (PIX) was computed as:

\[
\text{PIX} = 100 \times \frac{\text{BW}}{\text{CT}}
\]

where BW = bunch weight in kg and CT = cycling time in days.

Performance against Fusarium wilt
Trials for screening 30 of the accessions against fusarium wilt were established on separate sites at TREC. Cornmeal sand cultures of three isolates of Fusarium oxysporum f. sp. cubense (Foc), each of which represented a different VCG that is found in South Florida, were used to individually infest planting holes at planting and 6 months thereafter. Within an isolate/VCG treatment, accessions were completely randomized and replicated from five to eight times depending upon the availability of plantlets; replications were single plants. Plants were established in staggered, double rows whose centers were 9 m apart. Plants within a row were separated by 3 m and between plants in the neighboring tandem row by 2 m.

External evaluations of disease severity were made four times in 1997 and 1998 on a subjective 1 - 5 scale where: 1 = healthy; 2 = slight chlorosis and wilting with no petiole buckling; 3 = moderate chlorosis and wilting with some petiole buckling and/or splitting of leaf bases; 4 = severe chlorosis, wilting, petiole buckling and dwarfing of the newly emerged leaf; and 5 = dead. When equivocal symptoms were observed, internal, corrosive symptoms were assessed.

Analyses
ANOVARs were performed with the general linear models (GLM) procedure of SAS for PCs (SAS Institute 1989). Analyses of bunch weight and PIX were conducted only for clones for which at least four bunches were harvested, and of fruit taste and appearance for only those accessions for which a total of 10 or more evaluations were available (no cooking clone met the latter criterion) (Table 1). Mean disease severity ratings in Table 1 are from a single evaluation at the end of 1998.

Results
Agronomy, productivity and fruit quality
Mean suckering rate for the accessions ranged from 3.6 to 11.6 per mat during the first fruiting cycle (Ploetz et al. 1999a). Suckering generally decreased as the ploidy of clones increased, with diploids exhibiting a significantly higher rate than triploids or tetraploids (respectively, 7.34 versus 5.56 and 4.82; P < 0.05). No relationship was observed between genome and suckering rate.

Height at fruiting and cycling time also varied significantly. ‘Kandrian’ ABB was about 2 m taller than the shortest clones, and cycling time varied from 372 days for ‘Kumunamba’ AAB to 826 days for ‘Kandrian.’ Neither trait was significantly correlated with ploidy or genome.

Bunch weight was highly correlated with accession, ploidy, and genome, and ranged from 0.8 kg for ‘Pisang mas’ AA to 14.4 kg for ‘Kandrian’ (Table 1). It was significantly lower for diploids than for triploids and tetraploids. Productivity indices ranged from 0.1 for ‘Pisang mas’ to 2.7 for ‘Popoulu’ ABB. Twenty-two clones had PIXs greater than 1, an arbitrary level of acceptable productivity. No diploid AA accession approached this level, whereas triploids had higher, but not significantly different, mean indices than tetraploids (respectively, 1.27 vs 1.2).

Eleven of 20 cooking clones had mean taste ratings of 3 or higher (good to excellent), of which ‘Kofi’ ABB rated highest (3.8; Table 1). Sixteen dessert clones had mean ratings of 3 or higher, and 11 of these had appearance ratings of 3 or greater. Of these, the 398 accession of ‘Ney poovan’ AB from QDPI had the highest taste rating 3.79, although this was not significantly different from the rating for 12 other accessions.

Performance against Fusarium wilt
Mean severity ratings for several clones met or exceeded 2.5, an arbitrary threshold of susceptibility. However, for many clones of moderate susceptibility, their response was not significantly different from those of a lower susceptibility (Table 1).

VCG 0120. All plants of ‘Popoulu’ died by the first evaluation six months after planting, and by the completion of the experiment, some plants of ‘Silk’ (sport) AAB and ‘Ney poovan’ AB from 584 had also died. Mean disease ratings for the latter clones, respectively, 4.0 and 3.0, and for ‘Kluai namwa khom’ ABB, 2.5, were 2.5 or higher.

VCG 0124. Several plants each of ‘Silk’ (sport), ‘Sugar’ AAB and ‘Bluggoe’ ABB died, and mean ratings for these clones, respectively, 4.0, 3.3 and 3.3, as well as for ‘Pisang nangka’ AAA and ‘Inarnibal’ AAA, 2.7 and 2.5, rated 2.5 or higher.

VCG 0120. Six accessions met the 2.5 criterion of susceptibility, but only plants of ‘Pelipita’ ABB 564, ‘Silk’ (sport), ‘Ducasse’ ABB and ‘Sugar’ were killed.

Discussion
Prior to the mid-1990s, ca. 60 banana cultivars were grown in southern Florida, but only three of these, ‘Bluggoe’, ‘Hua Moa’ AAB and ‘Silk’ were
The productivity index = 100 X (BW/CT), where BW = bunch weight in kg and CT = cycling time in days. Statistical analyses of mean bunch weight and PIX were made only for clones for which at least 10 ratings were made (no cooking clone met this criterion).

Table 1. Performance of new banana accessions in South Florida.

<table>
<thead>
<tr>
<th>Accession(s)</th>
<th>N° Mean bunch productivity index</th>
<th>Dessert</th>
<th>Cooking</th>
<th>Reaction to isolates (VCG s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>AAA Genome</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Niyama yik</td>
<td>0 Nd</td>
<td>1.1</td>
<td>2.0</td>
<td>1.1</td>
</tr>
<tr>
<td>Pamotion</td>
<td>1229/576/-</td>
<td>96</td>
<td>96</td>
<td>96</td>
</tr>
<tr>
<td>Pisang jari buaya</td>
<td>0312/577/-</td>
<td>93</td>
<td>93</td>
<td>93</td>
</tr>
<tr>
<td>Pisang lenak manis</td>
<td>1183/576/-</td>
<td>91</td>
<td>91</td>
<td>91</td>
</tr>
<tr>
<td>Pisang mas</td>
<td>0635/579/-</td>
<td>90</td>
<td>90</td>
<td>90</td>
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<tr>
<td>Rose</td>
<td>0712/576/-</td>
<td>90</td>
<td>90</td>
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<tr>
<td>Señorita</td>
<td>1230/580/-</td>
<td>90</td>
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<tr>
<td>Veinte cohoh</td>
<td>1031/582/-</td>
<td>90</td>
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<tr>
<td>AB Genome</td>
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<tr>
<td>Kunnan</td>
<td>1034/583/-</td>
<td>90</td>
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<td>Noy poovan</td>
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<td>Noy poovan</td>
<td>0459/584/-</td>
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<td>AAAA Genome</td>
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<tr>
<td>Inanimal</td>
<td>0477/576/-</td>
<td>90</td>
<td>90</td>
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</tr>
<tr>
<td>Pisang nangka</td>
<td>1062/585/-</td>
<td>90</td>
<td>90</td>
<td>90</td>
</tr>
<tr>
<td>Williams</td>
<td>0570/587/-</td>
<td>90</td>
<td>90</td>
<td>90</td>
</tr>
<tr>
<td>Yangambi km5</td>
<td>1123/586/-</td>
<td>90</td>
<td>90</td>
<td>90</td>
</tr>
<tr>
<td>ABB Genome</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bluggoe</td>
<td>/-26/-</td>
<td>90</td>
<td>90</td>
<td>90</td>
</tr>
<tr>
<td>Ducasse</td>
<td>/-25/-</td>
<td>90</td>
<td>90</td>
<td>90</td>
</tr>
<tr>
<td>Dwarf kalapua</td>
<td>0812/368/171</td>
<td>90</td>
<td>90</td>
<td>90</td>
</tr>
<tr>
<td>Kandrian</td>
<td>0803/367/148</td>
<td>90</td>
<td>90</td>
<td>90</td>
</tr>
<tr>
<td>Prata aná</td>
<td>0962/592/-</td>
<td>90</td>
<td>90</td>
<td>90</td>
</tr>
<tr>
<td>Silk (sport)</td>
<td>1222/591/-</td>
<td>90</td>
<td>90</td>
<td>90</td>
</tr>
<tr>
<td>Sugar</td>
<td>/- 40/-</td>
<td>90</td>
<td>90</td>
<td>90</td>
</tr>
<tr>
<td>Walha</td>
<td>1033/592/-</td>
<td>90</td>
<td>90</td>
<td>90</td>
</tr>
<tr>
<td>ABBB Genome</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Bluggoe</td>
<td>/-26/-</td>
<td>90</td>
<td>90</td>
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<tr>
<td>Ducasse</td>
<td>/-25/-</td>
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<tr>
<td>Dwarf kalapua</td>
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<tr>
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<td>1222/591/-</td>
<td>90</td>
<td>90</td>
<td>90</td>
</tr>
<tr>
<td>Sugar</td>
<td>/- 40/-</td>
<td>90</td>
<td>90</td>
<td>90</td>
</tr>
<tr>
<td>Walha</td>
<td>1033/592/-</td>
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<td>AAAA Genome</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>FHIA-02</td>
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<td>90</td>
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<td>FHIA-17</td>
<td>1264/599/-</td>
<td>90</td>
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<td>FHIA-23</td>
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<tr>
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<td>0504/596/-</td>
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<td>90</td>
<td>90</td>
</tr>
<tr>
<td>Rimation</td>
<td>1010/201/-</td>
<td>90</td>
<td>90</td>
<td>90</td>
</tr>
</tbody>
</table>

*a* Accession performance was determined in two field studies at TREC during 1996 to 1998.  
*b* Cultivar names are those given by the original donor. Niyama yik and Rimation died due to low temperatures prior to their establishment in field studies.  
*c* Accession codes are, in order, those for: the International Transit Center (ITC) in Lueven, Belgium; the Queensland Department of Primary Industries (QDPI) in Maroochy, Australia; and germplasm obtained during a Musa collecting mission in Papua New Guinea (PNG) that was sponsored by the International Board for Plant Genetic Resources (IPGRI).  
*d* Accession names are those given by the original donor. Niyama yik and Rimina died due to disease severity was rated on a 1 – 5 scale where:  
1 = healthy, 2 = slight chlorosis and wilting with no petiole buckling, 3 = moderate chlorosis and wilting with some petiole buckling and/or splitting of leaf bases, 4 = severe chlorosis, wilting, petiole buckling and dwarfing of the newly emerged leaf, and 5 = dead.  
*e* Appearance and taste evaluations were made by panels at TREC and tropical fruit festivals in Homestead, Florida and West Palm Beach, Florida. Pisang mas, Veinte cohoh, Kunnan, Pisang nangka, Kumunamba, Prata ann, Sugar, FHIA-01, FHIA-02 and FHIA-27 are usually used as dessert bananas, and Koff, Popoulu, Bluggoe, Dwarf kalapua, Kandrian, Pelipita, Saba, and FHIA-03 are usually used as cooking bananas. Statistical analyses were conducted only for clones for which at least 10 ratings were made (no cooking clone met this criterion).  
*f* Representative isolates from each of the vegetative compatibility groups (VCGs) of Fusarium oxysporum f. sp. cubense that are found in South Florida were used to infest holes in which the different accessions were planted. Disease severity was rated on a 0 – 12 scale where:  
1 = healthy, 2 = slight chlorosis and wilting with no petiole buckling, 3 = moderate chlorosis and wilting with some petiole buckling and/or splitting of leaf bases, 4 = severe chlorosis, wilting, petiole buckling and dwarfing of the newly emerged leaf, and 5 = dead.
important. Since these cultivars are less than well adapted to conditions in the area, the evaluation of new germplasm was warranted (Ploetz et al. 1999a). All of the accessions and most of the cultivars that were assessed in these studies had not been grown previously in South Florida. Four of the cultivars, ‘Dwarf kalapua’ ABB, ‘Kandrian’, ‘Kofi’ and ‘Kumamamba’, were collected in Papua New Guinea during INIBAP-IPGRI collecting missions in the late 1980s, and to our knowledge had not been grown before in the Western Hemisphere (Arnau and Horry 1997, Sharrock 1990). In some cases, new accessions of old cultivars were introduced in the hope that they would perform better than those that are currently found in the area. For example, a large-fruited sport of ‘Silk’ from Tanzania and ‘Sugar’, the Australian version of this popular clone, were tested, even though they were presumed to be susceptible to Fusarium wilt. Their performance in the area was of interest since the ‘Silk’ (‘Manzano’) that is currently utilized in South Florida is less robust and produces smaller fruits and bunches than do ‘Silk’ clones in the FHIA collection (Franklin Rosales, personal communication).

Several of the tested clones had an AA genome. All shared the genome’s fruit characteristics of thin fruit skin and sweet flesh, but none were very productive, corroborating previous conclusions about the poor performance of AA clones (Stover and Simmons 1987). Twenty-two of 33 accessions had PIx greater than 1, but no AA accession approached this level of productivity (Table 1). Interestingly, both accessions of ‘Ney poovan’, an AB diploid, had PIx of 1.2 and 1.4 that actually exceeded ratings for some triploids and tetraploids in the study.

Many of the accessions displayed good to excellent tolerance to the isolates/VCGs of Foc that were tested (Table 1). With few exceptions, all of the AA clones and those from the FHIA breeding programme performed quite well. Interestingly, in a few cases different accessions of the same cultivar performed differently against a given VCG. ‘Ney poovan’ 594 was significantly more susceptible to VCG 0120 than ‘Ney poovan’ 398, whereas the ‘Silk’ (sport) was more susceptible to VCG 0120 than ‘Sugar’. Although differences in susceptibility among different ‘Silk’ accessions had not been reported previously, note has been made in East Africa of differences between two clones of ‘Ney poovan’, one of which, ‘Sukali ndizi’, develops symp- toms more slowly than the other, ‘Kisuhi’ (Wilberforce Tusheremirewe, personal communication). Finally, ‘Klui namwa khom’, a dwarf variant of ‘Pisang awak’ ABB, was less susceptible to VCG 01210 than ‘Ducasse’, a standard size accession of ‘Pisang awak’. Previously, a dwarf variant of Cavendish, ‘Dwarf Parfitt’ AAA, was shown to be more resistant to race 4 of Panama disease than Williams AAA (K.G. Pegg, personal communication).

Note is also made of the apparently anomalous reactions of the ‘Silk’ sport and ‘Sugar’, both of which are race 1 susceptible, and ‘Bluggoe’, which is a race 2 susceptible, to the test strain from VCG 0124. The original reports of race 2 in tropical America indicated that race 1 susceptibles were highly resistant to race 2, and that the race 2 susceptible, ‘Bluggoe’, was resistant to race 1 (summarized in Stover 1962). Although both races have been reported in this VCG (Ploetz and Pegg 1999), it is not clear whether the present results signify the activity of a new race of the pathogen, or whether environmental or edaphic conditions in South Florida are responsible. Clearly, a better understanding of pathogenic specialization in this fungus is needed (Stover and Buddenhagen 1986).

Although most of the accessions that were evaluated displayed at least one meritorious characteristic, only eight dessert and eight cooking clones produced reasonably high yields of acceptable fruit (i.e., productivity indices of 1 or higher and 3 or higher in taste tests) (Table 1). Unfortunately, some of the most popular and productive clones were susceptible. The highly rated ‘Silk’ sport from Tanzania was susceptible to all three VCGs in this study, and the productive and highly rated accession of ‘Bluggoe’ was susceptible to VCG 0124. ‘Popoulu’, another highly rated cooking banana and the most productive clone in these trials, was very susceptible to VCG 0120. These and other susceptible clones are not recommended for production in areas that have a history of fusarium wilt, but could be used in other areas. Certainly, the excellent flavor of ‘Ney poovan’ 398 and outstanding productivity of ‘Popoulu’ suggests that they could become commercially important in South Florida despite their major flaw of susceptibility.

The following highly ranked clones are resistant to fusarium wilt, and appear to have potential in all production areas in southern Florida. Based on these results, the dessert clones ‘Pisang Ceylon’, ‘FHIA-01’ AAAAB, ‘FHIA-02’ AAAA and ‘FHIA-17’ AAAA, and the cooking clones ‘Kumamamba’, ‘Kandrian’ and ‘Saba’ ABB, are recommended.

Acknowledgements

The authors thank Dr Jean-Pierre Horry, former germplasm officer for INIBAP and Ms. Ines Van Den Houwe, officer-in-charge of the INIBAP International Transit Center (ITC) in Leuven, Belgium, for supplying much of the germplasm in Table 1. The authors are also grateful to Dr Mike Smith and Ms. Sharon Hamill (QDPI) for donating some of the accessions and for supplying high-quality plantlets for this study. We acknowledge the technical assistance of Zaragoza Alegria and Ozzany Rodriguez.

References


Musa clones in Peru: classification, uses, production potential and constraints

Ulrike Krauss, Raúl Figueroa, Andrea Johanson, Enrique Arévalo, Raúl Anguiz, Oscar Cabezas and Luis García

Peru, in contrast to its neighbours, Brazil, Colombia and Ecuador (Figure 1), is not an important exporter of bananas and plantains. As a result, Peruvian Musa clones have received little attention internationally and their names are often different from those of the same clones in other countries. Indeed, the same clones frequently have different names and uses within Peru. However, like in many parts of Africa, Asia and the Americas, Musa plays an important role both in rural alimentation and as a cash crop for internal markets. Rengifo and Fasanando (1994) counted 37 Musa clones in agricultural fairs in the central Mayo valley (Figure 2). This number was exceeded only by the genus Capsicum (42) and by bean varieties (52) of different genera.

With the exception of the coastal region of Grau (Departments of Tumbes and Piura), the majority of Musa is produced and consumed in the eastern, tropical parts of the country (Figure 1), notably the Amazon, Apurímac, Ene, Huallaga, Marañon, Ucayali and Urubamba valleys and their lower tributaries (Figure 2). These areas also produce Musa for metropolitan markets where especially dessert-type bananas are highly valued by the middle class. This trade brings important income to the eastern valleys where illicit coca production is only gradually being replaced by cocoa, coffee, Musa and other tropical fruit crops.

Because of the importance of banana and plantain for sustainable development in many areas, the objective of this paper is to present and analyse information available on the classification, uses, production potential and constraints of common clones in Peru.

Musa clones

Local names of Peruvian clones along with regional and internationally recognised synonyms according to the classification by Stover and Simmonds (1987) are presented in Table 1. The most widely used Peruvian name is listed under “clone” and “Peruvian synonyms” are presented in alphabetical order.

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**Table 1: Musa clones and synonyms**

<table>
<thead>
<tr>
<th>Clone</th>
<th>Regional Name</th>
<th>International Name</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>AAA group:</strong> Alquizar, Canchaque, Datil, Flauta, Inmune, Montero, Ovilia Guineo and Seda Sharapino.</td>
<td></td>
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</tr>
<tr>
<td><strong>AAB</strong></td>
<td><strong>AA</strong></td>
<td></td>
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<tr>
<td><strong>AAAA</strong></td>
<td><strong>AAAB</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Abancay</strong></td>
<td><strong>Abancay</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Fhia-23</strong></td>
<td><strong>Fhia-1-1</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Fhia-01</strong></td>
<td><strong>Fhia-02</strong></td>
<td></td>
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<tr>
<td><strong>Fhia-18</strong></td>
<td><strong>Fhia-18</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Fhia-03</strong></td>
<td><strong>Fhia-03</strong></td>
<td></td>
</tr>
</tbody>
</table>

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 hybrids are now being evaluated in farmers’ fields (Anguiz 1998, Krauss, unpublished).

Peruvian publications on Musa germplasm should be interpreted with caution. Cuadraodo, Datil, Filipino, Guayaquil, Guineo, Indio, Lady’s Finger, Manzano and Morado are used by growers and authors for several different clones in different areas. The terms Guineo and Morado can refer to any variety with a dark pigmentation on the fruit or pseudostem. Suffixes further specify differences in colour and/or size. These subdivisions are beyond the scope of this article. Names of Cavendish clones are used as synonyms and do not necessarily match the international equivalent or even the same subgroup. Similarly, Seda and Guayauil (=Seda Guayaquil), both members of the Gros Michel subgroup, have been mistakenly assigned to the Cavendish subgroup by some authors and used as synonyms for any yellow, AAA-type banana. In San Martin, local names are often Quechua descriptions of fruit and plant characteristics, which the authors could not match with familiar varieties. Thus, the following clones may or may not be identical to those listed in Table 1 and/or to each other:

**AAA group:** Alquizar, Canchaque, Datil, Flauta, Inmune, Montero, Ovilia Guineo and Seda Sharapino.

**French plantain group (AAB):** All-paplátano, Balsino, Brashico, Ca-

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**Figure 1.** Musa-growing regions of Peru and contribution to national production in percentage.

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Table 1. Peruvian Musa clones, local synonyms, genomic classifications and international equivalents (in accordance with Stover and Simmonds 1987).

<table>
<thead>
<tr>
<th>Clone</th>
<th>Peruvian synonyms</th>
<th>International synonym (description)</th>
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<tr>
<td><strong>AA types</strong></td>
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<td></td>
</tr>
<tr>
<td>Moquicho</td>
<td>Azucarado, Bizocho, Bocadillo, Canelita, Ciento en Boca, Datil, Guineo, Guineo Mequiche, Lady’s Finger, Limenillo, Orito, Oro, Ouro, Perita, Platanito de Oro</td>
<td>Sucierr</td>
</tr>
<tr>
<td><strong>AAA types</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Gros Michel subgroup</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Seda</td>
<td>Seda Guayaquil</td>
<td>Guayaquil (Colombia), Seda Guayaquil (Equateur)</td>
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<tr>
<td>Guayaquil</td>
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<td></td>
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<td><strong>Cavendish subgroup</strong></td>
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<td></td>
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<tr>
<td>Filipino</td>
<td>Congo, Nanicaco, Poyo, Robusta, Valery</td>
<td>Giant Cavendish</td>
</tr>
<tr>
<td>Indio</td>
<td>Enano del Pais, Viejilla</td>
<td>Dwarf Cavendish</td>
</tr>
<tr>
<td>Montecristo</td>
<td>Lacatan</td>
<td>Lacatan</td>
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<td>Gran Enano</td>
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<td>Grand Nain</td>
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<tr>
<td><strong>Green-red subgroup</strong></td>
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<tr>
<td>Morado Claro</td>
<td>Guineo Colorado</td>
<td>Green-red</td>
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<tr>
<td><strong>Red subgroup</strong></td>
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<tr>
<td>Morado</td>
<td>Guineo, Guineo Rojo, Indio, Morado Oscura, Rojo</td>
<td>Red</td>
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<td><strong>Lujugira subgroup</strong></td>
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<td>nk 3</td>
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<td><strong>AAB types</strong></td>
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<td><strong>Plantain subgroup</strong></td>
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<tr>
<td>Inguri</td>
<td>Asapa Plátano, Arcanchaco, Común, Delgado, Dominico, Largo, Hembra, Paisano, Plátano Bueno, Plátano de Freir, Sancochado</td>
<td>Green French Plantain</td>
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<tr>
<td>Provinciano</td>
<td>Manzano, Tosco Pupusapa</td>
<td>French Plantain (Fewer hands than Inguri, with shorter, fuller fruit)</td>
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<td>Bellaco</td>
<td>Brraganete, Cuerno, Hartón, Macho</td>
<td>Hartón (5-7 hands)</td>
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<tr>
<td>Bellaco Plátano</td>
<td>Bellaco Plantano, Cuerno</td>
<td>Plantain corne (usually 7 hands)</td>
</tr>
<tr>
<td>Mameluco</td>
<td>Mamaluca, Mameluca, Bellaco Cachacho</td>
<td>Plantain corne (usually 2 hands with long fruit)</td>
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<td>Mysore 2</td>
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<td><strong>Maia Maoli subgroup</strong></td>
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<tr>
<td>Palillo</td>
<td>Canela, Caprona, Guayabo, Guayaquil, Maqueño, Rey, Vaporino</td>
<td>Ecuadorian Maqueño ?</td>
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<td><strong>Silk subgroup</strong></td>
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<td>Manzano</td>
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<td>Pacovan, Pome</td>
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<td><strong>ABB types</strong></td>
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<td><strong>Bluggoe subgroup</strong></td>
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<td>Huaybino Cenizo</td>
<td>Sapino Verde Cenizo</td>
<td>Silver Bluggoe</td>
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<td>Pelipita</td>
<td>Colombiano, Filipino</td>
<td>Pelipita</td>
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<tr>
<td>Sapo</td>
<td>Baliso, Buno, Chato, Cuadrado, Huaybino, Sapinio, Sapote, Sapucho</td>
<td>Bluggoe</td>
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<td>Sapo Plátano</td>
<td>Cotopatano</td>
<td>(Wrinkly fruit with black lines)</td>
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<td>Trujilliamo</td>
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<td><strong>Pisang awak subgroup</strong></td>
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<tr>
<td>Isla</td>
<td>Cuadrado, Manzano</td>
<td>nk (various clones, see Table 3)</td>
</tr>
</tbody>
</table>

1. This clone is suggested to have been brought to Peru from East Africa by the Portuguese via Brazil (Astocaza 1996).
2. Only in border region with Brazil?
3. nk = not know
be identified. Common, unidentified clones should be characterised using IPGRI descriptors and molecular techniques.

Within Isla (Pisang Awak subgroup), at least five, but possibly up to seven clones are distinguished: Isla del Alto Huallaga, Isla Guayaquil, Isla Maleño, Isla Nacional, Isla de Tingo María, Isla Vaporino (=Isla Baporino) and Isleño (Astocaza 1996, Figueroa and Wilson 1992, MINAG, INIA and CONFRUTA 1997, Rengifo and Fasanando 1994, SENASA and FAO 1997, Pérez and Anguiz 1998). Because of the importance of Isla (multipurpose) in Peru and its peculiar features, the main clones are compared in Table 3. Isla Maleño is grown in the coastal region of Tumbes whereas, the others are of wider distribution with predominance in the eastern valleys. The most remarkable characteristic of Isla is a pink hue of the pseudostem, leaves and fruit pulp. In the field, this can best be seen when leaves are viewed against the light. It covers the entire leaf surface apart from a 2-inch strip on the left margin. Isla is believed to have been introduced from Asia via the Canary Islands (hence the name) by the Spanish. It does not seem to have spread into neighbouring countries to any significant extent, and no clone in the Colombian Collection of Musaceae (Belalcázar, undated) corresponds to Isla.

Musa production in Peru

In this decade, the area under Musa has risen consistently in Peru (Table 4), which indicates a willingness of farmers to produce this crop. However, due to mediocre yields caused by poor agronomic practices and almost complete lack of disease control (Cavalié et al., Chingay and Molero, Figueroa, Perco et al., Tanchiva and Charpentier, Rivas and Palomino et al. 1986), an increase in productivity has been less pronounced (Table 4). In 1996, production reached over 1.3 million metric tons. The largest producers were the Departments of Ucayali (251,969 t), Loreto (251,943 t), Piura (225,091 t), Huánuco (156,008 t), Pasco (88,365 t), Junín (73,662 t) and Tumbes (71,887 t) (Fujimori et al. 1997) (Figure 1). National production shows relatively little fluctuation throughout the year (Figure 3). Although most of the production is consumed locally, sales in Lima’s largest fruit market (Figure 3) provide a steady income to growers (Figure 4).

Between Jaén and San Ignacio on the Ecuadorian border (Figure 1), a...
small percentage (4%) of Musa is grown under irrigation. Seda and Manzano are the most popular; whereas, Isla and Palillo are more rare (Díaz 1986). In San Martín, Inguiri prevails (Yengle 1986) although this ethnically mixed Department exhibits a tremendous diversity of Musa germplasm (Rengifo and Fasanando 1994). The same applies to Loreto. Inguiri with ca 80% of production used to be of greater importance than Bellaco (Tanchiva and Charpentier 1986). Owing to black Sigatoka, both clones have largely been replaced by Pelipita. Among fruit types, Seda, Manzano and Moquicho predominate, Mameluca, Maquisapa and Tosquino for cooking, and Isla and Prato for fruit are mostly back-yard crops in Loreto (Tanchiva and Charpentier 1986). The leading clones in the Huallaga valley are Inguiri, Palillo, Isla and Seda, followed by Morado, Manzano and Moquicho (Cavalié et al. 1986). The main clones in the Selva Central are Isla, Seda, Inguiri and Bellaco, followed by Manzano and Morado (Parco et al. 1986). In Ucayali, Inguiri, Bellaco and Sapo are favoured cooking types; Isla de Tingo María, Seda, Moquicho and Manzano the preferred fruit types; and Palillo and other Isla clones are multi-purpose (Rivas and Palomino 1986). In Mardre de Dios, Inguiri, Bellaco, Seda, Manzano, Moquicho and Morado predominate (Chingay and Molero 1986).

Uses of Musa in Peru
Dessert-type fruit are more appreciated in the coastal regions and cooking-types in the tropical East. Among dessert-types, which are consumed as fruit or drink, Cavendish clones are the least popular. Seda is highly favoured, but the spread of Fusarium wilt (Table 5) is increasingly limiting production. Moquicho is rising in popularity, rapidly filling the gap. Some lines are reported not only to be resistant to Fusarium wilt, but also to be tolerant to the nutrient-exploited, acidic, former coca soils which are often unsuitable for the production of other crops. Ripe Moquicho is enjoyed as fresh fruit or deep-fried in a batter and green fruit is boiled whole, without peeling. This clone is the only one

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Figure 2. Musa-growing regions of eastern Peru covered by the disease survey (shaded). Dark shading indicates the presence of black Sigatoka, light shading its absence.

Figure 3. National Musa production and wholesale volumes on Lima’s largest fruit market (x1000 t) throughout the year (adapted after Webb and Fernández 1997).

Figure 4. Wholesale prices of popular clones in Lima in $US/kg (after Webb and Fernández 1997).
transported to markets in wooden crates. All others are loaded onto trucks as whole bunches with little or no padding.

All plantain-types are boiled or fried, both green and ripe. Plantain flour and starch are produced in cottage industries in the eastern valleys. "Tacacho" is a popular dish in the eastern valleys prepared from mature but green, boiled, mashed plantains which are then fried with lard. "Patacones" are prepared by smashing barboiled or lightly fried plantain slices and refrying them in hot oil. Horn plantains are preferred for patacones. "Chifles", thin, deep-fried and crisp slices of green fruit, are occasionally prepared from plantain, but Manzano (Silk-subgroup) and Tosquino are preferred for making these chips on the coast.

As the market potential of the delicate Manzano (the peel of ripe fruit tends to split) is recognised, padding using palm leaves is gradually being adopted to protect this clone against mechanical damage and chilling injury during the Andean crossing. This process is slow since most people of the tropical east do not appreciate Manzano and feed it to pigs. But, in some areas, fruit of both the Silk and the Pome subgroup are eaten as fresh fruit when ripe. Manzano is not consumed by inhabitants of the high Andes because they report an adverse reaction to this clone. Palillo (Maia Maoli subgroup) is boiled (green or ripe) or fried ripe on the coast. In the tropical east, the main use of Palillo is for the preparation of fresh ("chapo") or fermented ("chicha de plátano") drinks from the raw, ripe fruit.

Bluggoe is eaten mostly as boiled, ripe fruit. It is not popular and is found only as a back-yard crop. Sapo Plátano is the only clone in the Bluggoe subgroup, which is also eaten raw. In contrast, Isla is enjoyed in any possible form throughout the country. It is one of the most popular Musa subgroups in Peru.

**Musa trade**

In contrast to most countries, farm gate prices in Peru are not determined by fruit weight but by number of pairs of fruits (fingers) in two quality categories. In 1997, the 1000-finger price ranged from US$ 33.00 for Bellaco and Palillo, US$ 28.00 for Isla, to US$ 15.00 for Manzano and Moquicho in Class 1 which accounts for 60% of production. The price of Class 2 is half that of Class 1. For comparison, Class 1 farm-gate prices are equivalent to an average of US$ 120-140 t⁻¹. Given this unusual remuneration system, agronomic recommendations should focus on the very early stages of inflorescence differentiation which takes place before emergence. At this time, the maximum number of hands and fingers are being determined (Stover and Simmonds 1987). After emergence, only fruit filling takes place and good crop husbandry then will be less profitable than at an earlier stage. This is a difficult task for extensionists because growers are more likely to take care of a visible bunch after flowering than a plant before emergence.

A further problem of the pricing system is that only pairs of fingers on the two whorls of a hand are counted. The number of fingers on an odd-numbered hand is rounded down. Thus, farmers lose approximately 10% of their income while traders win because retail prices in Peru are based on weight like elsewhere. Farmers do not remove odd fingers at early stages because growers are more likely to take care of a visible bunch after flowering than a plant before emergence.

In the wholesale market in Lima, are consumed throughout the year and prices are relatively stable. In contrast, Bellaco and Palillo, two varieties which, in Lima, are consumed only cooked, are most popular in the colder winter month. This is reflected in a seasonal price increase between June and September (Figure 4).

As mentioned above, Peru exports only small amounts of banana/plantain. Chile is the main destination with 700-1000 t/year⁻¹. In 1994, Ecuador, Italy and the Netherlands also imported Peruvian fruit (Fijimori et al. 1996). Significant amounts are imported from Ecuador when national supplies are insufficient in border regions.

**Pests and diseases**

The most problematic diseases in Peru are black and yellow Sigatoka and Cordana leafspot (Tables 5 and 6) (Anguiz and Nicolas 1998, Arévalo et al. 1998). Yellow Sigatoka, Cordana leafspot and the relatively harmless Cladosporium leafspot are ubiquitous; whereas, the more aggressive black Sigatoka, which reached Peru (Ucayali) in 1994, is still absent from Apurímac, Madre de Dios and Ucayali (Anguiz and Nicolas 1998, Arévalo et al. 1998) (Figure 2). Black Sigatoka is seriously affecting production in Loreto, San Martín and the Ucayali valley and exhibits the fastest expansion rate of all diseases (Table 5). It is now spreading upstream in the upper Huallaga valley. By late 1997, it had reached between Tocache and Aucayacu (Table 6, Figure 2). Fusarium wilt (races 1 and 2) is serious in some locations and expanding (Table 5). Moko is serious in Loreto (Pérez and Anguiz 1998, Tanchiva and Charpentier 1986). It also occurs in Patchitea-Ucayali but only sporadically in the Huallaga valley (Table 5) where Erwinia sp. is also present in the eastern valleys. The two whippeiding races of Fusarium and black Sigatoka is a serious threat to the Peruvian banana industry.

**Table 5. Disease incidence (%) of surveyed plants infested in Musa in valleys of eastern Peru in 1998.**

<table>
<thead>
<tr>
<th>Disease</th>
<th>Huallaga</th>
<th>Ucayali</th>
<th>Urubamba</th>
<th>Apurimac</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Lower</td>
<td>Central</td>
<td>Upper</td>
<td>Average</td>
</tr>
<tr>
<td>Yellow Sigatoka</td>
<td>100.0</td>
<td>95.0</td>
<td>97.6</td>
<td>98.5</td>
</tr>
<tr>
<td>Cordana leafspot</td>
<td>36.4</td>
<td>25.0</td>
<td>54.8</td>
<td>33.3</td>
</tr>
<tr>
<td>Nematodes</td>
<td>40.9</td>
<td>45.0</td>
<td>57.1</td>
<td>43.3</td>
</tr>
<tr>
<td>Fusarium wilt</td>
<td>0.0</td>
<td>0.0</td>
<td>50.0</td>
<td>11.1</td>
</tr>
<tr>
<td>Black Sigatoka</td>
<td>0.0</td>
<td>45.0</td>
<td>19.0</td>
<td>55.6</td>
</tr>
<tr>
<td>Finger tip rot</td>
<td>18.2</td>
<td>20.0</td>
<td>14.3</td>
<td>6.7</td>
</tr>
<tr>
<td>Moko</td>
<td>4.5</td>
<td>0.0</td>
<td>4.8</td>
<td>13.3</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>River Valley</th>
<th>Aguatia- San Alejandro</th>
<th>Pactheia Ucayali</th>
<th>Upper</th>
<th>San Francisco-Sibiva</th>
<th>Weighted average</th>
<th>Change from 1997</th>
</tr>
</thead>
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<tr>
<td>Yellow Sigatoka</td>
<td>88.9</td>
<td>60.0</td>
<td>77.8</td>
<td>47.1</td>
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<td>33.3</td>
<td>23.5</td>
<td>35.8</td>
<td>+10.8</td>
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<td>0.0</td>
<td>0.0</td>
<td>35.8</td>
<td>+13.3</td>
</tr>
<tr>
<td>Fusarium wilt</td>
<td>11.1</td>
<td>26.7</td>
<td>0.0</td>
<td>0.0</td>
<td>19.4</td>
<td>+22.8</td>
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<tr>
<td>Black Sigatoka</td>
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<td>0.0</td>
<td>18.7</td>
<td>+46.1</td>
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<td>6.7</td>
<td>20.0</td>
<td>5.9</td>
<td>13.4</td>
<td>nd ¹</td>
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<tr>
<td>Moko</td>
<td>0.0</td>
<td>13.3</td>
<td>0.0</td>
<td>3.7</td>
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<td>nd</td>
</tr>
</tbody>
</table>

¹ nd = no data.
present. The present distribution of Moko should be validated by modern diagnostic techniques. Banana streak virus and cucumber mosaic virus have been reported in Ucayali (Pérez and Anguiz 1998). Nematodes (Meloidogyne spp., Pratylenchus spp. and Radopholus similis) are widespread (Table 5). Cosmopolites sordidus and Meloidogyne hemipterus are serious pests (Diaz 1986, Rivas and Palomino 1986, Viera 1986). Castina licus and C. daedalus have been reported from Loreto (Tanchiva and Charpentier 1986). No fungicides are used for disease control. Cultural control, especially phytosanitation, is the recommended control method (Pérez and Anguiz 1998). The lack of drainage, weeds and excessive sucker populations often negate such control efforts. As a result, farmers do not see the benefit of sanitation and often do not practice it diligently.

Plantain and Bluggoe are regarded as resistant to yellow Sigatoka and most ABB-types are tolerant or resistant to black Sigatoka (Stover and Simmonds 1987). However, under poor disease management, serious infections occur in Peru. In a survey in 1997, yellow Sigatoka was found affecting Inguiri, Bellaco, Palillo, Manzano and Isla (Table 6). These results were confirmed by microscopy and PCR (according to Johanson and Jeger 1992). Stover and Simmonds (1987) reported that yellow Sigatoka resistance does not hold in the highlands of Colombia, and Munive (1985) confirmed that, under bad conditions, these clones can be seriously affected in Peru. Yellow Sigatoka is better adapted to high altitudes than black Sigatoka. However, the altitudes recorded in this survey (220-780 masl) were not correlated with disease incidence. Instead, a displacement of yellow Sigatoka by the more aggressive black Sigatoka was observed in the Ucayali where it has been present longest (Table 6). It was concluded that plantains and Palillo are moderately resistant to yellow Sigatoka in Peru, and Manzano and Isla are resistant but can be attacked under severe conditions. On the other hand, Moquicho is highly susceptible to yellow Sigatoka (Figueroa and Wilson 1992, Munive 1985, Stover and Simmonds 1987), but only moderately so to black Sigatoka (Stover and Simmonds 1987). The frequently suggested high susceptibility of Moquicho to black Sigatoka in Peru may be a result of misidentification of the pathogen. Field symptoms under local conditions are indistinguishable from those of black Sigatoka and atypical for yellow Sigatoka. However, PCR analyses, in most cases, confirmed the identity of the pathogen as Mycosphaerella musicola (Table 6). The reaction of Moquicho to Panama disease is also disputed (Table 2). It is possible that the synonyms listed in Table 1 represent different mutants. Datil has been reported as resistant and Moquicho as susceptible (SENASA and FAO 1997). Alternatively, pathogenic races of Fusarium oxysporum f. sp. cubense could have evolved on stressed root systems. The shortcomings in crop and disease management mentioned above, especially periodically flooded soils, also contribute to poor root health and concomitant soil-borne pest and disease damage. Panama disease may be reduced by inundation. It is surprising that bacterial wilts are only of localised importance outside Loreto. However, nematodes and banana borers destroy many plants. The causal agents and mecha-

Table 6. Distribution of foliar diseases in eastern Peru in October 1997.

<table>
<thead>
<tr>
<th>Geographic information</th>
<th>Area</th>
<th>Site</th>
<th>Altitude (m)</th>
<th>Cultivar</th>
<th>Black Sigatoka</th>
<th>Yellow Sigatoka</th>
<th>Cordana Leafspot</th>
<th>Cladosporium sp.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Apurimac Valley</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>San Francisco</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>San Francisco</td>
<td></td>
<td>780</td>
<td>Palillo</td>
<td>-</td>
<td>+</td>
<td>+</td>
<td>nd</td>
<td>nd</td>
</tr>
<tr>
<td>Huallaga Valley</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tingo Maria</td>
<td></td>
<td>680</td>
<td>Isla</td>
<td>-</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Afilador</td>
<td></td>
<td>660</td>
<td>Moquicho</td>
<td>-</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Marona Baja</td>
<td></td>
<td>670</td>
<td>Moquicho</td>
<td>-</td>
<td>+</td>
<td>+</td>
<td>nd</td>
<td>nd</td>
</tr>
<tr>
<td>Huallaga Valley</td>
<td></td>
<td>670</td>
<td>Isla</td>
<td>-</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Aucayacu</td>
<td></td>
<td>720</td>
<td>Isla</td>
<td>-</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Tocach</td>
<td></td>
<td>515</td>
<td>Bellaco</td>
<td>++</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
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<tr>
<td>Bahamartica</td>
<td></td>
<td>515</td>
<td>Palillo</td>
<td>++</td>
<td>+</td>
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<td>+</td>
</tr>
<tr>
<td>Bajo Almendra</td>
<td></td>
<td>463</td>
<td>Bellaco</td>
<td>++</td>
<td>+</td>
<td>+</td>
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<td>+</td>
</tr>
<tr>
<td>Juanjui</td>
<td></td>
<td>463</td>
<td>Inguiri</td>
<td>++</td>
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<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Huicungo</td>
<td></td>
<td>500</td>
<td>Inguiri</td>
<td>++</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Montevideo</td>
<td></td>
<td>500</td>
<td>Inguiri</td>
<td>+</td>
<td>+</td>
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<td>-</td>
</tr>
<tr>
<td>Pacicha</td>
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<td>++</td>
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<td>Picuyac</td>
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<td>510</td>
<td>Inguiri</td>
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<td>+</td>
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<td>Inguiri</td>
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<td>+</td>
<td>+</td>
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</tr>
<tr>
<td><strong>Ucayali Valley</strong></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Boquerón</td>
<td></td>
<td>700</td>
<td>Guayaquil</td>
<td>+</td>
<td>-</td>
<td>-</td>
<td>nd</td>
<td>nd</td>
</tr>
<tr>
<td>Boquerón</td>
<td></td>
<td>500</td>
<td>Moquicho</td>
<td>+</td>
<td>-</td>
<td>-</td>
<td>nd</td>
<td>nd</td>
</tr>
<tr>
<td>Aguaayllo</td>
<td></td>
<td>360</td>
<td>Seda</td>
<td>+</td>
<td>-</td>
<td>+</td>
<td>nd</td>
<td>nd</td>
</tr>
<tr>
<td>San Juan</td>
<td></td>
<td>256</td>
<td>Manzano</td>
<td>++</td>
<td>+</td>
<td>+</td>
<td>nd</td>
<td>nd</td>
</tr>
<tr>
<td>San Alejandro</td>
<td></td>
<td>295</td>
<td>Seda</td>
<td>-</td>
<td>+</td>
<td>+</td>
<td>nd</td>
<td>nd</td>
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<tr>
<td>Pucalpá</td>
<td></td>
<td>228</td>
<td>Morado</td>
<td>+</td>
<td>-</td>
<td>+</td>
<td>nd</td>
<td>nd</td>
</tr>
<tr>
<td>Campo Verde</td>
<td></td>
<td>220</td>
<td>nd</td>
<td>+</td>
<td>-</td>
<td>+</td>
<td>nd</td>
<td>nd</td>
</tr>
</tbody>
</table>

1 nd = no data
nisms of infestation and dissemination are often not known to farmers.

Future prospects and constraints

Pests and diseases are the most limiting factors for *Musa* production in Peru. The recently started evaluation of resistant germplasm under Peruvian conditions is an important step in addressing these problems. Disease-resistant FHIA varieties have been introduced to Peru. It remains to be seen how they perform in comparison with popular and robust local varieties such as Isla. Resistant varieties alone, however, will not solve all the problems since hardy, local varieties succumb to infection at present. Extension to improve crop husbandry must go hand in hand with the planting of suitable varieties to ensure sustainable production in the future. A top priority should be drainage. However, any suggestion to drain soils is refuted by the observation that plantations suffer seasonally from drought. Farmers intuitively believe drought damage would be more severe in drained soils. Extension services will have to employ practical methods, such as demonstration plots and farmer field schools, to prove that less drought stress is experienced in drained soils due to improved root health. Additional technology transfer is needed to introduce modern techniques which are widely practised in neighbouring countries, i.e. selection of planting material, planting density, sucker management, weed control and phytosanitary pruning. The economics of cultural practices are underinvestigated and most likely underestimated in Peru. The benefit/cost ratio of fertilisation during early bunch differentiation on marketable yields should be determined.

Marketing is limited by substantial quality losses in transit to metropolitan markets. Some transandean roads are in mediocre conditions and can be closed for days in the rainy season. However, poor post-harvest practices also contribute to losses. Harvesting techniques and packaging for transport should be priorities. Communication between customers and growers leaves room for improvement. Manzano enjoys a promising market potential in Lima. However, due to its unpopularity in the east where it is produced, this is not yet realised by growers. Ripe fruit can drop off the bunch and/or its peel splits open. One way to reduce this problem would be by sequential partial harvesting from hanging bunches, i.e., by harvesting the proximal hands earlier than the distal ones. The high-priced Isla is a robust variety with high disease tolerance. It also produces a fruit with a unique flavour and texture which may not be easily replaced. Isla clones should thus be included in any comparison of improved germplasm in Peru.

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References


Highland bananas in Colombia

Nigel S. Price

Musa in Colombia

Colombia is one of the world’s major growers of *Musa*. Data recently assembled by Thierry Lescot of CIRAD show that the country ranks fifth globally in terms of overall *Musa* production and is the world’s third biggest exporter of “Cavendish” bananas (Lescot 1998).

Domestic consumption of *Musa* by Colombia’s 36 million people is largely of AAB plantains and at 3 million tonnes Colombia is the world’s biggest producer (for which there is also a very small export trade) (Table 1). In addition both “Cavendish” and “Gros Michel” bananas are significant components of this domestic consumption. Whereas “Cavendish” bananas are generally grown in the lowland coastal regions of Colombia, both AAB Plantains and “Gros Michel” bananas occur mainly in the more central highland regions, often in association with coffee. Articles on the growing in Colombia of both these *Musa* types have appeared in previous issues of *INFOMUSA* (Lescot 1993, Grisales and Lescot 1993, Grisales and Lescot 1996).

Table 1. Relative production of major *Musa* types in Colombia. (Data compiled by T. Lescot 1998).

<table>
<thead>
<tr>
<th><em>Musa</em> type</th>
<th>Domestic consumption</th>
<th></th>
<th>Exports</th>
<th></th>
<th>Total production</th>
</tr>
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<tbody>
<tr>
<td></td>
<td>Tons (1000)</td>
<td>%</td>
<td>Tons (1000)</td>
<td>%</td>
<td>Tons (1000)</td>
</tr>
<tr>
<td>AAB Plantains</td>
<td>2970</td>
<td>96</td>
<td>120</td>
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<td>3090</td>
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<tr>
<td>Cavendish</td>
<td>524</td>
<td>26</td>
<td>1476</td>
<td>74</td>
<td>2000</td>
</tr>
<tr>
<td>Gros Michel</td>
<td>500</td>
<td>100</td>
<td>Ins</td>
<td>Ins</td>
<td>500</td>
</tr>
<tr>
<td>Highland/Cooking bananas¹</td>
<td>42</td>
<td>100</td>
<td>Ins</td>
<td>Ins</td>
<td>42</td>
</tr>
</tbody>
</table>

¹ As well as East African Highland banana (AAA-EA) this category also includes other cooking types such as Bluggoe.

Ins = Insignificant or unknown.

Highland bananas

Less well known is the small, but locally significant, growing of East African Highland banana (AAA-EA) in Colombia. In Africa in the Highlands bounding Lake Victoria (their presumed centre of diversity, if not origin, Simmonds 1966) these bananas are of great agricultural importance. In Uganda and her neighbours they constitute a major starchy staple, and as banana beer have a particular cultural significance (Champion 1970). The botanical and geographic origins and development of this *Musa* group are of interest not only to agriculturists but also to anthropologists and historians (Simmonds 1966, Davies 1995).

During a recent visit to the central Andean region of the Department of Antioquia in Colombia, East African Highland banana (AAA-EA) was frequently observed growing in association with coffee. Subsequent to this visit, and with the assistance of Colombian colleagues, further details on the growing of this particular *Musa* type, so far from its known region of origin, has been assembled.

Antioquia (see Figure 1) with its capital Medellin is, at 63,612 Km², one of the largest of the 32 Departments that make up the Republic of Colombia. Stretching from the Caribbean coast up to 4000 masl in the major part of the department (Figure 1) it is also one of the most important economically being a major producer of electricity and possessing substantial industry. Agriculturally, “Cavendish” bananas are important in the coastal North of the department whereas the Andean uplands of the southern part of Antioquia form a major coffee producing area with over 300,000 hectares being grown. Commonly grown in association with this coffee are AAB plantains (mainly the False Horn variety “Dominico Harton”), dessert bananas (in particular “Gros Michel”) and to a lesser extent, East African Highland banana (AAA-EA), known as “Guineo” (see photograph) which generally occurs between 1500 and 2000 masl.
Production and consumption

Data supplied by colleagues in Antioquia (Table 2) show the dominance of AAB plantain in food consumption in the region, forming half the total production and two-thirds of the urban consumption of the four major starchy staples grown. This data also shows “Guineo” bananas to constitute 1% of this production and 5% of urban consumption. Prices obtained in two outdoor markets and three supermarkets in Medellin again reflect the popularity of AAB plantain, at an average price of 470 pesos per kilo compared with 350 pesos per kilo for “Guineo” and 306 pesos per kilo for dessert bananas.

Clearly “Guineo” forms a very minor component of Musa production in the region overall, but one that is nonetheless highly appreciated by some. In Colombia “Guineo” is generally boiled and not cooked as “matoke” as in East Africa. It also forms a delicious constituent of a stew or soup, “Sopa de Guineo” (a recipe for such a “Sopa de Guineo” is available in the box, above right).

Discussion

The presence of East African Highland bananas in South America has been noted by others (Lescot 1998, Tezenas du Montcel, pers. comm., Jaramillo, pers. comm., Rossell 1998). The journey of “Guineo” to the Highlands of South America from its known centre of origin in a particular area of East Africa is, as Simmonds (1966) points out, unknown and will presumably remain so. East African Highland bananas are present (if infrequent) in many areas of Africa (Rossell 1998) and are of some importance in the Bamileke Highlands of West Cameroon (Bridge et al. 1995). Rossell (pers. comm.) attributes the presence of East African Highland bananas in West Africa to sea-borne introductions associated with the Portuguese “Voyages of Discovery”. This period presumably also saw the arrival of “Guineo” in the New World.

It is perhaps interesting to highlight the clear agronomic preference of these types for cooler Highland areas. This is evidenced by their cultivation not only in their region of origin in the East African Highlands, but their subsequent “migration” to, and subsequent preferential cultivation in, the Highlands of both West Africa and South America, inland from the coasts at which they would have been introduced.

Very little is known of the farming systems and production constraints affecting “Guineo” in Colombia. Lescot (1993) comments on the potential for basic agronomic research and technology transfer to contribute to the production sector of which “Guineo” forms a part. Clearly it is unlikely that significant resources will be specifically devoted to agronomic research on a minor variety such as “Guineo”. However, considerable research effort is being devoted to Highland bananas in East Africa (see C.S. Gold and B. Gemmill

Table 2. Relative production1 and consumption of four starchy staples in the Department of Antioquia, Colombia.

<table>
<thead>
<tr>
<th>Crop</th>
<th>Area planted (ha)</th>
<th>Yield (t/ha)</th>
<th>Production (MT)</th>
<th>% of total</th>
<th>% of total</th>
</tr>
</thead>
<tbody>
<tr>
<td>AAB Plantain</td>
<td>56 000</td>
<td>6.5</td>
<td>360 454</td>
<td>49</td>
<td>65</td>
</tr>
<tr>
<td>AAA-EA Bananes «Guineo»</td>
<td>1 500</td>
<td>4.8</td>
<td>7 406</td>
<td>1</td>
<td>5</td>
</tr>
<tr>
<td>Potato («Papa»)</td>
<td>9 800</td>
<td>17.8</td>
<td>173 345</td>
<td>24</td>
<td>19</td>
</tr>
<tr>
<td>Cassava («Yucca»)</td>
<td>11 000</td>
<td>17.5</td>
<td>193 837</td>
<td>26</td>
<td>11</td>
</tr>
</tbody>
</table>

1 Data supplied by the Department of Agriculture, Antioquia.
2 Whilst assuming all production is consumed, this column reports questionnaire responses obtained from the Managers of three supermarkets in Medellin, Antioquia.

“Sopa de Guineo”

(approximately 6 people)

Ingredients:

1 kg diced pork or beef.
300 – 600 gr. thinly sliced carrots.
500 – 1000 gr. diced potatoes.
500 gr. diced yucca (sweet cassava).
6 large “Guineo” bananas, broken in large pieces or diced according to preference.
300 gr. sliced (Capsicum) pepper.
300 gr. fresh beans.
200 gr. sliced onion.
A few cloves of garlic.
Fresh coriander.
Fresh cumin.
Salt and ground pepper to taste.

Add onions, salt, ground pepper, sweet pepper, garlic and cumin to 2.5 litres of water in a large casserole or saucepan and heat. After 10-15 minutes add carrots and fresh beans and bring to the boil.

Then add the meat, yucca, potatoes and the “Guineo” bananas. Return to the boil and cook gently until all vegetables and the meat are cooked.

Finally add the fresh coriander and continue to cook over a low to medium heat for a further 10-15 minutes.

Serve in bowls with a little fresh coriander.

Figure 1. Geographical location of the Department of Antioquia in Colombia.
Agronomic comparison of two types of propagules of Dominico Hartón plantain (Musa sp. AAB group)

Francisco Grisales L.

Farmers in the coffee zones traditionally grow plantains using rhizomes of various sizes as planting material. Unselected, untreated rhizomes weighting 3 to 6 kg are most commonly used. These have little physiological homogeneity and are often contaminated by banana borer weevils, nematodes, etc., which are limiting factors for the development of plants. Growers tend to use lateral suckers that are differentiated from the mother-plant and possess an independent root system and good reserves (1-2 kg); these are known as 'pajones' or sword suckers and are reputed to be vigorous, healthy and easy to handle (Belalcázar and Valencia 1990, Echeverri 1997). Other methods have spread in recent years, such as seedlings grown in seedbeds (suckers weighing 200-300 g in individual bags) and above all tissue culture material, which opened up broad prospects for growers in the central region because of their success in the banana agroindustry. In fact, the nursery material and tissue culture plants display a certain level of selection and require careful handling before planting. In the light of the foregoing, an experiment was performed to compare the productivity and quality of Dominico Hartón plantain propagated in a nursery and in vitro with recommended traditional propagation (sword suckers).

Material and methods

The experimental work was carried out from 1995 to 1998 in two regions suitable for plantain growing with distinct soil and climate features: Paraguaicito de Buenavista substation (Quindío) and Hacienda Chaguilito in Chinchiná (Caldas). The following planting material was tested at the two sites: tissue culture plants, nursery plants and sword suckers in a random layout with plot of 36 plants set out at 2.5 x 2 m. The tissue culture plants and the nursery material were placed in 20 x 25 cm perforated bags on a 3:1 soil:coffee pulp substrate. Each batch was managed individually with stress laid on the three fundamental practices: weed management by scything around the plots and selective application of glyphosate, potassium and magnesium fertilisation and desuckering, leaving two production suckers per plant. Further operations were performed as required and included deleafing, replanting suckers after the harvest and propping. Banana borer was also controlled at Paraguaicito by application of aldicarb (0.1 g per plant) and by trapping.

Productivity (average bunch weight) and quality were measured using the following criteria: first class (number of bunches per plot weighing more than 13 kg per plot), second class (bunches weighing 13 kg or less). Earliness at first harvesting (number of weeks to harvest) and the percentage of mutants (different to the clone Dominico Hartón) are complementary data.

The information was subjected to analysis of variance and Turkey mean comparison test (p = 0.05).

Results

Information concerning the productivity and quality of the three types of plant at the two experimental sites during the period 1995-98 is shown in Figures 1 and 2.

As can be seen in Figure 1, there was no significant difference in productivity between plants at Paraguaicito, whereas at Chaguilito the nursery plants were statistically poorer than the tissue culture plants and conventional suckers, which were themselves the same. It can also be seen that productivity was higher at Chaguilito than at Paraguaicito, where plant health problems disturbed the experiment.
The results for quality were similar. There was no significant difference between plants at Paraguaicito whereas the performance of the seedlings in bags at Chagualito was not as good as that of the other types of plant (Figure 2).

In the light of the foregoing, it can be said that the type of plant used has little impact on the production and quality potential of ‘Dominico Hartón’ plantain. This is particularly marked in the case of the in vitro material whose agronomic potential is greater than that of conventional suckers for other types of Musa (banana) (Londoño and Villa 1994, Vuylsteke and Ortiz 1996). However, this has not been clearly demonstrated in plantain since the published results do not agree (Vuylsteke and Ortiz 1996). This can be ascribed to the considerable sensitivity of the plant to its environment. With regard to the nursery material, it is difficult to explain the results at Hacienda Chagualito, but this is not important in practice since the difference observed in comparison with the other types of plants (2.9 kg per bunch) does not affect incomes, given the bunch marketing system used in the region. Finally, it is clear that suitably selected sword sucker planting material has high production potential when it is combined with good crop management and favourable conditions of soil and climate (this is the case of Chagualito).

Several differences were noted in the length of the period between planting and harvesting (earliness). It was observed at both experimental sites that sword suckers develop more slowly (approximately 63 weeks from plantation to harvest) than tissue culture plants and nursery seedling (approximately 59 weeks). This difference disappears after the first harvest, making it a feature of relatively little importance.

Tissue culture plants frequently display inflorescence anomalies that affect yields (Sandoval et al. 1991). Reversion percentages slightly higher than normal (3 to 4%) were observed in ‘Dominico’ bunches, showing that the genetic stability of the variety is not affected.

**Conclusions**

‘Dominico Hartón’ tissue culture material does not seem to be advantageous with regard to productivity and quality. The behaviour of the nursery plants was variable, but the differences in productivity and quality are negligible in a marketing system based on bunches.

Conventional material (sword sucker/puyón) developed satisfactorily and can be recommended if selection and crop management conditions are good.

**References**


The impact of defoliation on mineral distribution in bunches of ‘Dominico Hartón’ plantain (Musa AAB Simmonds)

Gerardo Cayón S. and Marta M. Bolaños B.

The growth and development of plantains depends essentially on the light intensity intercepted by the leaves, the rate of conversion of this radiation into biomass and the distribution of dry matter among the vegetative organs and the bunches produced. As the steady development of leaves is determinant for plant growth and productivity, they must remain functional from the start of flowering and throughout the entire duration of fruit development. The modification of the canopy of a crop by selective defoliation affects the development of leaf area and plant fruiting (Decoteau 1990).

*Musa* fruits are characterised by a high starch content in the green state and a high sugar content when they ripen. The mineral content is also high.

Starch is the dominant carbohydrate in green fruit, forming 48% of the dry matter or 12.7% of the fresh weight (Foulkes et al. 1978).

According to Belalcázar et al. (1991), at harvesting dry banana pulp contains approximately 0.28% nitrogen (N), 0.07% phosphorus (P), 1.1% potassium (K), 0.06% calcium (Ca), 0.12% magnesium (Mg), 20 to 40 ppm iron (Fe) and 2.5 ppm zinc (Zn).

Research performed on *Musa* shows that defoliation leads to a reduction of fruit weight that varies according to the period and number of operations (Ostmark 1974, Stover 1980, Satvanaravane 1986, Cayón et al. 1995). These aspects should be taken into account in phytosanitary defoliation operations combined with integrated management of yellow Sigatoka (*Mycosphaerella musicola*) and black Sigatoka (*Mycosphaerella fijiensis*) because these diseases particularly affect old leaves. It has been observed in ‘Dominico Hartón’ plantain that the mid and lower thirds of the foliage seemed to be more concerned in bunch development than the upper third. It is therefore recommended that nine functional leaves should be conserved from flowering onwards, although commercially acceptable bunches can be obtained when only the last six leaves grown by the plant are left (Cayón et al. 1995).

Several studies have been carried out on the chemical composition of plantain fruits, but none have covered the impact of defoliation on the mineral composition of the fruits. The objective of the study was therefore to assess the impact of successive defoliation operations during flowering on the distribution of minerals in the fruit and bunch rachis of ‘Dominico Hartón’ plantain.

**Material and methods**

The test was performed at the Palmira research station in the commune of Palmira in the Cauca valley department, 3°31’S, 76°19’W, at an elevation of 1001 m. Average annual temperature is 24°C, annual precipitation 1000 mm and average relative humidity 75%. These conditions are those of a dry tropical forest. The soil in the experimental plot is silty-clayey and the lowest when the plants were totally defoliaded in comparison with the other defoliations performed at the beginning of flowering.

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Thirds of leaves remaining</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nine leaves</td>
<td>Upper, mid lower</td>
</tr>
<tr>
<td>Six upper leaves</td>
<td>Upper, mid</td>
</tr>
<tr>
<td>Three upper leaves</td>
<td>Upper</td>
</tr>
<tr>
<td>Six lower leaves</td>
<td>Mid, lower</td>
</tr>
<tr>
<td>Three lower leaves</td>
<td>Lower</td>
</tr>
<tr>
<td>No leaves</td>
<td>None</td>
</tr>
</tbody>
</table>

The number of leaves conserved on each plant after the defoliations performed at the beginning of flowering.

**Results and discussion**

The results show significant differences in the concentration and distribution of minerals as a result of defoliation.

The nitrogen and potassium levels in fruits and bunch rachis are shown in Figure 1. The nitrogen level in fruit pulp was slightly higher in the plants that conserved three lower leaves during the entire period of growth of the bunch, while the other defoliation treatments had no effect. The nitrogen level in the peel was highest when the three upper leaves were left and was lowest when the plants were totally defoliaded. The nitrogen level was high in the bunch rachis of plants with nine leaves, six upper leaves and no leaves in comparison with the other defoliation treatments.

**Table 1. Chemical analysis of the soil in the experimental plot.**

<table>
<thead>
<tr>
<th>Location</th>
<th>pH</th>
<th>N (%)</th>
<th>OM</th>
<th>K ppm</th>
<th>Ca ppm</th>
<th>Mg ppm</th>
<th>Na ppm</th>
<th>CEC meq/100 g de sol</th>
<th>K ppm</th>
<th>Fe ppm</th>
<th>Mn ppm</th>
<th>Zn ppm</th>
<th>Cu ppm</th>
<th>B ppm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Palmira</td>
<td>6.8</td>
<td>0.09</td>
<td>2.9</td>
<td>0.4</td>
<td>12.9</td>
<td>5.0</td>
<td>0.29</td>
<td>11.9</td>
<td>14.9</td>
<td>63.5</td>
<td>76.0</td>
<td>7.0</td>
<td>2.1</td>
<td>6.2</td>
</tr>
</tbody>
</table>

*pH (potentiometer), soil: water ratio 1:10 (semi-micro Kjeldahl), S (Walker Black, colorimetry). N, Ca, Mg (ammonium acetate, pH 7.0) Al (Yuan). Fe, Mn, Zn, Cu (EDTA 0.01M, ammonium acetate 1N, pH 7.0). CEC (ammonium acetate 1N, pH 7.0 Nessler). P (Bray II, Bray Kurt stain). Particle size distribution (Bouyoucos method with sodium pyrophosphate, USDA soil textural triangle).
Pulp potassium content was identical in the treatments in which functional leaves have been conserved and increased with total defoliation. Similar pulp potassium levels (1.1%) were found by Belalcázar et al. (1991). The larger amount of potassium found in the pulp of fruits that grew on plants with no functional leaves can be explained by the fact that the growth of these fruits is very slow and stops at the initial stages because of the premature elimination of the carbohydrate source (Cayón et al. 1998) and the high mineral concentration during these stages (Belalcázar et al. 1991).

Potassium accumulation in the peel was greater in the treatments with nine and three upper leaves and decreased significantly in the other treatments. The greatest accumulation of potassium in the rachis was observed in the plants with six lower leaves, whereas the concentration in the rachis was not affected in the other treatments. The average mineral content in the whole fruit was only 5.3% of which 80% was in the form of K⁺; this seems to be caused by the fact that K⁺ plays an important role in the synthesis of starch from sucrose during fruit development (Salisbury and Ross 1994).

It can be seen in Figure 2 that the calcium and magnesium concentrations in fruit pulp were little affected by defoliation; however, these two minerals were present at higher levels in the peel and rachis of plants in which the three upper leaves were conserved. Lianes et al. (1990) considered that pulp calcium levels of 0.17 to 0.23% were low. An increase in the magnesium content of fruit peel and rachis of plants with no leaves was also observed.

The iron concentration in pulp and peel is also slightly enhanced by leaf elimination (Figure 3). The iron content of bunch rachis was low in the treatments with three and six lower leaves, with the youngest leaves of the plants removed. As for potassium, this is probably because the growth of fruits on leafless plants stops in the first stages of their development when the mineral concentration is at its highest, preventing migration to the peel and rachis.

The zinc content of fruit pulp rose with increased defoliation and it was significantly greater for the plants with three lower leaves and for the plants with no leaves (Figure 4). No obvious effect of defoliation was observed on the zinc concentration in the peel and rachis.

These results show that defoliation does not significantly reduce mineral accumulation in plantain rachis and fruit. The highest concentrations of potassium, magnesium, iron and zinc are found in the pulp of fruits that develop on leafless plants. As a result, the selective defoliation recommended...
as a phytosanitary method for the control of black and yellow Sigatoka does not cause a significant reduction in the mineral levels in the pulp of the clone ‘Dominico Hartón’. However, bunch weight decreases following this defoliation (Cayón et al. 1995).

The results of this work and of previous studies (Belalcázar et al. 1991, Cayón et al. 1998) shown in Table 3 confirm that bunch rachis and fruit peel have higher mineral, total sugar and crude protein contents than pulp, indicating that the former have considerable potential for use as a source of organic fertilizer and as raw material for the production of animal feed. Offem and Njoku (1993) reached the same conclusions, suggesting that farmers should carefully observe the moment of bunch appearance on each plant and harvest the bunch after 90 days, as at this age the fruits have the most favourable mineral content for human nutrition and a high peel mineral content with advantages for use in animal feed.

Conclusions

• The highest pulp nitrogen level is observed in the plants on which the three lower leaves have been conserved. The highest nitrogen level in peel and rachis is observed in plants with three and six upper leaves.

• The highest pulp potassium concentration is observed when the plant has been totally defoliated, whereas the level in the peel is higher in non-defoliated plants and decreases significantly with the removal of the lower leaves.

• The calcium and magnesium concentrations in fruit pulp is little affected by defoliation.

Table 3. Physicochemical composition of ‘Dominico Hartón’ fruit bunches.

<table>
<thead>
<tr>
<th></th>
<th>Pulp</th>
<th>Peel</th>
<th>Rachis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fresh matter (%)</td>
<td>54.00</td>
<td>38.00</td>
<td>8.00</td>
</tr>
<tr>
<td>Dry matter (%)</td>
<td>24.00</td>
<td>5.10</td>
<td>3.10</td>
</tr>
<tr>
<td>Starch (%)</td>
<td>42.00</td>
<td>31.00</td>
<td>6.00</td>
</tr>
<tr>
<td>Total sugars (%)</td>
<td>0.70</td>
<td>3.30</td>
<td>0.90</td>
</tr>
<tr>
<td>Protein (%)</td>
<td>1.80</td>
<td>5.30</td>
<td>7.00</td>
</tr>
<tr>
<td>Nitrogen (%)</td>
<td>0.30</td>
<td>0.80</td>
<td>1.10</td>
</tr>
<tr>
<td>Potassium (%)</td>
<td>1.20</td>
<td>3.10</td>
<td>3.10</td>
</tr>
<tr>
<td>Calcium (%)</td>
<td>0.20</td>
<td>0.50</td>
<td>0.60</td>
</tr>
<tr>
<td>Magnesium (%)</td>
<td>0.16</td>
<td>0.22</td>
<td>0.23</td>
</tr>
<tr>
<td>Iron (ppm)</td>
<td>31</td>
<td>82</td>
<td>204</td>
</tr>
<tr>
<td>Zinc (ppm)</td>
<td>11</td>
<td>33</td>
<td>27</td>
</tr>
</tbody>
</table>

• The highest mineral content is found in fruit peel and bunch rachis.

Acknowledgements

The authors thank the Quindio Coffee Growers’ Committee (Comité de Cafeteros del Quindío) for the technical and financial support for the performance of this study and Mrs Gloria Inés López for her careful patient work on the preparation of the manuscript.

References


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The overall goal of the project is to gain more insight in the different aspects of the association between nematodes and bananas in Vietnam. At the end of the second year, good progress has been made. The working conditions at the Agrobiotechnology Department of VASI have been improved: three rooms have been renovated to become an in vitro cold storage room, an in vitro propagation room and a working room. A greenhouse has been built for the purpose of screening experiments in pots.

The research activities undertaken until now include:

- a nematode survey on economically important banana genotypes in Vietnam;
- the establishment of in vitro cultures of Pratylenchus coffeae on carrot discs (O'Bannon and Taylor, 1968);
- two pot experiments in the greenhouse to screen the Vietnamese Musa germplasm for resistance/tolerance to P. coffeae and Meloidogyne spp.;
- a field experiment to screen the Vietnamese Musa germplasm for resistance/tolerance to Meloidogyne spp. During the survey, the nematode species most found were Meloidogyne, P. coffeae and Helicotylenchus multicinctus. The important banana nematode Radopholus similis has not been found on bananas in Vietnam until now. However, this species has recently been found on coffee and durian.
- From the pot experiments, we observed that infection with P. coffeae did not affect the general performance of the plants, while infection with Meloidogyne spp. resulted in an increase in the weight of the root system and a decrease in the number of standing leaves. None of the tested genotypes showed resistance or tolerance to Meloidogyne spp. There was indication that three Vietnamese genotypes show some resistance to P. coffeae: 'Tieu Xanh' (ITC1406, AAA), 'Tay But' (ITC1367, AA) and 'Tien' (ITC1368, AA). However, these observations need to be confirmed.

The following activities are planned for the next two years:

- a nematode survey on wild Musa spp. in natural habitats in Vietnam;
- further examination of the occurrence of R. similis on bananas in Vietnam;
- a field experiment to assess the damage and yield loss caused by P. coffeae and Meloidogyne spp. to economically important banana genotypes (already started);
- a study of the dynamics of Vietnamese banana root nematodes, both in the field and in the greenhouse;
- establishment of in vitro cultures of Meloidogyne spp. on transformed tomato roots on Gamborg B5 medium (already started);
- more screening experiments in pots in the greenhouse and in the field (already started).

The project is co-funded by the Flemish Office for Development Cooperation and Technical Assistance (VVOB), the Flemish Interuniversity Council (VL.I.R.) and the Australian Center for International Agricultural Research (ACIAR, with Dr J. Stanton as nematological adviser). The scientific coordinator is Dr D. De Waele from the Laboratory of Tropical Crop Improvement, KULeuven, Belgium.

More information concerning this project and the results can be obtained from:

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E-mail: ingegeert@fpt.vn

International seminar/workshop on banana Fusarium wilt disease
18-20 October 1999, Genting, Malaysia

A three-day international seminar/workshop on Fusarium wilt of banana was held in Genting, Malaysia on October 18-20, 1999. Organised by INIBAP-ASPNET and MARDI in cooperation with other Malaysian universities and institutions, the meeting reviewed the current status of Fusarium wilt of banana in many banana-growing areas of the world. It was attended by 70 participants from the academe, research institutions, government and the industry, representing 17 countries worldwide. Thirty-two papers were presented in the seminar covering relevant topics including industry/country reports on the state of Fusarium oxysporum f. sp. cubense (Foc) as a production constraint; research and development status on pathogen diversity, disease management technologies, varietal improvement, monitoring and screening methodology.

The seminar/workshop was bolstered by the participation of scientists of the PROMUSA Fusarium wilt working group who held their meeting following the 3-day seminar/workshop (see report of the meeting in PROMUSA News in this issue). Among the many interesting papers presented, the papers of Drs Natalie Moore and Suzanne Bentley of Australia, Dr Randy Ploetz of USA, and Dr Africano Kangire of Uganda, discussed the status of pathogen diversity in Foc. Dr Gisela Orjeda of INIBAP presented a summary of results of the International Musa Testing Programme Phase II (IMTP II), highlighting the stability of resistance of some improved hybrids in the many locations where they were evaluated.

Among the highlights of the seminar/workshop were:

- Country reports particularly from Asia showed that Fusarium wilt remains the biggest threat to the banana industry in this region.
Meetings, workshops

Organic bananas

International workshop on the production and marketing of organic bananas by smallholder farmers

31 October - 4 November 1999, Dominican Republic

Many small-scale banana farmers are facing increasing difficulty in competing in a free market economy. Production and diversification alternatives for such growers have become clear needs. One such possibility is the organic production of bananas, which has attracted considerable interest in both producer and consumer countries. As a result of this demand, INIBAP, CAB-International, and the Technical Centre for Agricultural and Rural Cooperation (CTA) jointly organised an International workshop on the production and marketing of organic bananas produced by smallholder farmers. The workshop was held in the Dominican Republic, by kind invitation of the Executive Director, Centro Para el Desarrollo Agropecuario y Forestal, Inc. (CEDAF).

The workshop had a specific focus on production and marketing requirements and constraints for organic bananas produced by small-scale farmers in the Caribbean region. Key players in the farmer-to-table chain were represented at the meeting. Participants included farmers and producer representatives, mainly from the Caribbean and Latin America regions, but also others with relevant experience to share from Africa. From the importing and marketing side, European and North American organic certification organisations, importers and retailers were represented. Other participants in the meeting included government representatives, donor agencies and representatives of a number of regional and international bodies.

The main aim of the meeting was to provide an impartial forum for discussion and information exchange, with the objective of establishing a nucleus to take organic banana initiatives further. The meeting was organised with the understanding that organic banana production would not provide a solution to all the problems facing the banana industry in the Caribbean. However, it is considered that organic banana production has the potential to provide a stable...
source of income for some smallholder producers, and a continuous, guaranteed supply of organic bananas is required for the market.

The meeting consisted largely of working group meetings, with discussions focusing on five major issues related to the production and marketing of organic bananas.

**Technical constraints to production**

This working group identified black Sigatoka and lack of soil fertility as the key constraints on the production side. It was noted that site selection is crucial in any organic initiative and it was recommended that organic production should be based on an entire watershed with a sufficiently large area. This would thus require a co-ordinated approach and a critical mass of farmers. A systems-based approach to production was also recommended with participatory research methodologies being employed towards addressing the key constraints.

It was agreed that a heavy presence of black Sigatoka exists, it is extremely difficult to produce Cavendish varieties organically. However other varieties with potential for organic production, either as a Cavendish replacement or as speciality bananas for niche markets are available.

The main research needs were identified as:

- Guidelines for site selection;
- Strategies for black Sigatoka management – including biocontrol; methods to reduce impact such as replanting, shade/mixed cropping; organic spray applications;
- Integrated pest management;
- Banana breeding, focusing on resistance to black Sigatoka and nematodes and dwarfness;
- Field selection and evaluation of varieties;
- Delivery mechanisms for beneficial micro-organisms such as mycorrhizae;
- Post harvest research on crown rot and latex stain and the post-harvest handling of new varieties;
- Improvement of soil fertility.

It was recommended that demonstration farms be set up to facilitate the training of farmers in the application of new technology packages. In addition the need for information sharing, the creation of linkages and the exchange of experiences was highlighted.

**Mechanisms to support small-scale farmers converting to organic farming**

It is clear that conversion to organic farming requires the farmer to make some considerable investment in time and resources, both financial and human. For the individual smallholder such investment may be difficult without some external support. This group identified the urgent need for training and information for farmers who are considering converting to organic production. It was recommended that “leader farmers” should be specifically targeted for training, not only in technical issues, but also in record keeping and skills associated with team building and negotiating. Farmer groups, or co-operatives provide the ideal forum for discussion and provide the framework through which support services can be provided.

The need for financial support during conversion was highlighted and it was noted that some possibilities exist in the framework of linkages with ‘Fair Trade’ or ‘Pesticide-free’ labels. An enabling environment, in terms of local institutional support for organic farmers and a favourable policy framework, is also essential in encouraging farmers to convert. In the longer term, public awareness and education at all levels will be a major element in maintaining organic production and reducing the risks of “contamination” from outside sources and abuse of organic systems.

Specific research needs were identified as:

- Research on socio-economic/technical aspects of conversion in tropical agroecosystems to identify locally appropriate approaches;
- Local adaptation of participatory research and training techniques, such as farmer field schools;
- Market research for diversification systems to help plan diversification associated with conversion;
- Research on the potential impacts of organic farming on the national scale to help support investments.

**Organic certification**

The certification of organic production is an extremely important issue for small holder producers. At the present time most certification is carried out by international certifiers using national inspectors. The high cost of international certification was noted by this group, together with the need to develop the capacity for certification at the national level. The advantages of carrying out certification nationally include the reduced administrative and management costs and the greater understanding that would develop between producers and certifiers. However, national certification has to overcome problems of credibility on the side of the importer, increased possibilities for conflicts of interest, financial limitations, the need for accreditation and the lack of human resources.

The market benefits of linking organic and fair trade certification are clear, even though fair trade does not embrace all the standards of organic products. It was noted that it would be particularly desirable to have the same
Marketing of organic products

This group noted that there is presently some confusion regarding the market for organic bananas. From the demand side, it is felt that organic bananas are presently far from meeting the market potential, whereas on the production side there is a conception that organic bananas cannot be sold. In order to assess the real situation with regard to demand and supply, members of the working group agreed to from a task force to collect relevant information. The need for more solid price information was also highlighted, together with the need to identify realistic price premiums for organic bananas by country. There is a clear need for transparency in such information and the establishment of a global monitoring system was recommended.

It was recognised that there is a market for different types of bananas, so long as they meet basic criteria with respect to appearance, taste, shelf-life and ripening characteristics. The market for organic bananas is no longer considered a niche market, but is rather seen as a mainstream market, with similar quality demands. One important aspect is the need to create consumer-producer solidarity, through which consumers can be educated to understand the limitations and constraints of producers.

Total quality assurance and exporting

The goal of total quality assurance was defined as the development of a well-flavoured banana, without progressive defects and with attractive appearance to consumers, wherever and whenever they wish to purchase it.

The group highlighted the need to define quality criteria for Cavendish and for other varieties according to stakeholders demands. Such stakeholders would include consumers, regulatory bodies and distributors/retailers. It is also necessary to understand how these criteria relate to the quality aspects of the fruit, both for Cavendish and for other varieties. Research is therefore needed to understand the factors determining quality and to develop guidelines and minimum standards for producers and ripeners.

There is a need to define smallholder production system protocols which will ensure that a quality product, meeting the identified criteria is achieved. In addition, it was recommended that smallholder audit trails be put in place and an audit trial manual be developed.

Specific areas for research include methods for controlling crown rot in organic systems and for minimising latex stains on fruit.

Summary of conclusions

The meeting recognised that a growing market for organic bananas does exist, particularly in Europe and North America. In contrast, local markets have a low awareness of organic issues, but have the potential for growth. Organic banana initiatives are in place, particularly in the Dominican Republic, and have been shown to work well with organised groups of small-scale producers. It is clear that organic production methods are more sustainable than traditional methods and could provide an alternative market opportunity for smallholders.

In general the meeting acknowledged the importance of information sharing and dialogue between all the stakeholders, and the desirability of partnerships between the producers and the market. In addition, a co-ordinated approach and collective commitment are essential, particularly in the case of small-scale producers. Other important issues include the need for further research in a number of areas, the need for training of new organic farmers and the need for greater efforts in public awareness, both amongst producers and consumers.

Regarding the suitability of organic banana production for the Windward Islands, it was noted that there are several factors in favour of this. These include the absence of black Sigatoka and farmer associations, the possibilities to link organic production to tourism, especially eco-tourism, the existence of a market demand and the interest of younger farmers. On the other hand, a number of factors are against organic banana production in this region. These include the topography of the islands, the large numbers of small-scale farmers, lack of organic materials for improving soil fertility, the high labour cost, an ageing farming community, problems of land tenure especially for younger farmers, • and lack of technical knowledge.

Follow-up actions

A number of specific immediate action points were identified during the meeting. These are:
• To carry out, in the short term, feasibility studies with farmers on the socioeconomic and agronomic potential for organic banana production in the Windward Islands;
• To put in place further variety evaluation trials. These are al-
A common problem confronting banana researchers and horticulturists in Southeast Asia is the presence of numerous cultivar names and synonyms in the different languages of the region. The fact that the same cultivar is often known by several different names in the different countries of the region results in confusion and duplication of research efforts. Knowledge of synonyms can also promote regional understanding and communication as well as banana trade and commerce. Solutions to these problems were the subject of a regional workshop held at the Southeast Asian Banana Germplasm Resources Center in Davao, Philippines on September 1 – 4, 1999. The workshop was co-sponsored by INIBAP-ASPNET and BPI/DNCRDC (Bureau of Plant Industry/Davao National Crop Research and Development Center) of the Department of Agriculture. The participants were the curators of National Banana Germplasm Collections of Malaysia, Indonesia, Thailand, Vietnam and the Philippines.

Banana classification to genome group was carried out based on the taxonomic scorecard suggested by Silayoi and Chomchalow (1987), a modified version of the original designed by Simmonds and Shepherd. This allowed the numerous banana varieties to be divided into various genome groups (AA/AAA, AAB, AB, ABB, BB/BBB etc.). After identifying the species and genome group, the individual cultivars were classified following the latest version of Descriptors for Banana (Musa spp.) and Musa Germplasm Information System (MGIS) published by INIBAP /IPGRI and CIRAD. The highly discriminating descriptors on plant stature, pseudostem and leaf characteristics, bunch and fruit characters, male bud and male flower characters are recorded. Horticultural performance such as data from planting to flowering, from flowering to harvest, harvest to first ratoon, number of suckers at first harvest, bunch weight, number of hands and fingers, fruit size and quality were observed.

With the aid of botanical illustrations, photographs and actual field study and observation at the regional banana variety collection of BPI in Davao, an inventory of cultivar names and synonyms was prepared by the curators of national banana variety collections of Southeast Asia.

Table 1 presents the list of banana cultivar names and synonyms of Southeast Asia while Table 2 contains the list of cultivars unique to each country of the region.

The workshop refrained from using the internationally recognized subgroups and from using the system of nomenclature proposed by Simmonds and Shepherd, which replaces the species name with genome groups, as they felt that this could easily lead to errors and confusion. They adopted instead the simple but precise and stable method of Cheesman and the International Code of Nomenclature for Cultivated Plants.

Results and recommendations

The curators of national banana variety collections in Southeast Asia evaluated the existing banana classification schemes and agreed on a common and standardized format which is a simple but precise and stable system of nomenclature to identify the species and cultivars of banana.

The three tier system using species, genome group and cultivar was adopted. Following Cheesman’s recommendations, the edible diploid and triploid derivatives of Musa acuminate Colla and Musa balbisiana Colla will adopt the name of their respective wild parents. The hybrids of the two species will be classified under Musa x paradisiaca Linn as recognized by the International Code of Nomenclature for Cultivated Plants.

The banana taxonomists of the region identified 62 cultivars with synonyms in Southeast Asia and listed them in Table 1. Many other cultivars were found to be unique to the countries of the region and their names are presented in Table 2.

In order to help germplasm curators in other parts of the world properly identify banana cultivars originating from Asia, the banana taxonomists of the region recommended the development and adoption of a referral system to enable banana taxonomists from other regions of the world get advice on the correct identity of banana varieties from the relevant national curator.

Furthermore, the banana taxonomists present at the meeting offered to provide additional assistance if necessary to germplasm curators worldwide in the identification of accessions originating from Southeast Asia.

The participants in the workshop recommended that similar workshops should be held in India, Sri Lanka, Bangladesh, Myanmar and possibly Pakistan in order to sort out the synonyms which exist in these countries. Importance should also be given to the problem of synonymy in the South Pacific.

References


Workshop on banana cultivar names and synonyms in Southeast Asia

1-4 September 1999, Philippines
### Table 1: Banana cultivar names and synonyms in Southeast Asia.

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<td>Pisang Awak 13</td>
<td>Pisang Siem 13</td>
<td>Klui Namwa Daeng</td>
<td>Chuoi Tay</td>
</tr>
<tr>
<td><strong>Musa x paradisiaca</strong></td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Triploid ABB (cooking)</td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Species</td>
<td>Cultivar Name</td>
<td>Genome</td>
<td>Synonyms</td>
<td>Synonyms</td>
<td>Synonyms</td>
<td>Synonyms</td>
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<tr>
<td>Musa x paradisiaca</td>
<td>Matavia</td>
<td>Triploid ABB</td>
<td>Pisang Abu Keling</td>
<td>Pisang Kepok Hijau</td>
<td>Klui Som</td>
<td>Chuoi Ngop Lun</td>
</tr>
<tr>
<td></td>
<td>Kratsila</td>
<td>Triploid ABB</td>
<td>Pisang Abu Perak</td>
<td>Pisang Kepok Awu</td>
<td>Klui Haks Muk</td>
<td>Chuoi Silver Bluggoe</td>
</tr>
<tr>
<td></td>
<td>Maduranga</td>
<td>Triploid ABB</td>
<td>Pisang Abu Bujal</td>
<td>Pisang Kepok Awu</td>
<td>Klui Nom Mi</td>
<td>Chuoi Ngop Cau</td>
</tr>
</tbody>
</table>
Table 1. (continued)

<table>
<thead>
<tr>
<th>Species, Genome</th>
<th>Philippines</th>
<th>Malaysia</th>
<th>Indonesia</th>
<th>Thailand</th>
<th>Vietnam</th>
<th>International</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Musa x paradisiaca</strong>&lt;br&gt;(cooking)</td>
<td>Pelpia&lt;br&gt;Pondol</td>
<td>Pisang Kari</td>
<td>Kluai Tip</td>
<td>Chului Nong Dao</td>
<td>Chului Ng Pha Kao</td>
<td>Pelipita</td>
</tr>
<tr>
<td><strong>Musa x paradisiaca</strong>&lt;br&gt;Tetraploid ABBB (cooking)</td>
<td>Taparot 6&lt;br&gt;Sabang Puit</td>
<td>Pisang Abu Siam</td>
<td>Kluai Thepparat</td>
<td>Chului Gao</td>
<td>Taparot</td>
<td></td>
</tr>
<tr>
<td><strong>Triploid ABB</strong>&lt;br&gt;(cooking)</td>
<td>Saba Cardaba&lt;br&gt;Gubad&lt;br&gt;Pua-Dalaga&lt;br&gt;Turangkog&lt;br&gt;Sabang Puit</td>
<td>Pisang Nipah&lt;br&gt;Pisang Kepok&lt;br&gt;Pisang Kepok Besar&lt;br&gt;Pisang Kepok Kuning&lt;br&gt;Pisang Kepok Putih</td>
<td>Kluai Hin&lt;br&gt;Klurai Phama Haek Kuk&lt;br&gt;Klurai Chua&lt;br&gt;Klurai Sap&lt;br&gt;Klurai Leg Chang Kud</td>
<td>Chului Mat&lt;br&gt;Chului Chua&lt;br&gt;Chului Sap</td>
<td></td>
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</tr>
</tbody>
</table>

1 Chromosome counts in the Philippines, diploid; in Malaysia and Thailand, triploid; at the International Atomic Energy Commission in Vienna sometimes diploid, other times triploid.
2 Sometimes cooked. 3 Preferred cooked. 4 Ploidy to be confirmed by chromosome counts (see INFO MUSA 7 (1): 5-6). 5 To be verified.

Table 2. Banana cultivars unique to each country in Southeast Asia.

<table>
<thead>
<tr>
<th>Species, Genome</th>
<th>Philippines</th>
<th>Malaysia</th>
<th>Indonesia</th>
<th>Thailand</th>
<th>Vietnam</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Musa acuminata</strong>&lt;br&gt;Diploid AA (dessert)</td>
<td>Eda-an&lt;br&gt;Veneite Cohol&lt;br&gt;Moring Princesa&lt;br&gt;Garo&lt;br&gt;Manang&lt;br&gt;Suyak&lt;br&gt;Inabaca&lt;br&gt;Binakotong&lt;br&gt;Lonsing&lt;br&gt;Talapan&lt;br&gt;Kati&lt;br&gt;Bu-oy</td>
<td>Pisang Serindek&lt;br&gt;Pisang Jarum&lt;br&gt;Pisang Ekor Kuda</td>
<td>Pisang Liat&lt;br&gt;Pisang Masan&lt;br&gt;Pisang Hutan&lt;br&gt;Pisang Berlin&lt;br&gt;Pisang Cici Kuning&lt;br&gt;Pisang Cici Merah</td>
<td>Kluai Khai Boran #1&lt;br&gt;Klurai Lai&lt;br&gt;Klurai Hom Thong Son&lt;br&gt;Klurai Hom Jan&lt;br&gt;Klurai Nam Thai</td>
<td></td>
</tr>
<tr>
<td><strong>Musa acuminata</strong>&lt;br&gt;Diploid AA (cooking)</td>
<td>Sarosoco&lt;br&gt;Binawe&lt;br&gt;Guyod&lt;br&gt;Golimpang&lt;br&gt;Talip&lt;br&gt;Tarakitok</td>
<td>Pisang Buloh 1&lt;br&gt;Pisang Angleng&lt;br&gt;Pisang Biltung&lt;br&gt;Pisang Bakar&lt;br&gt;Pisang Byok</td>
<td>Chului La Rung&lt;br&gt;Klurai Cau Tay&lt;br&gt;Klurai Tieu Cao Hong</td>
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</tbody>
</table>

1 Sometimes eaten cooked.
2 Many aborted seeds; leaves are used as wrapping material, male bud is cooked as vegetable or eaten fresh in various salad preparations, pseudostems are fed to animals, fruits with seeds eaten fresh.

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2 Many aborted seeds; leaves are used as wrapping material, male bud is cooked as vegetable or eaten fresh in various salad preparations, pseudostems are fed to animals, fruits with seeds eaten fresh.
Mobilizing IPM for sustainable banana production
Edited by E.A. Frison, C.S. Gold, E.B. Karamura and R.A. Sikora
ISBN: 2-910810-98-4
This 265-page book gathers together 16 scientific articles presented during a meeting held in Costa Rica in July 1998 focusing on the production of environmentally sustainable and economically profitable banana and plantain.

Participants from ten different countries provided information on the various aspects and concepts regarding organic/environmentally friendly banana production and the characteristics of several alternative agricultural systems are described. The agricultural and/or scientific constraints to conversion of current production systems in the short and medium term are presented. This book covers issues such as precision agriculture, alternative varieties resulting from genetic improvement programmes, conventional and organic fertilisation methods, soil management, pests and organic production as well providing information on markets for organic bananas.

The information presented in this book will be of interest to producers, researchers and teachers, stimulating through its reading a more active participation in this type of agriculture, with its many challenges and difficulties.

This book is available in Spanish; the English version is expected by the beginning of year 2000.

Requests for copies can be addressed to INIBAP-LACNET Office, Costa Rica.

Books, etc...
A tribute to the work of Paul H. Allen: A catalogue of wild and cultivated bananas:
Compiled and edited by F.E. Rosales, E. Arnaud and J. Coto
ISBN: 2-910810-35-6
This publication results from a collaboration between FHIA, Honduras and INIBAP and provides information on the tremendous work carried out by Paul Allen during the 1950’s and 60’s to build and characterise the Musa collection of the United Fruit Co. (now FHIA’s collection). The book contains data on 337 accessions of banana collected by Dr Paul H. Allen during missions mainly in South East Asia and New Guinea in the 1960s. Information about each accession is provided in a MUSAlogue-type format, with one accession being described per page. The information included is based on the content of banana score cards compiled by Dr Allen. These score cards were developed in order to record the morpho-taxonomic observations and evaluation data collected on the varieties in the collection. The majority of this data was entered into a database in order to produce this monograph. As a result, a safe copy of this valuable and historical work now exists. This publication aims to make known a regional and historical «wealth».

To request a copy of the book, please contact the Information/Communications Unit at INIBAP Headquarters.

Bananas and food security
Edited by C. Picq, E. Fouré and E.A. Frison
ISBN 2-910810-36-4
INIBAP has just released the proceedings of the first International Symposium on the socioeconomics of non-export banana production ‘Bananas and food security’ held in November 1998 in Douala, Cameroon (see INFOMUS A 7(2): 24-26). The proceedings include 61 contributions from all over the world and cover the following topics: Importance of bananas economically and as a source of food (16 contributions); Diversity and dynamics of the sectors (18 contributions); Organisation of markets and marketing (13 contributions) and Production systems (14 contributions). Papers are published in their original language (English or French) and include abstracts in both languages. These proceedings will provide a valuable tool for sharing the wide range of experiences and information presented during the symposium and will promote increased activity in the area of socioeconomics.

To request a copy of the book, please contact the Information/Communications Unit at INIBAP Headquarters.

Diseases of banana, abacá and enset
CABI Publishing
Edited by David R. Jones
544 pages, 260 colour plates
This book, released in November 1999, provides a comprehensive guide to the diseases of banana, abacá and enset caused by pathogenic fungi, bacteria, viruses and nematodes. In addition, descriptions of banana disorders of uncertain etiology, genetic abnormalities of banana and problems of banana caused by climate change are included.
by climatic conditions, mineral deficiencies and toxic concentrations of chemicals are also included. Almost every disease and many of the other problems are illustrated in colour to enhance the value of the book as a diagnostic tool. Information is also provided on the origin and classification of banana, the safe movement of Musa germplasm and banana breeding, including possibilities for genetic engineering for disease resistance. Dirk De Waele, Eric Fouré, Friedhelm Gaulhi, Simon Gowen, Marie-Line Iskra Caruana, Yair Israel, David Jones, Emmanuel Lahav, Ben Lockhart, Xavier Mourichon, Randy Ploetz, Ronald Romero, Phil Rowe, Laszlo Sagi, Jean-Louis Sarah, John Thomas and others have written in their fields of expertise for the various sections within the book.

The publication is recommended for all those studying, researching and working in the areas of banana, abaca and enset cultivation, especially plant pathologists. It replaces an earlier title by R.H. Stover entitled *Banana, Plantain and Abacá Diseases* that was published in 1972 by the then Commonwealth Mycological Institute.

**Diseases of Banana, Abacá and Enset** can be ordered from CABI Publishing, CABI International, Wallingford, Oxon, OX10 8DE, UK (Tel: +44 1491 832111; Fax: +44 1491 829292; Email: orders@cabi.org). It costs £85.00 plus £2.50 for postage and packaging. Cheques should be made payable to CABI Publishing. Orders from North and Central America should be sent to Oxford University Press, 2001 Evans Road, Cary, North Carolina 27513, USA (Tel: +1 800 451 7556; Fax: +1 919 677 1303). The cost in this case is US$160.00 plus US$3.50 postage and packaging. Sales tax needs to be added by residents of NC and CA. Cheques should be made payable to Oxford University Press.

**Black Sigatoka disease of banana and plantain: a reference manual**

Kathelyne Craenen

ISBN: 978-131-156-8

This 60-page reference manual published by IITA provides a thorough guide to the assessment of black Sigatoka disease and its control measures. The author has drawn largely on her own practical experience in this field and made use of extensive literature on the disease. This manual will be useful to researchers and students in assisting them in methods of evaluating and controlling black Sigatoka disease in their environment.

To obtain a copy, please contact IITA: Mail address: C/o Lambourn & Co, 26, Dinwalt road, Croydon CR9 3EE, UK. Fax: (234-2) 2412221, email: ilita@cgiar.org.

**A guide to banana production in Jamaica: a reference manual**

B. K. Dazdie


This 192 page-manual was produced as a part of an international collaborative project between the Jamaica Banana Board and the Natural Resources Institute (ZEF), Germany. It provides an analysis of the preliminary benefits and impacts that could be brought about by the dissemination of tissue culture banana plantlets to resource poor farmers in Kenya. The study describes Kenya’s banana varieties, and the pests and diseases they suffer from. It also analyses the banana farming system and trade and marketing channels. It discusses the tissue culture process and the advantages and disadvantages of tissue-cultured plantlets in terms of their likely effect on yields, production costs, farm incomes and the welfare of producers and consumers. The study concludes that the potential growth in average yields through using tissue cultured-plantlets is substantial.

To order this publication please contact the ISAAA SEAsia Centre, c/o IRRI, PO Box 3127, 1271 Makati City, The Philippines. Or write to publications@isaaa.org. All publications from ISAAA are sent free of charge to developing countries; others are charged $25 per ISAAA Briefs.

**El cultivo del plátano: Guía práctica**

Sylvio L. Belalcázar C.

This well-illustrated 38-page manual written in Spanish presents, in a simple and practical way, the technologies de-
To obtain a copy, please contact the author at the following fax numbers:
National (Colombia): (096) 7493071, International: (57-6) 7493071 or by email: belcar@armenia.multi.net.co.
Mailing address: A.A. 1069, Armenia, Quindio, Colombia.

**Announcements**

**International colloquium for the optimisation of plant nutrition**

8-13 April 2000, Cairo, Egypt

The International Association for the Optimisation of Plant Nutrition (IAOPN) is organising the Xth International Colloquium for the optimisation of plant nutrition: “Plant Nutrition for the next Millennium.”

The meeting will be held from April 8-13, 2000, Cairo Sheraton, Cairo, Egypt.

**Organic agriculture group - ACTAF IV national meeting, May 1999**

17-19 May 2000, La Havana, Cuba

The Organic Agriculture Group of the Cuban Association of Agricultural and Forestry Technicians (ACTAF), in coordination with the Ministry of Agriculture and the National Association of Small Farmers (ANAP), announce the IVth National meeting of Organic Agriculture at EXPO-CUBA in Havana city, from 17 to 19 May 2000.

The IVth meeting will examine the contribution of organic agriculture and agroecology to the transformation of Cuban agriculture towards sustainable rural development. All interested parties are invited to share a few days of reflection and exchange of experiences. Study tours, field days and courses are also being organised before and after the event. For more details of each of the activities, please consult the web page: http://www.foodfirst.org or contact the following:

**General information**

Ing. Marta Pérez Pérez Executive Secretary Grupo de Agricultura Orgánica - ACTAF
Apartado Postal 4029 C.P. 10400 Ciudad de La Habana, Cuba
Tel/Fax: (537) 845387
E-mail: acraf@minag.gov.cu

**Study tours and field days**

Lic. Ricardo Reyes Veiga
Comercial Agropecuaria CATEC
Tel: (537) 212164/212064
Fax: (537) 666071
E-mail: catec@ip.etecsca.cu

**ACORBAT 2000**

31 July-4 August 2000, San Juan, Puerto Rico

The XIVth Meeting of the Association for the Cooperation in Banana Research in the Caribbean and in Tropical America (ACORBAT) will be hosted by the University of Puerto Rico, Mayagüez Campus, College of Agricultural Sciences in San Juan, Puerto Rico, from July 31st through August 4th, 2000.

The meeting will dedicated to Dr. Heber Irizarry, distinguished banana researcher and cofounder of ACORBAT, and to Mr. Ramiro Jaramillo, member and founder of the ACORBAT and former regional coordinator of INIBAP for Latin America and the Caribbean.

The programme will have various sessions of open fora where different topics will be developed throughout the presentation of research and its results through oral sessions, conferences, round tables, graphic presentations, and field days.

To submit a paper, please contact:
Dr. José Andrés Chavarria, President, Technical/Scientific Presentations Committee:
Agricultural Experiment Station, University of Puerto Rico
PO Box 9031, Mayagüez Campus, Mayagüez, PR 00681-9031
Tel.: (787) 2653859,
Fax: (787) 8337765
E-mail: j_chavarria@rumac.upr.clu.edu

For registration, contact:
Mrs. Fátima Ortiz Colberg
Office of International Programs
University of Puerto Rico - RUM
PO Box 9030
Mayagüez, PR 00681-9030
Tel.: (787) 8343413
E-mail: f_ortiz@rumac.upr.clu.edu

Detailed information on the above meetings is available on the INIBAP website, ‘News’ section, at the following address: http://www.inibap.fr

**INIBAP news**

**Recruitment**

INIBAP has recently recruited two new Programme Assistants for its headquarters office in Montpellier.
Gillian Moffat, an Irish national, has a BSc in Marketing Management (specialisation International Marketing) from the Dublin Institute of Technology. Gillian spent one year at the University of Montpellier in 1997 as part of her degree course and is fluent in French. Gillian took up her appointment as Programme Assistant on 11 October and is working for Bertus Eskes, Cacao Programme, replacing Bernadette Sellers, and for Jean-Vincent Escalant, PROMUSA.

Anne Causse, a French national, has an M.A. in Applied Foreign Languages (Maîtrise - Langues Étrangères Appliquées) English and Spanish and a DESS (Higher Degree) in translation, from Montpellier University. Anne spent 18 months in the U.K. as part of her university course. Since leaving University, she has worked in both the medical and research sectors in Montpellier, including CIRAD. Anne took up her new position as Programme Assistant on 22 November and will be working for Hubert Omont, on the new Commodity Chains Programme and Suzanne Sharrock, Germplasm Conservation Scientist.

New germplasm available from the INIBAP Transit Centre

FHIA-25, an improved cooking banana hybrid developed by FHIA Honduras, has now completed virus indexing and is available for distribution by INIBAP. FHIA-25 is a high yielding, dwarf variety with excellent cooking qualities, which is resistant to black Sigatoka. This hybrid is considered by FHIA to have great potential as a possible alternative to plantains and East African highland bananas which are badly affected by black Sigatoka. This hybrid (INIBAP accession no. ITC 1418) is available from the INIBAP Transit Centre in Belgium as well as from the Regional Multiplication Centres in Costa Rica (CATIE) and Cameroon (CRBP).

A full list of improved varieties available at the INIBAP Transit Centre can be obtained from INIBAP, Montpellier (Requests should be addressed to Suzanne Sharrock).

Reinforcement of European collaboration in banana research

CIRAD, France and the Katholieke Universiteit Leuven (KUL), Belgium are well known as two European research organisations with important research programmes on bananas. Efforts are underway to strengthen the collaboration between these two banana programmes. Dr Emile Frison of INIBAP recently attended the second planning meeting between KUL and CIRAD, where it was clear that prospects look good for the establishment of a strong partnership in Musa research, building on the considerable strengths and complementarity of the two organisations.

INIBAP launches new web site

A new and comprehensive web site has recently been launched by INIBAP. This web site is currently only available in English, but French and Spanish versions will be released soon.

The web site features a wide range of information about INIBAP and INIBAP projects and for the first time provides internet access to INIBAP’s databases. The web site will be further developed over the coming months, with a particular focus on pages dedicated to the regional networks.

Online access to databases

Two INIBAP databases, MUSALIT and BRIS are available through the web site. MUSALIT is INIBAP’s comprehensive bibliographic database, previously only available in printed form as MUSARAMA. The on-line access allows searches to be made by author, title, subject area, country and date of publication. The database includes more than 5000 entries and is continually being updated by INIBAP. BRIS is a database of researchers working on Musa. It contains details of more than 800 scientists, providing contact details and areas of specific interest for each scientist. The BRIS database is searchable by name, institute, country and area of research.

International Musa Germplasm Collection

A list of accessions available from the International Musa Germplasm Collection maintained by INIBAP is also available on the INIBAP web site. This list provides information on the name, classification and code number (ITC number) of accessions which have completed virus indexed and are available from INIBAP.

Useful links

In order to help Musa researchers access to relevant information quickly and easily, the INIBAP web site features a large number of links with other useful web sites. These links are kept up-to-date and checked regularly to ensure their relevance and usefulness.

You can visit the new INIBAP web site at the following address: http://www.inibap.fr

CD-ROM

For those who do not have ready access to the Internet, INIBAP has developed a CD-ROM including most of the information provided on the web site. The CD-ROM MusaDoc 1999 contains selected INIBAP publications in various linguistic versions (proceedings, books, technical guidelines, fact sheets etc.) as well as the two databases, MUSALIT and BRIS. MusaDoc 1999 will be available from January 2000.

RISBAP training workshop on Info/doc databases

In September 1999 a training workshop on the improved INIBAP info/doc databases package (running on Winisis, the Windows version of CDS/ISIS) was held in Thailand for the members of the Regional information system on banana and plantain for Asia and the Pacific (RISBAP). The full process of information management, from the primary document to the information search in the databases was revised using standard worksheets. Another objective of this workshop was to discuss the constraints in implementing a national information system and to suggest possible procedures to stimulate the collection of information. It was recommended that each of the ten RISBAP representatives would be responsible for the national implementation of the improved package and for assigning an information person to data
The 9th INIBAP-ASPNET RAC meeting was held on 2-5 November 1999 in Guangzhou, China. The President of South China Agricultural University, Prof. Luo Shiming, hosted the conference.

In his report, Dr Agustin B. Molina, INIBAP/ASPNET Regional Coordinator, described the various activities that had taken place during the year. These include seminars, workshops, training, information development and exchange, research and development support and facilitation of activities on germplasm collection, conservation, characterisation and evaluation. He also highlighted the areas in which INIBAP/ASPNET will give priority in the coming years. These include, making available improved germplasm and superior landraces to small-scale growers, and developing and implementing effective IPM systems that will help to alleviate the ever-pressing problems of pests and diseases in the region.

To maximise the outputs of the meeting, Chinese scientists were invited to present papers on relevant banana research and development in China. Dr Chen Houbin of SCAU and China’s RAC representative, gave his report on the Banana Collection; Prof. Li Fengnian of the Fruit Institute, GAAS reported on the Status of Banana Production; Prof. Xiao Huogen of SCAU on Identification, Indexing and Molecular Biology of BBTV; Prof. Liao Jinling of SCAU on Research Status of Banana Nematodes. A special guest presenter, Prof. Hong-Ji Su of National Taiwan University (NTU) presented a very comprehensive paper on the Development and Application of Molecular Diagnostic Probes for Detection, Characterisation, and Management of Banana Viruses. Virus detection is an important component of producing disease-free planting materials, which is a major element of disease management of virus diseases in Taiwan and other countries.

Dr Ramon Valmayor presented the results and recommendations of the Banana cultivar names and synonyms workshop. Initial tables on the banana synonyms and unique cultivars in South-east Asia were also presented which will later be published as an INIBAP bulletin (see meeting report in this issue).

Results of the Nematode project in Vietnam was reported by Dr Ho Huu Nhi while Prof. Det Wattanachaiyingcharoen presented the results of the Banana exploration and geographic imaging system in Thailand. Dr Rene Espino presented the Philippine Banana Network on Research, Development and Extension and its agenda, which is a recent development in the Philippines.

Dr S.C. Hwang, Director of the Taiwan Banana Research Institute (TBRI), provided a report on Recent Developments on Banana Fusarium Research and Development in Taiwan. Dr Hwang highlighted TBRI’s success in developing Fusarium wilt resistant clones through somaclonal variant selection. The planting of resistant clones integrated with the use of disease-free tissue culture planting materials were the basis of the survival of the banana industry in Taiwan. In the spirit of international collaboration Dr Hwang announced that TBRI will make available through INIBAP, two TBRI high-yielding, Fusarium-resistant clones for inclusion in the IMTP III program.

Country reports outlining the current thrusts and future priorities of banana and plantain research and development in the various countries in the region were delivered by the RAC members. Dr Siti Hawa Jamaluddin of Malaysia, Mr Bob Williams of Australia, Dr N.I. Bhuiyan of Bangladesh, Dr Djoko Said Damarjati of Indonesia, Dr Rene Rafael Espino of Philippines, Dr Sujatha Weerasinghe of Sri Lanka, Prof. Det Wattanachaiyingcharoen of Thailand, Dr Ho Huu Nhi of Vietnam Mr Tom Osborn of the Secretariat of the Pacific Community and Dr Shin-Chuan Hwang of Taiwan Banana Research Institute likewise presented their respective country/institution reports. It was interesting to note that the common prime concerns of all the countries are the alleviation of diseases and pest problems, and the availability of improved hybrids/varieties. Marketing and value adding were also mentioned as important topics.

Recommendations from the discussion and planning session:

• The establishment of an operational breeding network in the region with INIBAP-ASPNET acting as facilitator.

Networking for BRIS

A survey was carried out in 1999 to update the database of Musa researchers. Partners and regional staff who distributed surveys during meetings also generated feedback. As a result, more than 150 researchers’ records were added and/or updated. BRIS includes now 824 Musa researchers. An updated directory of researchers is in preparation and will be available early in 2000.

Asia and the Pacific

Highlights of the 9th INIBAP-ASPNET Regional Advisory Committee (RAC) meeting

The 9th INIBAP-ASPNET RAC meeting was held on 2-5 November 1999 in Guangzhou, China. The President of South China Agricultural University, Prof. Luo Shiming, hosted the conference.

This year’s RAC meeting was highlighted by paper presentations on important banana research and development activities in China, an update on the 9th year of operation of ASPNET, and a report on special INIBAP/ASPNET projects. In addition, reports were provided on specific topics from selected RAC members and special guests, and country reports were provided on directions in banana research and development. Paper presentations were followed by discussions and the planning of priority activities for collaboration in the region.

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Results of the Nematode project in Vietnam was reported by Dr Ho Huu Nhi while Prof. Det Wattanachaiyingcharoen presented the results of the Banana exploration and geographic imaging system in Thailand. Dr Rene Espino presented the Philippine Banana Network on Research, Development and Extension and its agenda, which is a recent development in the Philippines.

Dr S.C. Hwang, Director of the Taiwan Banana Research Institute (TBRI), provided a report on Recent Developments on Banana Fusarium Research and Development in Taiwan. Dr Hwang highlighted TBRI’s success in developing Fusarium wilt resistant clones through somaclonal variant selection. The planting of resistant clones integrated with the use of disease-free tissue culture planting materials were the basis of the survival of the banana industry in Taiwan. In the spirit of international collaboration Dr Hwang announced that TBRI will make available through INIBAP, two TBRI high-yielding, Fusarium-resistant clones for inclusion in the IMTP III program.

Country reports outlining the current thrusts and future priorities of banana and plantain research and development in the various countries in the region were delivered by the RAC members. Dr Siti Hawa Jamaluddin of Malaysia, Mr Bob Williams of Australia, Dr N.I. Bhuiyan of Bangladesh, Dr Djoko Said Damarjati of Indonesia, Dr Rene Rafael Espino of Philippines, Dr Sujatha Weerasinghe of Sri Lanka, Prof. Det Wattanachaiyingcharoen of Thailand, Dr Ho Huu Nhi of Vietnam Mr Tom Osborn of the Secretariat of the Pacific Community and Dr Shin-Chuan Hwang of Taiwan Banana Research Institute likewise presented their respective country/institution reports. It was interesting to note that the common prime concerns of all the countries are the alleviation of diseases and pest problems, and the availability of improved hybrids/varieties. Marketing and value adding were also mentioned as important topics.

Recommendations from the discussion and planning session:

• The establishment of an operational breeding network in the region with INIBAP-ASPNET acting as facilitator.
and providing some opportunities for assistance.
- Collecting missions in gap areas:
  - Continue collecting in Irian Jaya, Indonesia
  - Pursue collecting missions in Sabah and Sarawak, Malaysia
  - Explore possible collecting missions in Bangladesh, Burma, Laos, Cambodia
- Continued regional participation in MGIS and RISBAP.
- Adoption of the recommended classification scheme proposed by the curators of the Banana names and synonyms workshop.
- INIBAP to make available varietal information such as agronomic and disease resistance characteristics, on improved hybrids/ clones and commercially planted natural clones, so that countries may have a comprehensive basis of selecting varieties to include in their NEPs and/or IMTP trials.
- Need for training of participants in IMTP on the set up of experiments and the collection of data for standardisation in carrying out IMTP III.
- The need for a regional germplasm multiplication and distribution centre.
- Request for additional training on virus indexing, and production of antisera.
- Call for quarantine consciousness and implementation of quarantine at the national, regional, and global levels.
- Validation of ITC germplasm.
- Determination/Validation of ploidy status of germplasm collection using cytological techniques (Vietnam, China and partial (half) for Indonesia.)

**Pisang Raja Awards**

Following the tradition of the ASPNET RAC meeting, the 1999 Pisang Raja and institutional Awards were presented by the INIBAP ASPNET Coordinator to outstanding banana scientists and institutions. The Pisang Raja awardees were Dr Chen Houbin, Director of the Tropical Subtropical Fruit Research Laboratory, South China Agricultural University and Prof. Hong-Ji Su from National Taiwan University. The Institutional Award was given to South China Agricultural University.

The Asia and Pacific network of INIBAP operates under the guidance of its Regional Advisory Committee (RAC). The RAC members represent the National Agricultural Research Systems (NARS) of member countries (Australia, Bangladesh, China, India, Indonesia, Malaysia, Philippines, Sri Lanka, Thailand and Vietnam) and institutions (Taiwan Banana Research Institute and the Secretariat of the Pacific Community - representing 22 countries in the South Pacific).

**Sri Lankan Department of Agriculture and INIBAP collaborate to improve banana production**

**Banana virus disease management workshop**

According to recent surveys conducted by plant pathologists from the Horticultural Research and Development Institute (HORDI), Sri Lanka, about 80 percent of banana plants in Sri Lanka are affected by viruses, particularly by banana bract mosaic virus and banana bunchy top virus. To help Sri Lankan scientists understand how to manage these diseases, INIBAP-ASPNET, in collaboration with HORDI, held a workshop on Banana virus disease management at the Plant Genetic Resources Development Center (PGRC) in Gonnoruwa, Kandy on July 27, 1999. The workshop, attended by more than 60 banana researchers, policy makers and professors from government institutions and academe reviewed the distribution and severity of banana virus diseases in the country, and discussed and formulated action plans to alleviate the disease problem. The workshop was opened by Dr S.D.G. Jayawardena, Director General of the Department of Agriculture who raised concerns on the impact of the diseases to the local banana industry. The workshop was strengthened by the technical presentations from Dr Agustin B. Molina, Regional Coordinator, INIBAP-ASPNET and Professor H.J. Su, a noted banana virologist from the National Taiwan University. Prof. Su described the epidemiology and management of these diseases and emphasized the importance of integrated management strategies, based on the use of disease-free planting materials coupled with appropriate post-planting cultural practices.

Recommendations from the workshop included:
- The implementation of a national disease management programme;
- An eradication and rehabilitation programme based on the use of disease-free planting materials;
- The implementation of a national banana seed-piece certification programme.

Two centres, namely the Virology Laboratory at HORDI, Gonnoruwa and the Adaptation Research Station in Homagama, Colombo were recommended as virus-indexing centres.

**Training in virus indexing**

Following from the virus management workshop, INIBAP-ASPNET, together with HORDI, organised a hands-on Virus Indexing training course, which was conducted on August 26-28 at the laborato-
ries of the Plant Genetic Resources Center at Gannoruwa, Paredeniya. Twenty-two researchers and technicians working in tissue culture laboratories in the Department of Agriculture and universities participated in the training. The principal trainee was Prof. H.J. Su, virologist of the National Taiwan University, assisted by Dr I. Ariyaratne, virologist at HORDI.

The training focused on the use of two indexing procedures, ELISA and PCR-based techniques. Banana samples used in the training showed positive reactions to four viruses, CMV, BBTV, BBrMV, and BSV. This confirms the presence of the four viruses, already identified by field symptoms. Prof. Su provided the antibodies and primers used in the training. He also donated through INIBAP, more than US$ 2000 worth of reagents and instruments. The hands-on training was essential for the Department of Agriculture as it starts to implement a national banana virus disease management programme based on the use of disease-free planting materials.

Taiwan provides support in fight against virus diseases in Asia

At the recently held Regional Advisory Committee meeting of INIBAP-ASPNET, Professor Su, virologist of the National Taiwan University, donated antibodies to the representatives from the Philippines and Sri Lanka. This donation of antibodies forms part of the commitment made by Prof. Su to provide antibodies free to INIBAP-ASPNET members for the next two years, until they are able to produce their own antibodies for use in national virus indexing programmes.

Africa

INIBAP Regional Coordinator joins editorial board of Musafrica

Eldad Karamura, the INIBAP Regional Coordinator for Eastern and Southern Africa has recently joined the editorial board of Musafrica, the plantain and banana newsletter which is published by the International Institute of Tropical Agriculture (IITA). This move came about as a result of discussions held during the MUSACO meeting which took place in Douala, Cameroon in November 1998. It was agreed that Musafrica would become an outlet for Musa science in Africa, cosponsored by IITA and INIBAP. It was agreed that Musafrica would continue to function as both a newsletter reporting on issues and events of relevance to banana and plantain scientists working in Africa and as an avenue for the publication of scientific results. In addition to changes in the editorial board, new deadlines for submissions have been set in order to bring Musafrica back up to a twice-yearly publication. The new deadlines are: 1st March for the first issue of the year and 1st August for the second.

The current issue of Musafrica (June 1999) is available from IITA and contains the following articles:

- **Focus**: A review of the banana IPM meeting held in Nelspruit, South Africa, November 23–26, 1998.
- **Research Notes**: Financial appraisal of plantain sucker production in Ghana.
- **Germplasm evaluation**: Multiplication and distribution of banana streak virus (BSV) tolerant hybrids.
- **News and views** – a summary of information from IITA regarding Musa research activities.

Please send contributions for future issues to: Dr J. Hartman (Editor-in-Chief, Musafrica), IITA, c/o Lambourn & Co, Carolyn House, 26 Dingwall Road, Croydon, CR9 3EE, UK.

Zaag de Beer of the Institute for Tropical and Subtropical crops (ITSC), South Africa. Representatives of BARNESA member countries, as well as representatives from IITA, ICIP, and IRAZ attended the meeting.

**Coordinator’s report**

The BARNESA Coordinator provided a report on the progress made over the past 12 months. Four technical workshops were organised during the year, focusing on IPM, tissue culture and in situ conservation. In addition, a number of project proposals were developed and submitted to donors, with the result that a project on in situ conservation of Musa has now started in Uganda and Tanzania and projects on banana baseline information for the region and integrated pest management will commence early in 2000.

**BARNESA strategic plan**

Following a review of the BARNESA strategic plan by the consultancy group ECART, on behalf of the European Union, it was recommended that the network should take steps to align itself more closely with the strategy of ASARECA, and adopt a more market-oriented approach. It was agreed that the Coordinator would seek appropriate advice on recasting the strategic plan. In addition, it was noted that the present members of the Steering Committee are almost exclusively researchers and the market sector is not properly represented. In order to help the network address marketing issues, it was agreed that the composition of the Steering Committee should be reassessed.

Report of the 5th BARNESA Steering Committee Meeting, held in Nairobi, Kenya on 23 September, 1999

The 5th BARNESA Steering Committee meeting was hosted by the Kenya Agricultural Research Institute (KARI) and convened under the Chairmanship of...
Chairmanship
The Steering Committee agreed to change the length of tenure for the Chairperson from one to two years. Mrs Mary Wabule of KARI, Kenya was elected BARNESA Chairperson for the period 1999/2001.

Logframe training
As part of this year’s BARNESA Steering Committee meeting, a training course on the use of logical frameworks as a tool in project development and management was held for BARNESA Steering Committee members. This course was facilitated by Dr Mike Carter of the Centre for Rural Development and Training, University of Wolverhampton, UK. During the workshop participants studied the principles, development and use of logical frameworks and developed a draft logical framework for a proposed regional Integrated Pest Management (IPM) project.

As part of the training course, participants carried out a Stakeholder Analysis to identify the stakeholders of such a project, their interests and importance relative to the objectives of the project, and their influence on the project achieving those objectives.

Participants analysed the problem that the proposed project would be seeking to address; they also examined the way in which problem analysis can link into the logical framework. Considerable time was then devoted to completing a logical framework for an IPM project. The logical framework was completed in stages through group work followed by plenary discussion.

Field visit
A field visit was organised by KARI to allow BARNESA Steering Committee members to become more familiar with some Musa research activities being carried out in Kenya. The visit included the tissue culture laboratory of the University of Jomo Kenyatta University, a commercial laboratory which produces banana plantlets for sale to farmers. This was followed by a visit to farmers’ fields where participants were able to see a number of introduced varieties, including FHIA varieties, being produced by smallholder farmers. The farmers visiting are using tissue cultured planting materials and are developing skills in weaning and hardening of tissue cultured plantlets.

In situ conservation of bananas in East Africa
A project focusing on the in situ conservation of bananas in Uganda and Tanzania has recently been initiated in East Africa. The project, funded by the International Development Research Centre (IDRC) of Canada is being implemented by INIBAP, through its Regional Office in Kampa. The project activities will take place in two sites in each country. The objectives of the project are to identify and characterise the indigenous germplasm being maintained in farmer’s fields in each country and to study the factors affecting such on-farm conservation. Through the project, INIBAP hopes to identify threats to genetic diversity conservation and study ways to overcome these and thus prevent genetic erosion. The project will also focus on raising the awareness of local communities on the importance of diversity conservation and look at the possibilities for the long-term conservation of varieties on-farm through the enhanced utilisation of diversity.

3rd Steering Committee meeting of MUSACO
Plantain and banana producers in Ghana should be obtaining improved yields following the release of high yielding varieties of plantain and banana. Ghana’s Crop Research Institute has released FHIA-21 under the local name ‘Apef hema’ (Queen of French plantains) and FHIA-OL known as ‘Kwadu Bempa’ (the gentleman banana). More than 80% of farmers in the Bas Congo province of the Democratic Republic of Congo cultivate plantain for sale. If confirmed in other countries this will indicate a shift in the status of plantain which has hitherto been considered as a subsistence crop. Farmers sold only what was left after their requirements at home had been satisfied. CRBP has developed high yielding plantain-type hybrids which should contribute significantly to increased production of the crop in the sub-region if they are adopted after agronomic and taste tests that will take place in the countries. These are some of the pieces of information reported by representatives during the third annual regional steering committee meeting held in Abidjan on 23 and 24 November 1999 presided over by Mrs Adele Sambo from Gabon. Mrs Sambo was elected unanimously to chair the steering committee to replace the late Jean Pedro who until his death last October was the chairman.

The meeting began with a minute’s silence in honour of the late chairman and of Lancine Conde a Musa researcher from Guinea (Conakry) who had been killed in a hunting accident. Dr Kassoum Traoré, Deputy Director General of the Centre National de Recherche Agronomique (CNRA) of Côte d’Ivoire gave the opening address. He emphasised the necessity for partnership to advance agricultural research in the sub-region. Present at the opening ceremony were Mr Kouassi Martin, DG of the Agence nationale pour le développement rural (ANADER) and Dr Osseni Bouraima, Director of Cooperation and Scientific Information at CNRA. Eleven (Benin, Cameroon, Congo Republic, Côte d’Ivoire, Democratic Republic of Congo, Gabon, Ghana, Guinea, Nigeria, Senegal and Sierra Leone) out of 12 member countries were represented so were IITA, INIBAP and CRBP.

In updates on research activities in their countries, several country-representatives indicated the need to inventory the diversity of germplasm of the two crops existing in their countries, thus the need for prospecting, collecting and characterising landraces. Those countries that have already collected local germplasm expressed the need for assistance in characterising these materials.

The training needs expressed were the same as those indicated at the last year steering committee viz. characterisation of Musa germplasm, scientific writing and IPM methods. In addition, participants requested training in the development of logical frameworks. The coordination office was encouraged to spare no effort in sourcing for funds for some of these courses, as they are necessary for the advancement of Musa research in the sub-region.

The Regional Coordinator in his report to the gathering expressed his satisfaction with progress of the network. Germplasm evaluations are going to take place in seven countries. A project on Musa cultivation in peri-urban zones of two cities in Ghana (Kumasi and Sekondi) and one in Benin (Cotonou) is underway (see below). The coordination office and INIBAP headquarters have prepared proposals for funds to expand research activities in network member countries.

To document the results of research and development activities that have taken place in the past in the sub-region and those ongoing, it was agreed that each country will prepare a monograph on the state of art of Musa research and development. Also, a database on current research and development activities will be created. Each country will complete a questionnaire that the coordination office had prepared for that purpose.

Jean Vincent Escalant, secretary of PROMUSA, invited scientists from the sub-region to participate in the programme after presenting its structure, objectives and some of the current activities.

The meeting recommended that:
1. The diversity of Musa at the regional level is documented. This will require that...
collection expeditions be conducted especially in the central Africa basin where diversity seems to be very high. National scientists will be trained in techniques of collecting and in characterising Musa germplasm.

2. Technologies available in the sub-region are inventoried. Fact sheets or other appropriate publications should be prepared on these technologies for wide distribution.

3. A meeting be held after the 2000 MUSA/CO Steering Committee meeting during which (1) countries will report on information gathered in the baseline data collection surveys that are to be conducted and (2) a regional research programme will be developed in a bottom-up process.

Finally, the Committee expressed their gratitude for funds received from Belgium in support of the coordination office with the hope this support will continue. The committee reiterated its support for the joint CRBP/MUSA/CO proposal submitted to the European Union for funding under the 8th European Development Fund. The steering committee exhorts the Gatsby Charitable Foundation to expand its support of Musa research activities to include more countries in West and Central Africa within the framework of MUSA/CO.

Peri-urban Musa production in West Africa

Increasing urbanisation is common in many developing countries. The growing low-income urban population is more-and-more resorting to the cultivation of food crops in their backyards, on road sides and in unused open spaces. In the humid lowlands of West and Central Africa, plantains are one of the dominant crops found in these gardens. This crop is easy to grow, does not need to be replanted each season and produces fruit year round. Moreover, as plantains are a staple food crop in this region, a good market for this crop exists in the nearby cities.

The French Ministry of Cooperation has recently approved a 2-year project to enable researchers and development workers in Ghana and Benin to distribute improved hybrids to peri-urban plantain and banana growers. As part of the project, farmers will be taught methods for the mass production of healthy planting material. The project will be managed in the framework of MUSA/CO (Musa Research Network for West and Central Africa) and INIBAP, through its Regional Office for West and Central Africa, will be the executing agency.

Latin America and the Caribbean Report of the 8th Regional Advisory Committee meeting of INIBAP-LACNET

This year, the 8th Regional Advisory Committee meeting of INIBAP-LACNET was marked by a special gathering held in Havana, Cuba from November 5 to 8. For the first time, the RAC meeting took place under the auspices of FORAGRO (Foro Regional de Investigación y Desarrollo Tecnológico Agropecuario para América Latina y el Caribe). The purpose of FORAGRO is to provide a forum to facilitate dialogue, articulation and strategic alliances among the different actors that make up the National Agricultural Research and Development Systems in Latin America and the Caribbean. Dr Jorge Kondo, Chairman of FORAGRO, took the initiative of sending special invitations to the LACNET member countries to participate in this meeting. The meeting also benefited from the valuable collaboration of the staff from the Ministry of Agriculture of Cuba, who was highly efficient in making all the local arrangements.

The main purpose of the meeting was to lay the groundwork for the establishment of a Plantain and Banana Research and Development Network for Latin America and the Caribbean under the auspices of FORAGRO and owned by all the participant countries. Under such an initiative, INIBAP would continue to provide support in LAC as one of the various network sponsors. This initiative marks the beginning of a new stage regarding horizontal cooperation in Musa among the countries involved in LAC.

Thirty-five scientists from 13 countries of the region participated in this meeting. The countries represented were: Bolivia, Brazil, Colombia, Costa Rica, Cuba, Dominican Republic, Ecuador, Honduras, Jamaica, Mexico, Panama, Puerto Rico and Venezuela. Dr Franklin E. Rosales and Mrs Lisette Vega (Coordinator of INIBAP-LACNET and Administrative Assistant, respectively), also attended the meeting together with Drs Emile Frison and Jean Vincent Escalant from INIBAP Headquarters. Among the representatives and special guests were Thierry Le- scot (CIRAD-FLHOR, France), Dr Elkin Bustamante (CATIE, Costa Rica), Dr Bart Panis (KUL, Belgium), Drs Rodolfo Araúmbulo and Jorge Chang (FUNDAGRO), and Dr Richard Taylor (EARTH, Costa Rica).

The meeting was opened with presentations from Drs Rodrigo Avendaño (FORAGRO's representative), Alfredo Gutiérrez, Vice Minister of Agriculture, Cuba, Emile Frison, and Franklin Rosales. This was followed by a presentation by Dr Richard Taylor on “Scenarios and future vision of agriculture in Latin America and the Caribbean”, followed by two more special presentations, one by Dr Franklin Rosales regarding INIBAP’s origin and development and the other by Dr Bart Panis from KUL, Belgium on “Current and Future Collaboration of KUL with Latin American and the Caribbean countries”. Country reports were also provided by the various country representatives.

The remaining sessions were devoted to working group discussions on the following topics: genetic improvement, integrated pest management, crop management and socioeconomic development. The groups identified specific objectives and impact areas in the different topics. The activities defined within each impact area were discussed during a plenary session where weaknesses and strengths were also analyzed. The last session of the meeting was dedicated to discussing and analyzing a proposal of a cooperation agreement to establish the Network and a Network Declaration document was produced and approved by all the participants.

It was agreed that the new network (MusaLAC) will be launched in the early part of 2000 at a meeting to be held in Pereira, Colombia, by kind invitation of CORPOICA and the University of Tolima.

Participants in the meeting were able to visit the Research Center on Genetics and Biotechnology (CIGB) during the field trip, where Dr Carlos Borroto, Deputy Director a.i., shared valuable information on the latest research on banana and plantain. The participants also visited some banana and plantain fields where they were able to observe FHIA hybrids which are now widely cultivated in Cuba.

During the closing dinner, a special recognition was granted to Dr Ruben Guevara Moncada, Director General of CATIE, Costa Rica. Dr Guevara has been a strong Network collaborator during his two periods as Director General of the Institution, especially by hosting INIBAP’s Regional Office and providing administra-
Plantains named as priority crop in West and Central Africa

The 12th Plenary Meeting of CORAF/WECARD (Conseil Ouest et Centre Africain pour la Recherche et le Développement/West and Central African Council for Agricultural Research and Development) has ranked banana and plantain as a priority for crop for research in the humid central zone of the sub-region. Bananas and plantains also feature as a priority in the peri-urban sector, together with root and tuber crops, vegetables and maize.

Plantain evaluation in Guinea

Bananas and plantains form an important part of the diet in Guinea. They are eaten cooked in several forms - boiled, roasted, fried etc. and sweet bananas are also eaten uncooked. The market for bananas and plantains in Conakry is far from being saturated and there is a growing interest in producing the crop in the Guinée Maritime region for this market.

A study was carried out by IRAG, evaluating two varieties of plantain introduced as *in vitro* plants. The two varieties evaluated were Kelong Mekintu, a French medium plantain, and Orishèle, a false horn plantain. The varieties were tested in 12 farmers’ fields. The results showed that both varieties yielded well (28.5 and 28.8t/ha). Although there were no significant differences in yields between the two varieties, the variety Orishèle was preferred by both local farmers and consumers.

Improvised varieties start to make an impact in Tanzania

Bananas are the major staple food crop for around one million people living in the Kagera region of Tanzania. In recent years, yields have declined, largely as a result of declining soil fertility, increasing pest and disease pressure and drought. As part of the Kagera Community Development Project (KCDP), funded by the Belgian Government, improved *Musa* varieties are being introduced, propagated and disseminated throughout the region (See INFOMUSA 7 (1): 15–17). 19 different varieties have been obtained from the INIBAP Transit Centre and are being multiplied and distributed for evaluation. In collaboration with a number of different governmental and non-governmental organisations, large numbers of plants are being multiplied locally for evaluation both on-farm by farmers and in trials managed by extension workers. Some of the new varieties are clearly out-yielding local varieties, particularly in areas hard hit by declining soil fertility and drought. Initial indications of the on-farm trials are that the new varieties are having a major impact on improving the food security of poor farmers in the Kagera region. The demand for new varieties is high and in some areas these are now being planted in preference to the traditional varieties. The most popular varieties to be evaluated so far are FHIA-01, FHIA-03 and Yangambi Km5. However FHIA-17, FHIA-23 and SH3436-9 are expected to also prove popular when they are introduced to farmers.

More information about this project is available from KCDP, PO Box 1745, Bukoba, Tanzania.

Musa evaluation in Nicaragua

The *Musa* evaluation project in Nicaragua, involving partners from Belgium (VVOB and KUL), together with the Universidad Nacional Autónoma de Nicaragua (UNAN-Léon), the Centro de Enseñanza Técnica Agropecuaria (CETA-Chinandega) and BANANIC is progressing well. The project aims to introduce, evaluate and disseminate improved varieties of banana and plantain to farmers in the Leon and Chinandega region. So far, the project is collaborating with 50 farmers in 15 communities. Fifteen accessions have been introduced from the INIBAP Transit Centre and following preliminary evaluation in the University's test farm, nine are being multiplied for distribution to farmers. The University's tissue culture laboratory will produce around 5000 plants for distribution this year. Next year, it is hoped that this number will increase to 15,000 plants. Further information about this project is available from: http://www.unanleon.edu.ni/~vitro/

Asia and Pacific

Bananas reduce blood pressure

Researchers in India believe that bananas can be used to treat hypertension and have demonstrated that eating just two bananas per day can reduce blood pressure by 10%. Scientists attribute the lower blood pressure to compounds in the fruit which behave like ACE-inhibitors - a class of medicine widely used to treat...
A new botanical garden has recently been established in Thailand to serve as an area for field conservation of local banana germplasm, general recreation and education. The park, named Royal Queen Sirikit Botanical Garden, gives recognition and honour to the Queen of Thailand. Prof. Wattanachaichayngcharoen, Thai representative to INIBAP-ASPNET’s Regional Advisory Committee, serves as the adviser to the project. The banana grove will serve as a conservation area for national banana germplasm as well as having an education function who those interested in banana or botanical taxonomy. While the garden is still on trial as an educational and recreational centre, the demonstration site will be contained within a one-hectare area. If this proves successful, the site will be expanded to 10 hectares. The Royal Queen Sirikit Botanical Garden is open to the public and will eventually hold the entire Thai banana collection complete with international accessions. The Government of Bangkok also plans to construct a museum for both banana and Thai culture.
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Instructions to authors

Typescripts should be prepared in English, French or Spanish and submitted in duplicate to the Managing Editor. They should be double-spaced throughout. All pages (including tables figures, legends and references) should be numbered consecutively. Include the full name of all the authors of the paper, together with the addresses of the authors at the time of the work reported in the paper. Indicate also the author nominated to receive correspondence regarding the paper.

If the typescript was prepared on a computer, please send a copy on diskette (or by e-mail) along with the printed ones, indicating the name and version of the wordprocessor used.

- Abstracts: An abstract not exceeding 200-250 words should be sent in the same language as the typescript, as well as translations (including the title) into the two other languages, if this is possible.

- Acronyms: These should be written in full the first time they appear in the text, followed by the acronym in parenthesis.

- References: All literature references made in the text should be referred to by author(s) and year of publication (e.g., Sarah et al. 1992, Rowe 1995). A list of references, in alphabetical order, should be provided at the end of the text. Please follow the style shown below:
  Tables: These should be numbered consecutively and referred to by these numbers in the text. Each table should include a title.
  Illustrations: These should be numbered consecutively and referred to by these numbers in the text. Each illustration should include a clear and simple caption.
  Graphs: provide the corresponding raw data with the graphs.
  Drawings: provide originals if this is possible.
  Black and white photographs: provide them on bright paper and with good contrast.
  Colour photographs: provide good quality proofs and films or original slides.

Note: When plant material used for the experiments reported originates or is registered in the INIBAP genebank, its accession number (ITC code) should be indicated within the text or in a tabular form.

Thank you in advance for following these instructions.
This will facilitate and accelerate the editing work.
The following publications are available from headquarters:


The following publications are available from ASPNET:


The third meeting of the Fusarium wilt working group (FWWG) was held on 21-22 October, 1999 in Kuala Lumpur, Malaysia, on the occasion of the International Seminar “Fusarium wilt of banana: towards sustainable cultivation”.

Participants
Current FWWG members and invited participants:
- Zaag de Beer, Julio Hernandez, Siti Hawa Jamaluddin, Africano Kangire, Natalie Moore (rapporteur), Gisella Orjeda (INIBAP, PROMUSA), Aristoteles Pires de Matos, Randy Ploetz, Mike Rutherford, Suzy Bentley, Liew Kon Wui, Nik Masdek, Agustín Molina, Ibrahim Omar, Anita Severn-Ellis, Altus Viljoen.

Introduction
The working group discussions covered four main areas:
- Fusarium wilt management issues
- IMTP Phase III
- Issues relevant to other PROMUSA working groups
- Updating of Fusarium wilt working group documents

Fusarium wilt management issues
The discussions on this topic involved issues related to pathogen diversity, disease management strategies, epidemiology and other relevant research issues. This report provides an overview of the discussions held and highlights some specific issues. Full details of recommendations for action, research opportunities and possible partners for collaboration are provided in Table 1.

Pathogen diversity
Pathogen diversity was discussed in terms of both genetic diversity of the pathogen and diversity in pathogenicity of isolates of *Fusarium oxysporum* f. sp. *cubense* (*Foc*). It was noted that there is a need for training in the use of DAF and VCG techniques, and that further collection and analysis of samples is still required in some parts of the world. It was recommended that a centralised database of *Foc* genetic diversity be developed and that this be linked with information regarding the reaction of *Musa* species/hybrids to *Foc* (e.g. MGIS database). The need for a protocol for pathogenicity testing using purified isolates of *Foc* was also noted, to enable each country to do their own testing. In relation to diagnostics, there is a need for a detection system for *Foc* to assist diversity host range and biological and cultural control studies.

Disease management strategies
In relation to disease management strategies, the need for education and farmer-awareness was highlighted, especially regarding the use of clean planting material and resistant varieties. Quarantine measures also play an important role in preventing the spread of the disease and must be addressed at the individual country level. Further research is required on the increased sus-
ceptibility of tissue-cultured plants to *Foc* and the use of beneficial microorganisms to improve plant vigour and resistance. A number of areas for research in relation to biological, chemical and cultural control methods were identified, see Table 1. In addition, close linkages with the Genetic improvement working group were recommended in relation to the development of resistant varieties. Furthermore, the creation of a banana breeding/selection programme located in Asia was strongly supported.

**Epidemiology**
Areas related to epidemiology where further research is required include studies on the effects of water logging, cold stress and pH on the pathogen, temporal and spatial development of the disease and pathogen survival rates.

**Other research topics**
The group identified three other priority areas for research:
- The development of a plantlet screening test (PST) to assist in evaluation of material from breeding programmes and to assist in bioassays
- The collection and evaluation of local germplasm for reaction to *Foc*
- Further investigations into False Panama Disorder.

**IMTP Phase III**
The need for training in germplasm evaluation protocols for countries participating in IMTP for the first time was highlighted as a priority. In addition, attention should be given to ways to promote the adoption of resistant varieties following IMTP evaluation. The use of demonstration plots was recommended, and in particular linking such plots to farmer training in aspects such as the use of clean planting material.

**Issues relevant to other PROMUSA working groups**
The FWWG reviewed the report of the Genetic improvement working group presented in *PRO* PROMUSA No. 2 (INFO* MUSA* Vol 7, No. 2). Some revisions to the Fusarium wilt table were made and the revised table is presented below (Table 2). In addition, the FWWG emphasised that the identification of molecular markers for *Foc* resistance should be given priority.

The FWWG highlighted the fact that priority within the group is being given to the development and release of a plantlet screening test for validation in other labs. Other working groups, particularly Nematology, may be able to collaborate in this.

** Updating of Fusarium wilt working group documents**
The Fusarium wilt working group reports prepared following the first global PROMUSA meeting (Guadeloupe, March 1997) were reviewed and updated. The revised documents will be made available via the PROMUSA website.

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**Table 1. Summary of recommendations for action and research opportunities in relation to Fusarium wilt management issues developed during the Fusarium wilt working group meeting, Kuala Lumpur, October 1999.**

<table>
<thead>
<tr>
<th>Issue</th>
<th>Recommendations for action</th>
<th>Research opportunities</th>
<th>Possible research collaboration</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Pathogen diversity</td>
<td></td>
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</tr>
<tr>
<td>1.1. Genetic diversity</td>
<td>Training program in DAF and VCG techniques (including isolation and storage of cultures) – INIBAP to coordinate</td>
<td>Develop centralised database of genetic diversity with access to all under auspices of INIBAP/PROMUSA</td>
<td>DPI, CRCTPP, UF, USM, CABI, ICIA, TBR, KARI, etc.</td>
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<tr>
<td></td>
<td>Link research on VCGs of <em>Foc</em> with VCG coordinator and link with database</td>
<td>Collection and analysis still required in some parts of the world – identify geographic areas for collection</td>
<td>All countries, all institutions</td>
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<tr>
<td></td>
<td>Where appropriate, replicate reference collections (reference strains of <em>Foc</em>) for use as national reference collections (storage and use must be appropriate for quarantine)</td>
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<td></td>
<td>FWWG to develop standardised format for information on isolates in collections</td>
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<tr>
<td></td>
<td>Note to international journal systematics to rename <em>Foc</em> from Heliconia to different forma specialis (S. Bentley)</td>
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</tr>
<tr>
<td>1.2. Pathogenic diversity</td>
<td>MGIS to add a module to record reaction of landraces and hybrids with <em>Foc</em> - possibility to link with <em>Foc</em> database</td>
<td>Collate existing host range data for various sites/countries throughout world – IMTP database + data from different countries</td>
<td>CABI/East Africa</td>
</tr>
<tr>
<td></td>
<td>Develop draft protocols for pathogenicity testing using purified isolates of <em>Foc</em> to enable each country to do their own testing</td>
<td>Collection and analysis still required in some parts of the world – identify geographic areas for collection and diversity studies</td>
<td></td>
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<tr>
<td>Issue</td>
<td>Recommendations for action</td>
<td>Research opportunities</td>
<td>Possible research collaboration</td>
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<tr>
<td>1.3. Diagnostics/detection system</td>
<td>Submit purified strains of DNA of <em>Fusarium oxysporum</em> and relevant <em>Fusarium</em> spp. to CRCTPP culture collection for evaluation of specificity of detection system (S. Bentley) (check current AQIS permit first)</td>
<td>Develop detection system for <em>Foc</em> (system required for plant and soil to assist diversity, host range and biological and cultural control studies)</td>
<td>CRCTPP, etc.</td>
</tr>
<tr>
<td>2. Disease management strategies</td>
<td></td>
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</tr>
<tr>
<td>2.1. Education and awareness</td>
<td>Produce general factsheet for banana growers/general public</td>
<td>Enhanced surveys may be required in some countries to assist in national/regional distribution of different strains/VCGs of <em>Foc</em></td>
<td>DPI/CABI/INIBAP</td>
</tr>
<tr>
<td></td>
<td>Encourage use of farmer demonstration plots for education - link with demonstration plots for use of tissue culture and for introduction of resistant varieties (i.e. include susceptible controls)</td>
<td>Alternative host studies: need to collate existing data for <em>Foc</em> and conduct new studies where appropriate natural opportunities exist (e.g. oil palm in Malaysia)</td>
<td>Chiquita and UPLB in Philippines; MARDI and EPA in Malaysia</td>
</tr>
<tr>
<td>2.2. Quarantine measures to prevent spread of pathogen</td>
<td>Each country to adapt information sheet developed in 2.1 above for local situations/regulations – target education of enforcers of quarantine protocols</td>
<td>Research may be required in future to test/improve current protocols for farm hygiene etc.</td>
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<tr>
<td></td>
<td>Collate existing protocols to develop information sheet for disinfecting machinery, implements, foot baths etc.</td>
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<td></td>
<td>FFWG should assess effectiveness of current recommendations as necessary to improve/address gaps</td>
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<tr>
<td></td>
<td>Current FAO protocols for safe movement of banana germplasm should be followed for national and international quarantine</td>
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<tr>
<td>2.3. Clean planting material</td>
<td>Use farmer demonstration plots to educate about benefits of clean planting material/tissue culture plants</td>
<td>Need to investigate why tissue culture plants are more susceptible to <em>Foc</em></td>
<td>QDPI + others?</td>
</tr>
<tr>
<td></td>
<td>Collate tissue culture management protocols for adoption to appropriate guidelines for smallholders</td>
<td>Investigate beneficial microorganisms to improve plant vigour and resistance</td>
<td>QDPI, USM, ICIA, ARC-ITC, EMBRAPA, etc.</td>
</tr>
<tr>
<td></td>
<td>Develop local systems for traceability of planting material from accredited sources in order to monitor subsequent disease outbreak</td>
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<tr>
<td>2.4. Development of resistant varieties</td>
<td>Suggestion of a banana breeding/selection programme located in Asia warrants further investigation</td>
<td>Identify more hybrids, landraces, and primitive diploids and evaluate locally (see 4.2. below and recommendations from PROMUSA Genetic improvement working group)</td>
<td></td>
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<tr>
<td></td>
<td>Existing breeding programmes refer to data on pathogenicity testing and <em>Foc</em> database</td>
<td>Develop faster Plantlet Screening Test (PST) (see 4.1.) to aid in resistance evaluation of germplasm</td>
<td></td>
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<tr>
<td></td>
<td>FFWG needs to collate results of resistance evaluation of wild materials in germplasm collections</td>
<td>Host pathogen interactions yet to be fully understood for this pathosystem: - mechanisms of host defence - pathogenic mechanisms</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Breeding programmes need to exchange landraces and wild species</td>
<td>Markers for resistance to assist breeding and selection effort</td>
<td>CIRAD-FHLOR, CRCTPP, etc.</td>
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<tr>
<td></td>
<td>Global access to local <em>Fusarium wilt resistant</em> germplasm through INIBAP-ITC procedures (and inclusion in IMTP III)</td>
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<tr>
<td>Issue</td>
<td>Recommendations for action</td>
<td>Research opportunities</td>
<td>Possible research collaboration</td>
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<tr>
<td>2.5. Adoption of disease resistant varieties</td>
<td>Training needed in utilisation and evaluation of protocols for IMTP III</td>
<td>Identify pathways of technology transfer and adoption by farmers</td>
<td>All participating countries (DFID project commencing in Africa)</td>
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<tr>
<td></td>
<td></td>
<td>Develop and apply local protocols for adoption of resistant varieties before release to address issue of fairness of distribution (INIBAP-ASPNET, National Evaluation Programmes)</td>
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<td></td>
<td></td>
<td>Use of demonstration plots recommended – link with demonstration plots for grower education about use of clean planting material (see 2.3.)</td>
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<td></td>
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<td>Disseminate outputs of upcoming DFID project on adoption pathways</td>
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<td></td>
<td>Each country needs to develop protocols for the marketing of new varieties</td>
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<tr>
<td>2.6. Chemical/biological control</td>
<td>Use of SAR agents – zinc, salicylic acid, Bion, phosphorus acid, “Ecolife” citrus</td>
<td>Characterise wilt suppressive soils</td>
<td>QDPI, CRCTPP, ARC-ITC, ICIA</td>
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<td></td>
<td>Investigate use of vesicular arbuscular mycorrhizae, bacteria and fungi for biological control (related to studies for improvement of tissue culture plant vigour (see 2.3. above)</td>
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<tr>
<td>2.7. Cultural control</td>
<td>Collate and make available results of research into cultural control methods (e.g. from TBRI and India)</td>
<td>Investigate role of soil amendments - Molasses - “mustard oil seed cake” – Bangladesh - wood amendments (also useful for nematode control) - soil analysis survey</td>
<td>QDPI, ARC-ITC, CABI, HRC (Bangladesh) + others?</td>
</tr>
<tr>
<td></td>
<td>Test economic viability of methods under different conditions</td>
<td>Rotation/Annual cropping - test efficacy of biocontrol strategies in these systems</td>
<td>TBRI (Taiwan), SCAU, NRCB, India, and commercial companies, EMBRAPA, Bangladesh</td>
</tr>
<tr>
<td></td>
<td>Local grower discussion groups to develop directions and on-farm trials</td>
<td>Water management see 3.1</td>
<td>South Africa, QDPI, UPLB</td>
</tr>
<tr>
<td>3. Epidemiology - disease physiology</td>
<td>Investigate effect of water-logging/hypoxia and cold stress in relation to increased incidence of FW (also pH of whole soil profile)</td>
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<tr>
<td></td>
<td>Temporal and spatial development of disease e.g. in Tropical race 4 data opportunity for new Cavendish plantations in Malaysia</td>
<td>Masters and PhD opportunities</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Pathogen survival in infected plant material – in soil and in absence of living host material (banana and alternative hosts) on surface (incorporated and on surface)</td>
<td>Masters and PhD opportunities</td>
<td></td>
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<tr>
<td></td>
<td>Study of disease spread from point source/local development studies</td>
<td></td>
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<tr>
<td></td>
<td>Need development of detection system to support these objectives (see 1.3.) and need information on alternative hosts (see 2.2.)</td>
<td></td>
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</tr>
<tr>
<td>4. Other research issues of current importance</td>
<td>Protocols should be useable in diverse locations/labs and be distributed to protocols for validation in other labs, including those where non-endemic strains can be tested</td>
<td>1 Optimise USM protocols (including testing in different laboratories) 2 Validate with field reaction data</td>
<td>USM, UF, UPLB, CABI strains, QDPI</td>
</tr>
<tr>
<td>4.1. Plantlet Screening Test</td>
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</tbody>
</table>
Table 1. (continued)

<table>
<thead>
<tr>
<th>Issue</th>
<th>Recommendations for action</th>
<th>Research opportunities</th>
<th>Possible research collaboration</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.2. Collect and evaluate native germplasm for reaction to Foc</td>
<td>National programmes to supply authenticated and submit to ITC with signed material acquisition agreement</td>
<td>Expand and authenticate identity</td>
<td>All countries, all institutions</td>
</tr>
<tr>
<td></td>
<td>Need verification of identity of germplasm in ITC</td>
<td>Once identified, assess reaction of native germplasm to Foc</td>
<td></td>
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</tbody>
</table>

Table 2. Genetic improvement working group priority table modified with respect to Fusarium wilt working group priorities.

<table>
<thead>
<tr>
<th>Fusarium wilt</th>
<th>Status</th>
<th>Research gaps</th>
<th>Priority</th>
</tr>
</thead>
<tbody>
<tr>
<td>Genetic resources</td>
<td>Yes</td>
<td>- Landraces (primitive diploids)</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Advanced hybrids</td>
<td>1</td>
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<tr>
<td></td>
<td></td>
<td>- Other sources of resistance e.g. transgenic</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Mechanisms of resistance (pathogen diversity, segregating populations, r genes)</td>
<td>1</td>
</tr>
<tr>
<td>Breeding programmes</td>
<td>Yes</td>
<td>- Asian breeding programmes</td>
<td>1</td>
</tr>
<tr>
<td>- Available hybrids</td>
<td>Yes but not enough</td>
<td>- Resistance to race 4</td>
<td>1</td>
</tr>
<tr>
<td>- Early evaluation stage</td>
<td></td>
<td>- Plantlet screening test</td>
<td>1</td>
</tr>
<tr>
<td>- Multilocal and farmer evaluation</td>
<td></td>
<td>- Optimising and validation of EST protocols</td>
<td>1</td>
</tr>
<tr>
<td>Global evaluation</td>
<td></td>
<td>- Quarantine</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Other diseases</td>
<td>1</td>
</tr>
<tr>
<td>Control methods available</td>
<td>yes</td>
<td>- Awareness and evaluation</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Adoption of new cultivars</td>
<td>1</td>
</tr>
</tbody>
</table>
FAO/IAEA 3rd Research coordination meeting of the collaborative research project on “Cellular biology and biotechnology, including mutation techniques for creation of new useful banana genotypes”

This meeting was organised from 4 to 8 October 1999 in Colombo, Sri Lanka, by the International Atomic Energy Agency (IAEA). The purpose of the meeting was to review the progress in induced mutations and related biotechnologies in banana research achieved since the last meeting in October 1997, discuss the strategy for further research and prepare a detailed programme of work for all participating institutes and laboratories. INIBAP publishes hereunder the abstracts of presentations made.

Abstract of presentations

**In vitro manipulation and mutation breeding for the improvement of banana**
Mak Chai 1, Y.W.Ho2, K.W.Liew3, Azahar Mohd4, J.M.Asif5 and A.A. Mohamed6

1University of Malaya, 2United Plantations Bhd, 3University of Science, 4Institute of Nuclear Technology Research, Malaysia.

*In vitro* manipulation and gamma irradiation were used for the improvement of local cultivars. The project has utilised the following strategies: selection and micropropagation of natural variants of selected cultivars; exploitation of somaclonal variants; mutation induction by using gamma irradiation; chromosomal manipulation through *in vitro* polyploidy induction; utilisation of genetic resources of wild bananas (*Musa acuminata* ssp. *malaccensis*).

**Micropropagation and evaluation of natural variants**
Traditional banana cultivars were collected in small villages, micropropagated and then evaluated for Fusarium wilt tolerance in the Fusarium ‘hot spot’ (a quarantined field infested with *Fusarium oxysporum* f. sp. *cubense* (Foc) race 4, VCG 01213). After two years, the cultivars still surviving in the ‘hot spot’ are Pisang Jari Buaya, Pisang Abu, Pisang Serendah and the introduced ‘Goldfinger’. However, their suitability and potential as commercial clones is still questionable.

**Exploitation of somaclonal variants**
Our previous report indicated that a Pisang Rastali (AAB) selection derived from tissue culture was found to survive for more than three years in a field heavily infested with Fusarium wilt when all other clones planted at the same time died. When suckers from these tolerant Pisang Rastali plants were micropropagated and challenged in the Fusarium ‘hot spot’ together with Cavendish, Pisang Berangan and Pisang Mas plants, they showed 51% survival whereas plants of all other clones had died. Further selection was made for Pisang Rastali plants showing growth vigour as well as absence of split pseudostem. Micropropagated plants of these selected Pisang Rastali were evaluated again in a replicated trial in the ‘hot spot’ in comparison to Pisang Berangan (AAA), an early maturing Cavendish banana called ‘Novaria’ (Mak et al. 1996) and ‘Goldfinger’ (AAAB), a tetraploid banana which is known to have multiple disease resistance particularly to Fusarium wilt. After two years, this selected Pisang Rastali remained highly tolerant to Fusarium wilt in comparison to ‘Goldfinger’. It should also be noted that Novaria showed 7% of resistance during this trial.

**In vitro mutation breeding**
Induced mutation is capable of changing unique characteristics of an outstanding unique characteristics of an outstanding since the last meeting. After two years, the clone was first selected Pisang Rastali and then evaluated for Fusarium wilt tolerance in the ‘hot spot’. It remained highly tolerant to Fusarium wilt when all other clones planted at the same time died. Further selection was made for Pisang Rastali plants showing growth vigour as well as absence of split pseudostem. Micropropagated plants of these selected Pisang Rastali were evaluated again in a replicated trial in the ‘hot spot’ in comparison to Pisang Berangan (AAA), an early maturing Cavendish banana called ‘Novaria’ (Mak et al. 1996) and ‘Goldfinger’ (AAAB), a tetraploid banana which is known to have multiple disease resistance particularly to Fusarium wilt. After two years, this selected Pisang Rastali remained highly tolerant to Fusarium wilt in comparison to ‘Goldfinger’. It should also be noted that Novaria showed 7% of resistance during this trial.
Mycosphaerella sp. Priority has been given to Asia: a project proposal is being developed to be submitted to the European Commission (5th PCRD7/INCO-DEV).

- efficiency, durability and management of resistance. Analysis of resistance (CIRAD/CRBP, IITA and FHIA): collaboration between breeding programmes would allow a better understanding on what genes are inherited (PR, HR)
- Development of early screening methods. An artificial inoculation method under controlled conditions is being developed jointly by CIRAD and CRBP. Leaf fragments are maintained through in vitro condition after inoculation with conidia.

Nematology working group
It has been agreed that a PROMUSA Nematology working group meeting will be organised during the 14th Symposium of NSSA to be held in 2001 in South Africa. Paul Speijer has also been proposed to be a member of the organising committee of the Symposium. It is suggested that the proceedings of the Nematology Working group meeting will be published as a specific output of the meeting.

Information exchange and visibility
In order to facilitate the exchange of information between the members of the different working groups, INIBAP has set up a number of e-mail listservers. One for anyone interested in the overall Programme, promusa@cgiar.org and one specific listserver for each of the working groups:

- promusagen@cgiar.org for the Genetic improvement working group
- promusasig@cgiar.org for the Sigatoka working group
- promusavir@cgiar.org for the Virology working group
- promusanem@cgiar.org for the Nematology working group
- promusafus@cgiar.org for the Fusarium working group.

The PROMUSA web site has also been updated and you are invited to visit it and send your comments and ideas for improvement as well as additional links and information to be included.

The address of the site is: http://www.inibap.fr/promusa/


A mutation breeding programme was initiated in 1992 for the popular local cultivar Pisang Berangan with the objective of using gamma irradiation to induce genetic variation so as to provide an opportunity to select plants tolerant to Fusarium wilt disease.

Some selections of gamma irradiated Pisang Berangan (AAA) which appeared promising for tolerance to Fusarium wilt disease had been identified for confirmation trials.

An early screening technique for Fusarium wilt by using in vitro plants in a double-tray system has been developed and is now adopted for preliminary screening of somaclonal variants and mutagenic plants for Fusarium wilt tolerance at known concentrations of Fusarium oxysporum f. sp. cubense.

In vitro polyploid induction
In vitro polyploid induction has produced an autotetraploid Pisang Mas (AAA) for field evaluation. The tetraploid plants showed drooping leaves and non-compact pseudostems. However, such features tend to disappear, as the plants grew older.

Utilisation of genetic resources of wild bananas (Musa acuminata ssp. malaccensis)
Seed progenies of some populations of Musa acuminata ssp. malaccensis produced through zygotic embryo culture were screened for their response to Foc race 4 using the ‘double tray’ method. Within each progeny, segregation was observed for Fusarium wilt tolerance. Highly susceptible seedlings as well as the susceptible check (Pisang Berangan) died within four weeks. The potentials of using such segregating seed progeny for susceptibility and tolerance to Fusarium wilt are being investigated.

References

Mutagenic treatment of in vitro cultures for the improvement of plantain (Musa sp.)

Pearl Wharton-Gill and E. Willabus
National Agriculture Research Institute, Mon repos, East Cost Demerara, Guyana.

Since all popularly cultivated varieties are susceptible the use of resistant/tolerant genotypes of plantain is highly desirable to control Moko disease (Ralstonia solanaceaearum race 2) in Guyana. The successful introduction of such new genotypes however, will depend largely on their adaptability to the local agro-ecological environment, as well as farmers’ and consumers’ acceptance. Agromically elite clones can be improved genetically to create resistant/tolerant cultivars that are desirable. This can be achieved through the use of induced mutation combined with in vitro techniques.

A Research coordinated project with collaboration between NARI and FAO/IAEA/BADC was undertaken to genetically improve elite local plantain clones, using irradiation in combination with in vitro techniques. The ultimate aim was to create resistant and/or tolerant genotypes with desirable agronomic traits. The project is now in its fourth year.

The main objectives for this the fourth year of the project were:

- To collect, micropropagate elite plantain clones and ship these to IAEA for irradiation treatment;
- To develop a technique to isolate R. solanaceaearum from soils using selective media;
- To screen irradiated plantlets for resistance/tolerance to moko disease;
- To genetically characterize R. solanaceaearum isolates.
Field collection, micropropagation of elite clones to meristem cultures and shipment to IAEA for irradiation treatment are ongoing. However, a re-current problem of contamination of the cultures upon arrival at IAEA in Austria needs to be addressed.

In an attempt to develop a technique to isolate <i>R. solanacearum</i> from soil, two semi-selective media were used. These were: Tetrazolium chloride amended with chormaphenicol (TZCC) and Potato Dex- trose Agar amended with crystal violet (PDACV). The media were compared for their efficiency in isolating the bacterium from artificially and naturally infested soil. Results showed that TZCC was significantly better than PDACV regardless of soil type.

For the field screening trials, irradiated and non-irradiated (control) plantlets were established in naturally infested fields. Plants are currently under observation for disease resistance/tolerance and performance in agronomic traits. At this stage however, there are no obvious differences in the overall performances of the irradiated and control plants. Monitoring will continue into the second and third ratoon crops.

AFLP was performed on extracted DNA of isolates of <i>R. solanacearum</i> with the aim of determining the level of polymorphism among the indigenous isolates. The analysis revealed a high level of polymorphism among the eighteen local isolates profiled. This preliminary finding has important implications for the development of germplasm with desired traits. Development of efficient and reliable transformation and regeneration techniques combined with advanced genomic infrastructure (i.e. bioinformatics, EST libraries, electo-optics analysis etc.), are expected to enhance the probability of attainment of breeding objectives which were unachievable until now. However, it is crucial to start with a good and stable genetic baseline and with plants free of viruses, microorganisms and nematodes. To this end, tissue culture is a powerful tool for banana breeders and the entire industry. However, this technology is hindered by somaclonal mutations, which appear in the course of the in vitro culture process. On the other hand, somaclonal variants can be used for selection of elite clones with respect to yield and fruit quality. Being a major banana propagator from tissue culture as well as a molecular breeder, Rahan Meristem is currently engaged in a project aimed to elucidate the mechanisms of somaclonal variation in “Cavendish” bananas.

Most common somaclonal variations in “Cavendish” clones fall into three classes: variants showing either over (Giants) or lower sensitivity (Dwarf) to GA and those which exhibit variegated leaves. All types are strongly induced by the duration of tissue culture and by the rates of multiplication from a single explant. We postulated that at least in part the correlation between somaclonal mutations and the extent of tissue culture stems from activation of transposable elements.

“Copia-like” retro-tranposable element was transcribed after a long duration of banana clones in tissue culture. The R-500 (a Rahan selection of “Grand Naine”) genome contains at least three copies of the gene BR-1. Upon extensive tissue culture a distinct mutant exhibiting long and narrow leaves was isolated. The phenotype of the mutant is detectable in vitro and was stable for at least 18 months in the field. The transcript of BR-1 was detectable in the mutant by RT-PCR. Southern analysis with BR-1 specific probe revealed an intensification of the existing bands. We postulate that the intensification of the bands on the Southern blot reflects transposition of the transcribed element in the vicinity of the original sequence. We are in the process of sequencing and characterizing a genomic clone carrying the BR-1 sequence. If retro-elements comprise the natural cause of somaclonal variation, we would expect a limited variety of mutants.

Field selection

The components of yield in bananas are bunch weight, the number of bunches per hectare and the time interval between cycles (flowering earliness). Due to somaclonal variation, individual clones often differ with respect to yield and fruit quality. The deviation within a micropropagated population of clones was used for explant selection.

The selection scheme was initiated with three hundred mats (three plants per mat) of ‘Grand Nain’ banana plants which were propagated by meristem culture from six mother clones according to Cronauer and Krikorian (1984). After three months of ex-vitro hardening, the plants were transferred to the Western Galilee Banana Experimental Station. Bunch bearing stems (ratoons) were selected according to practices of banana cultivation in the Western Galilee (Israel). During the six years of the experiment, bunches were weighed and data collected (Table 1).

Based on the results of the above experiment, the best clones were multiplied by meristem culture as mentioned above. The performance of these clones in total yield, though differing from each other, was consistently above the control population.

### Table 1. Bunch data.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Clone</th>
<th>5-1</th>
<th>6-6</th>
<th>37-5</th>
<th>42-5</th>
<th>17-1</th>
<th>Control</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bunch weight (kg)</td>
<td>37.82</td>
<td>37.47</td>
<td>35.68</td>
<td>37.44</td>
<td>33.44</td>
<td>30.47</td>
<td></td>
</tr>
<tr>
<td>Bunches/ha/year</td>
<td>2.83</td>
<td>2.83</td>
<td>3.00</td>
<td>2.83</td>
<td>2.33</td>
<td>1.74</td>
<td></td>
</tr>
<tr>
<td>Calculated yield</td>
<td>88.19</td>
<td>87.38</td>
<td>88.10</td>
<td>87.31</td>
<td>64.22</td>
<td>43.59</td>
<td></td>
</tr>
</tbody>
</table>
Involvement of retro-transposons in somaclonal variation

Clearly, somaclonal variation is induced by the extensive of tissue culture manipulations. However, the mechanism of somaclonal mutations in bananas is unknown. In recent studies Hirochica et al. (1996), provided clear evidence that extensive duration of rice cell culture activated retro-transposing elements. Furthermore, the tobacco retro element Tto undergoes transcriptional activity by wounding as well as by methyl jasmonate (Takeda et al. 1998). The structural features as well as transcriptional activation of retro-elements resembles retroviruses. Under normal conditions they remain dormant and upon activation they are transcribed, reverse transcribed to CDNA molecules and reintegrated in new chromatic regions.

We have examined the activation of retro-elements in the banana genome by extensive in vitro conditions, which induced abnormal phenotypes. Somaclonal variants with both high and low sensitivity to GA were generated after extensive durations in tissue culture. Both ‘off-types’ were detectable by a relatively simple bioassay developed in our laboratory (Table 2). The results obtained by this assay provide evidence to the hypothesis that ‘Dwarf’ and ‘Giant’ phenotypes are related to GA sensitivity. Sandoval et al. (1995) have shown that in addition to the difference in sensitivity, partitioning between the different GA metabolites differed between ‘Dwarf’, ‘Giant’ and the normal phenotypes.

Using degenerate primers taken from published sequence of rice ’Tos 17’ (Hirochica et al. 1996), we have isolated a putative 344 bp retro-transposon homologue from the Musa genome.

The DNA of the pre-cultured meristem and the mutants was analysed by Southern hybridization using BR-1 as a probe. The probe hybridized to two fragments in the control, while the LNL mutant hybridized to at least four additional fragments. The addition of bands on the Southern blot indicates a propagation of the retro-element in the LNL mutants. At this point, the number of integrated copies represented per band is unclear. However, in the LNL the hybridized signal was intensified. This may indicate multiplication of retro-elements in a close proximity to the original retro sequence. A cascade form of retro-elements has been reported in other species (San Miguel et al., 1996). This phenomenon may explain the high frequency of a single phenotypic variation. If a gene associated with GA sensitivity resides in close proximity to the original retro-sequence and the distribution of insertions is biased to short distances, we expect a high rate of mutants involving GA sensitivity. We are currently investigating this hypothesis.

References


Approaches to the genetic improvement of Musa spp.


Table 2. Influence of GA3 on “internode” length of in-vitro normal and mutant banana plantlets.

<table>
<thead>
<tr>
<th>Clone/treatment</th>
<th>Normal (cv. Grande Naine)</th>
<th>Dwarf (Grande Naine mutant)</th>
<th>Extra dwarf mutant</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control (hormone free)</td>
<td>14.2 b</td>
<td>10.8 c</td>
<td>9.6 d</td>
</tr>
<tr>
<td>GA (10 mg/l)</td>
<td>21.7 a</td>
<td>14.9 b</td>
<td>9.6 d</td>
</tr>
</tbody>
</table>

Plantlets were grown for 5 weeks on GA-containing or hormone-free media. Various approaches to the genetic improvement of Musa have been undertaken at the Boyce Thompson Institute. This abstract summarises recent accomplishments.

A genetic transformation system has been developed for three closely related Yucca spp., all of which are fungal pathogens Musa spp. M. fijensis and M. musicola - the causal agents of black and yellow Sigatoka, respectively, and a newly characterised Yucca spp. species were transformed with a construct carrying a gene encoding green fluorescent protein (GFP). Transformants of each species, expressing GFP constitutively throughout the hyphae and in conidiospores, were used to examine and compare infection processes on the banana cultivar Grand Nain. For all three species, leaf penetration was exclusively via stomata, and hyphae grew between rather than into cells. Haustorium-like structures were not observed. The use of GFP-expressing transformants allowed us to observe fungal growth in vivo in greater detail and with more ease than was previously possible and to view several events not previously reported. All three species were able to grow extensively within leaf tissue that eventually turned necrotic, at which point they grew saprophytically on the dead tissue. Additionally, leaf necrosis and chlorosis was often observed in advance of saprophytic growth of the mycelium on necrotic tissue, suggesting secretion of a phytotoxin. Infection structures known as stomatopodia were formed above stomatal openings on both host and non-host species, indicating that banana-specific signals are not required for this event. A self-inhibitor of conidiospore germination has been identified and partially characterized and a light activated phytotoxin has been identified from in vitro grown M. musicola.

A protocol was developed for establishment of embryogenic suspension cultures from shoot tip sections of the banana cultivar Rashali. These cultures were used for Agrobacterium-mediated transformation using a binary vector carrying the uidA gene for 3-glucuronidase expression.
Southern blot analysis confirmed the integration of the uida gene in sixteen β-glu-curonidase-expressing plants.

Retroelements are ubiquitous features of eukaryotic genomes, often accounting for a substantial fraction of their total DNA content. A sequence from banana which shows significant homology to gypsy-likeLTR retroelements from other species was identified and partially characterised. The element named monkey, shows high homology to the reverse transcriptase, RNAsH and integrase genes of retroelements from plants, fungi and yeast. Southern hybridisation indicated that monkey is present in both the A and B Musa genomes and that it is found at around 1000 copies/cell in cv. Grand Nain. Chromosomal localisation by fluorescent in situ hybridisation indicated that copies of monkey are concentrated in the nucleolar organisers regions and co-localise with rRNA genes. Other copies of monkey appear to be dispersed throughout the genome.

Finally, banana is being developed as a vaccine delivery vehicle for the developing world using transgenic plants expressing subunit vaccines. Positive results have been obtained using the potato model system. Human volunteers developed antibodies to the LT-B subunit of the E. coli LT toxin upon ingesting raw potatoes expressing LT-B. Similar results have been obtained using potatoes expressing Norwalk virus coat protein.

Analysis of Musa genome using flow cytometry and molecular cytogenetics

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Conventional breeding of improved bananas and plantains has been hampered by complicated genetic system characteristic for genus Musa. It is becoming clear that the efficiency of classical breeding may be improved by incorporating various biotechnological approaches and molecular techniques. Effective breeding will also rely on in depth characterisation of natural germplasm. While a significant progress has been made in the analysis of the nuclear genome of Musa at molecular level, the knowledge of the genome at nuclear and chromosomal level remains poor. Our research activity is focused on filling these gaps. To aid in effective analysis, we have developed novel approaches including DNA flow cytometry (Dolezel et al. 1994), high-resolution chromosome analysis (Dolezel et al. 1998) and molecular cytogenetics (Dolezelová et al. 1998). Using these methods, the knowledge of Musa genome at chromosomal and nuclear level has been significantly expanded.

The results obtained so far confirmed the usefulness of DNA flow cytometry. The technique has been used to determine genome size (Dolezel et al. 1994, Lysák et al. 1999), to select solid tetraploids after polyploidization of diploids in vitro (Van Duren et al. 1996) and for large scale ploidy screening (Dolezel et al. 1997) e.g., in progenies obtained in various breeding programmes, and for verification of ploidy in poorly characterised accessions. For instance, flow cytometric analysis of nuclear DNA content was performed in four Musa accessions previously considered natural acuminata x balbisiana tetraploids (Horry et al. 1998). One of them, a clone called “Kluai Tiparot” (ITC 0652), has been considered a reference for natural tetraploid banana. The results showed that Kluai Tiparot (ITC 0652) and other two clones were triploid. This unexpected observation indicates that natural acuminata x balbisiana tetraploid cultivars are even more rare than generally believed.

Fluorescence in situ hybridisation (FISH) has been used to analyse the structure of Musa chromosomes. Recently, we have studied the distribution of a monkey retrotransposon within the Musa genome (Balint-Kurti et al. 1999). The results showed the element was preferentially localised to nucleolus organiser regions (NORs). This observation was surprising as all retroelements that have been physically mapped so far in plants showed either relatively uniform distribution over all chromosomes or were localised to centromeres. This result adds a second chromosome domain to the list of sites of preferential retroelement accumulation in plants. The localisation of many copies of monkey to NORs, and the correlation between the number of copies of rRNA genes, and the number of monkey retroelements suggested simultaneous evolution and amplification of monkey and rRNA genes. These data would indicate that the retroelement entered the Musa genomes prior to separation of M. acuminata and M. balbisiana.

In addition to the analysis of chromosome structure, attention has been paid to the development of other approaches that will be useful in the attempts to link genetic and physical maps of the genome. An integrated genome map would be useful for effective breeding as well as for isolation of genes of interest by map-based cloning. An essential step in the development of the integrated map is the accumulation of sufficient numbers of cytogenetic markers across the Musa genome. A partial TaqI genomic library has been constructed for diploid clone “Pisang Mas” (ITC 0653) and screened for repetitive DNA sequences. Candidate clones were characterised with respect to their size, genomic organisation (tandem – dispersed) and their abundance. The work is in progress to study the distribution of these clones on Musa chromosomes. A novel protocol for isolation of high-molecular-weight DNA in Musa has been developed (Simková et al. 1999). Preliminary results indicated that the quality of DNA obtained according to this protocol was significantly higher compared to the traditionally used protocols. The work is in progress to construct a genomic BAC library. The library will be used to select clones containing low amount of repetitive DNA sequences as well as clones containing molecular markers. These clones will be physically mapped to chromosomes using FISH and serve as physical landmarks.

Acknowledgements

We thank Ir. I. Van den houwe, Musa curator of the INIBAP Transit Centre at the Katholieke Universiteit, Leuven (Belgium) for the supply of plant material. We are grateful to Mr. R. Tusková and Ms. J. Weiserová for excellent technical assistance. This work was undertaken as a part of the Global Programme for Musa Improvement (PROMUSA) and was supported by the Research Contract No. 8145/RB from the International Atomic Energy Agency, Vienna.

References


Chimerism in Musa spp.

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The genetic improvement of bananas and plantains (Musa spp. L.) using biotechnological approaches, such as in vitro mutagenesis (Novak 1992) and genetic transformation (May et al. 1995, Sagi et al. 1995) of multicellular meristems leads to a high degree of chimerism. Usually, repeated vegetative propagation must be carried out to dissociate chimeras but detailed studies as to the number of cycles required (e.g. three) (Van Harten et al. 1998) has yet to be verified. In general, mutated cells are difficult to monitor, however mutations which result in a change in genome number may be an exception in this respect since they can easily be induced by colchicine treatment. Monitoring chimerism dissociation requires a rapid and precise method for ploidy screening at the early stage of plant development. Various phenotypic traits including stoma size, stomata density and pollen size are unsuitable for large-scale selection because screening for cytochimeras and polyploids by these indicators is slow and unreliable (Adniya and Aridjan 1994, Van Duren et al. 1996, van den Hout et al. 1995). While ploidy estimation can be done by chromosome counting, this is difficult in Musa due to the small size of its chromosomes (Osui et al. 1996, Dolezel et al. 1998), flow cytometric analysis of nuclear DNA content is being increasingly used for large-scale ploidy screening (Dolezel 1998) and this has already been established in Musa spp. (Dolezel et al. 1994, Dolezel et al. 1997).

To monitor chimerism dissociation assessed by three propagation systems (shoot-tip culture, multi-apexing culture and corn slide culture), ploidy chimerism (mixoploidy) was first induced by colchicine treatment of shoot-tips and chimera dissociation was monitored by flow cytometry.

The results showed that when using shoot-tip culture, during three subcultures just after colchicine treatment, the average percentage of cytochimeras was reduced from 100% to 36%, and from 100% to 24% when propagating by the corn slide culture technique; whereas the multi-apexing technique allowed a reduction of the average percentage of cytochimeras from 100% to 7% after the same number of subcultures. Nevertheless, none of the systems led to complete elimination of chimerism. The general concept of chimerism was reviewed and factors that may influence chimera dissociation in vitro were discussed in the presentation at the third FAO/IAEA Research Coordination meeting on cellular biology and biotechnology including mutation techniques for creation of useful banana genotypes.

Acknowledgements

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References


Van Duren M., R. Morpurgo, J. Dolezel & R. Afza. 1996. Induction and verification of autotetraploids in diploid banana (Musa
Factors enhancing in vitro production of haploids plants in anthers and isolated microspores of *Musa* spp.

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Bananas and plantains provide a staple food for nearly 400 million people. However the sustainable production of this crop is threatened by increasing disease pressure (Horry 1992).

Pollen production in *Musa* has not been well studied in the past and re-search in this area is rare.

Studies of pollen viability, germination rates and ploidy levels have been carried out on nine diploid *Musa* clones Malaccensis pahang (AA), Malaccensis cici (AA), Malaccensis annan (AA), Bocadillo (AA), Pisang Mas (AA), Pisang Lillian (AA), Tugia (AA), Peciolos oscuros (AA) and Tani (BB). Three of these diploids gave promising results for regeneration via somatic embryogenesis from pollen grains and anther cultures.

In this study, inflorescences of nine diploid clones of approximately 10-11 months old were collected from the CORPOICA nursery fields in Armenia, Quindio, Colombia. The purpose of the study was to investigate the physiological conditions related to the length of inflorescence, age and quantity of pollen produced (Perea Dallos 1998). Three clones were selected based on the quantity of pollen produced: Malaccensis pahang, Tani and Pisang Lillian. Anther cultures were established from these clones. It was determined that hormone levels of 1-3 mg/l of 2,4D, in combination with 0.5mg of kinetin gave the best results for somatic embryogenesis. The addition of 1-3 mg/l of 6-BAP resulted in shoot initiation from the somatic em-bryos.

References

Microsatellite markers for genome analysis in *Musa* and *Mycosphaerella*

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A number of locus-specific microsatellites, also called simple sequence repeat (SSR) or sequence-tagged microsatellite site (STMS) markers have been developed for *Musa* genome analysis and *Mycosphaerella* typing using a new SSR enrichment method. SSR markers derived from *M. acuminata* spp. malaccen-sis detected polymorphisms also in other representatives of Eumusa as well as Rhodochlamys (n=11), Australimusa (n=10), Callimusa (n=10), and even in Ensete (n=9). Levels of expected and observed heterozygocity were highest in diploid *M. acuminata*. Variations among triploid plantains (AAB) was low. Chloro-plast SSRs excluded all investigated *M. balbisiana* accessions as female ances-tors of African plantains. *M. acuminata* spp. *banksii* is the most like “A donor” and *M. balbisiana* type Honduras the most likely “B donor” of African plantains. In order to quantify the genetic diversity of the black leaf streak pathogen *Mycosphaerella fijiensis*, SSR markers have been used to investigate hierarchi-cally sampled isolates from Nigeria and Mexico. Allel numbers varied from 2-7 per locus. Each isolate was charac-terised by a unique haplotype. All SSR markers tested so far turned out to be species-specific. Future applications of SSR markers in both the host plant and the pathogen will include genomic mapping and linkage analysis of Sigatoka from the height of tissue cultured plants. The suckers of the above selected plants were proliferated in vitro up to M3V8 and plants regenerated were grown subsequently in the field. Flower initiation was observed at the sixth month in 85% of the regenerated plants. The suckers of the second gen-eration (first ratoon) were also proliferated in vitro (M3V8) to test the second ratoon (third generation).
and Fusarium resistance genes as well as fungal avirulence genes.

The use of AFLP and MSAP techniques for the detection of polymorphisms in plants micropropagated from inflorescence and sucker explants of *Musa* AAA cv. 'Grand Naine'

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Recently the DNA fingerprinting technique of amplified fragment length polymorphism (AFLP) has been successfully used to detect differences in polymorphisms between normal and dwarf off-types of *ex vitro* banana plants (Engelborghs et al. 1998). By using isoschizomeric restriction enzymes with differing sensitivity to DNA methylation, this technique has been now been adapted for the detection of changes in DNA methylation and has been given the acronym of MSAP for methylation sensitive amplified polymorphism (Xiong et al. 1999). We report here the use of AFLP and MSAP for the detection of polymorphisms in micropropagated plants of *Musa* Grand Naine, regenerated from male inflorescence and sucker explants.

Our preliminary results for AFLP, using 10 combinations of primers to analyse 30 regenerants (15 sucker-derived and 15 inflorescence-derived) from one mother plant, indicates that there are more polymorphisms among the regenerants derived from the male inflorescence (63.6%) than those of the sucker-derived regenerants (39.6%). These results may be indicative of a more indirect pathway of organogenesis for inflorescence-derived plantlets than that of sucker-derived.

Our results to date with the same family of regenerants using MSAP with 8 combinations of primers gave 101 methylation events out of a total of 543 bands. This gives 18.6% and is in a similar range to the 16.3% reported in the rice genome by Xiong et al. (1999). Only seven DNA methylation polymorphisms were found (four combinations of primers gave rise to the seven polymorphisms) and there was no significant difference between sucker and inflorescence - derived plants. However two primer combinations indicated some distinct differences between the methylation patterns observable in plants propagated conventionally by 'bits' and those of the same clone propagated *in vitro*.

In our future work we intend to analyse the mother explant DNA from 10 clones and the regenerants from another mother plant. In respect to the further application of the MSAP technique, we aim to re-examine the *ex vitro* plants and a larger population of conventionally-propagated individuals, to determine whether some DNA methylation polymorphisms are intrinsic to the micropropagation technique or are a product of developmental regulation. It has not yet been established whether the increased number of polymorphisms in the inflorescence derived regenerants will have any significance at the level of the phenotype and therefore to complete this analysis we will evaluate the phenotypes in the field.

References


Morphological and molecular characterization of genetic variation in induced mutants of Philippine banana cultivars


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This report describes the most recent results of our efforts to (1) generate useful mutants of Philippine banana cultivars ‘Lakatan’ (AAA) and ‘Latundan’ (AAB) and (2) to evaluate the usefulness of DNA markers to characterize the variation observed in the mutant populations. Three populations of advanced generation (M,V) radiation induced mutants of ‘Lakatan’ and ‘Latundan’ were taken out from culture and subsequently established in the field. Morphological characterization of each clone was carried out using the IPGRI descriptors for banana (IPGRI-INIBAP/CIRAD 1996). Occurrence of banana bunchy top virus (BBTV) infection was also monitored and disease rating was conducted based on symptomatology. Morphological off-types and desirable clones were selected from each population and further characterized using non-radioactive (Promega 1996) microsatellite (Kaemmer et al. 1997) and amplified fragment length polymorphism (AFLP) (Vos & al. 1995) analyses.

Morphological variants were observed for almost all of the traits measured. However, only a small proportion of variant phenotypes was observed in each population; the highest proportion was observed in populations irradiated with 3 Gy fast neutron (LK-3 and LT-3) than with 40 Gy gamma ray. Irradiation using 40 Gy gamma ray and 3 Gy fast neutron did not result in substantial variation in morphological traits in both Latundan and Lakatan cultivars. No BBTV resistant clone was obtained. Nonetheless, morphologically desirable, promising clones (e.g. large fruit size) have been selected from the irradiated materials. Further testing of the next generation clones will be undertaken to determine the genetic stability of the selected clones.

Nine *Musa* SSR primers received from University of Frankfurt were tested using 10 representative samples of 'off-type' and 'typical' phenotypes from each irradiated population plus two non-irradiated clones of Lakatan and Latundan. Five SSR primer pairs (STMS-1, -7, -9, -10, AGMI-93) were able to differentiate the Lakatan from the Latundan clones. However, none of the primers tested was able to discriminate among the irradiated clones within Lakatan or Latundan populations. AFLP and silver stain protocols were optimized using 10 AFLP primer pairs (+3/+3) with five selected clones. A total of 301 AFLP bands were produced from the 10 primer pairs with a mean polymorphism level of 51.14%. Like SSRs, each of the 10 AFLP primer pairs used was able to differentiate easily the Lakatan from the Latundan clones. Moreover, two of the AFLP primer pairs tested were able to differentiate two desirable mutant clones from other Lakatan clones and the non-irradiated Lakatan clones.
tional SSR and AFLP primers need to be tested to find more discriminating markers and possibly to establish correlation between specific markers and traits, these results may have potential implication for identification of mutant strains.

References
IPGRI-INIBAP/CIRAD. 1996. Descriptors for Banana (Musa spp.). IPGRI, Rome, Italy; INIBAP, Monpeller, France/CIRAD, Monpeller, France.


Selection for banana resistance to black leaf streak disease
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This programme aims at filling the understanding of the different factors dealing with the role of Mycosphaerella fijiensis toxins in the black leaf streak (BLS) disease development and with the mechanisms of action of these metabolites to allow their successful implementation for selecting banana genotypes resistant to BLS.

Cultivars Grande Naine, susceptible to M. fijiensis infection, and Fougamou, resistant to M. fijiensis infection, served as reference cultivars. A set of bioassays (induction of necrosis on banana leaves, electrolyte leakage assay and measurement of the chlorophyll fluorescence) were initially developed to document stress effects of ethyl acetate crude extract (EaCE) from culture filtrates of M. fijiensis (Harelimana et al. 1997). All these assays exhibited EaCE light-dependent toxicity on banana cultivars as well as a correlation between the susceptibility to EaCE and the sensitivity to M. fijiensis infection. Moreover, swelling of the chloroplasts was the first cellular abnormality observed with electron microscopy in the Grande Naine EaCE-treated leaves.

During the last two years, our works aimed at (1) identifying the toxic metabolites found in the EaCE, (2) analysing the correlation between susceptibility to purified metabolites and sensitivity to the pathogen infection and (3) understanding the mechanisms of action of the M. fijiensis toxic metabolites.

Fractionation of the EaCE, performed by column chromatography methods, revealed the existence of four main fractions with similar biological activities based on chlorophyll fluorescence as well as on necrosis induction. The toxicity of these purified fractions was light-dependent. The sensitivity of the reference cultivars to these fractions was correlated with susceptibility to M. fijiensis infection (the cultivar Grande Naine being more susceptible to the purified fractions than the cultivar Fougamou). The fraction containing juglone (fraction A) exhibited the highest toxicity and this metabolite was detected in the crude extracts of four M. fijiensis strains. These observations led us to pursue more detailed analysis with juglone only. Globally, injection tests with juglone (and EaCE) on the set of banana cultivars worked in the frame of the Co-ordinated Research Programme gave rise to a similar ranking as the sensitivity to M. fijiensis infection.

On the basis of electron microscopy data and the light-dependent toxicity of the four toxic fractions and crude extracts, we suspected chloroplasts to be a target site of these toxins. We therefore developed a bioassay using isolated chloroplasts.

Banana chloroplasts were isolated by the mechanical disruption method of leaf tissues (Leegood and Malkin 1986). The functioning ability of isolated chloroplasts, assessed by the Hill reaction [based on electron exchange performed by lighted chloroplasts according to the equation “H2O + A → AH2 + 1/2 O2”], where A represents an electron acceptor such as 2,6-dichlorophenoindophenol (Allen and Holmes 1986)], confirmed the integrity of the isolated chloroplasts obtained with our protocol.

Juglone activity on isolated chloroplasts was assessed by adding this compound to a Grande Naine functioning chloroplast suspension followed by an evaluation of their electron exchange ability in comparison to a control. The quantity of reduced DCPIP was smaller in chloroplast suspension treated with juglone than in the control, demonstrating a direct toxic effect of juglone on banana isolated chloroplasts.

Comparison between the susceptible cultivar (Grande Naine) and the resistant one (Fougamou) was performed with their respective isolated chloroplasts. The decrease of chloroplasts functioning ability due to juglone addition was greater for Grande Naine than for Fougamou. These preliminary results showed that the toxic effect of juglone on isolated chloroplasts is higher for the cultivar Grande Naine than for the cultivar Fougamou. The ranking of our banana reference cultivars for their sensitivity to juglone at the entire plant level seems to be similar to that observed with tests on isolated chloroplasts.

References


Genetic improvement of Musa spp. by in vitro mutational plant breeding
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Bananas and plantains (Musa spp.) are major tropical food crops for millions of people in developing countries, like our country where they are important components in the diet. In Cuba, they occupy about 46,000 ha and bananas take
of results obtained in an early pilot experiment. 2000 vitroplants were irradiated and these plants were evaluated in field conditions.

Refinement of propagation techniques for some genotypes (AAB) to be irradiated ‘CEMSA 3/4’ clone was established in vitro to develop somatic embryogenesis using MS medium (1962) supplemented with the following hormonal concentrations: BAP/IAA (0/0, 5/0, 10/0, 0/3, 5/3, 10/3, 0/5, 5/5, 10/5, 0/7, 5/7 and 10/7 µM).

The somatic embryogenesis was developed in two stages: ‘Zanzibar’ and ‘Navolean’ genotypes were studied within the collaborating project IAEA/BADC/FAO/KUL/INIBAP and later, studies ended at INIVIT where other genotypes (‘Montanas de Baracoa’ and ‘CEMSA 3/4’) were included and are nowadays in evolution.

Results obtained
From plants selected previously from irradiated clones (‘Parecido al Rey’, ‘Gran Enano’ and ‘Burro CEMSA’), a possible mutant from ‘Parecido al Rey’ clone will be studied.

Nine promising plants from ‘SH 3436-L-9’ with a shorter stature were selected and they will be evaluated in the next cycle.

In vitro establishment was obtained with meristematic shoot-tip at BAP and IAA (5/5µM) concentrations reducing considerably the phenolic oxidation.

Finally, production of somatic embryos was feasible and new perspectives exist for genetic improvement at medium and large term by mutation induction and transgenesis.

Development of aseptic culture systems of Radopholus similis for in vitro host-pathogen studies

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Among nematodes parasitising bananas throughout the world, Radopholus similis (Cobb) Thorne, the burrowing nematode, is one of the most damaging causing severe yield losses in commercial as well as local consumption cultivars (Sarah et al. 1996). Chemical control with nematicides is currently the most used method although it is dangerous, toxic and expensive. Therefore nematode control through genetic improvement is widely encouraged. Until now many Musa cultivars were screened looking for possible sources of resistance against this root pathogen. This screening research is time consuming as it is carried out under field or greenhouse conditions mainly (Pinochet 1988, Price 1994). In vitro screening could facilitate and speed up the process. In addition to screen the existing Musa cultivars and the improved hybrids from the breeding programs, natural plant resistance genes could be evaluated using Arabidopsis thaliana Lineaus as a model system.

The objective of this study was to establish an aseptic culture system for R. similis and to determine whether R. similis, reared on the callus tissue, could infect and reproduce on in vitro banana plantlets and in vitro A. thaliana.

In a first part of this research a suitable in vitro culturing system was developed for R. similis. The most common used technique for culturing R. similis are carrot discs (O’Bannon and Taylor 1968). Although reproduction is very high, this culturing system makes in vitro studies difficult as it is easily contaminated, since the nematodes feed on carrot tissue that has only been surface sterilized. Reproduction on carrot callus, as an alternative, was lower, but the nematodes were free of bacteria and fungi. However, when R. similis populations reared on carrot callus were inoculated in the greenhouse, the reproductive fitness and pathogenicity was very low. As a second alternative alfalfa callus was used for culturing aseptic R. similis populations. This culturing system had the same advantages as carrot callus. In addition, after testing in the greenhouse reproductive fitness and pathogenicity was confirmed. The R. similis population reared on alfalfa callus could reproduce and cause necrotic lesions in the roots of the susceptible cultivar Grande Naine, being not significantly different from a population reared on carrot disc.

In a second part of this research, the reproduction of the sterile R. similis on in vitro Musa was studied. The in vitro ‘Grande Naine’ was a good host: the population increased 126-fold in eight weeks. The nematodes were able to penetrate and reproduce in the roots.
Lesions were observed in the root cortex. In a third part, the reproduction of \textit{R. similis} on \textit{in vitro} \textit{A. thaliana} was studied. \textit{Radopholus similis} could successfully penetrate and develop in \textit{A. thaliana} under monoxenic conditions: 10 weeks after inoculation the population reached 975 individuals. The recovery of 367 females and the presence of males indicated that the life cycle was completed. All verimorphic developmental stages were observed in the roots and the medium prior extraction.

In conclusion, \textit{in vitro} alfalfa callus is a good aseptic culturing system, which can produce sufficient sterile \textit{R. similis} on a more continuous base compared to carrot discs. The nematodes cultured on the callus tissue can infect and reproduce in \textit{in vitro} banana plantlets and \textit{in vitro} \textit{A. thaliana}. This opens new perspectives for rapid \textit{in vitro} screening. Still the use of these systems for screening for resistance to \textit{R. similis} needs to be confirmed in the future.

References


Côte F.X., R. Domergue, S. Monmarson & C. Teisson. 1998. Cryopreservation of \textit{Musa} cell suspensions at an early stage as they can get contaminated very quickly, loose their morphogenic potential with time and are prone to somaclonal variation. The first data on somaclonal variation among suspension-derived plants are now available (Côte \textit{et al.} 1998).

References


Bottlenecks in the generation and maintenance of morphogenic banana cell suspensions and plant regeneration via somatic embryogenesis therefrom


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During the last decade, \textit{Mus}a embryogenic cell suspensions were successfully initiated from callus (Dhed’a \textit{et al.} 1991, Dheda’a 1992, Schoofs 1997, Schoofs \textit{et al.} 1998) and (fe)male flowers (Escalant \textit{et al.} 1994, Côte \textit{et al.} 1996, Grapin 1995, Grapin \textit{et al.} 1996, 1998) of many genotypes and landraces. The initiation of a banana suspension takes 9 to 26 months depending on the type of explant and landrace. Low embryogenic responses hamper the optimization of the induction and early initiation steps. Only 1 out of 2 to 1 out of 5 good embryogenic calluses result in a “good” i.e. highly regenerable and transformation-competent suspension. Clearly, their initiation is still far from routine. The main problem related to the use of callus is the need for a prolonged culture in the presence of very high BA concentrations and its possible effect on the ploidy level. Flow cytometry analysis provides a very powerful tool to quickly determine the ploidy level of starting material and suspensions. This is important, as the initiation of suspensions is so time and labour consuming. Also of prime importance is the cryopreservation (Panis \textit{et al.} 1990, 1992) of cell suspensions at an early stage as they can get contaminated very quickly, loose their morphogenic potential with time and are prone to somaclonal variation. The first data on somaclonal variation among suspension-derived plants are now available (Côte \textit{et al.} 1998).

References
