First Global Conference of the International *Musa* Testing Program

First Meeting of the *Musa* Breeders’ Network

Honduras, 27 April-3 May 1994
INFOMUSA

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To avoid missing issues of INFOMUSA, notify the editorial office at least six weeks in advance of a change of address. The general objective of INIBAP is to improve the productivity of smallholders who grow banana and plantain mainly for domestic consumption. However, the wellbeing of those smallholders whose livelihood is derived from growing dessert bananas and plantains for export is also an INIBAP concern. INIBAP's specific objectives are:

- to initiate, encourage, support, conduct and coordinate research aimed at improving the production of banana and plantain;
- to strengthen regional and national programs concerned with improved and disease-free banana and plantain genetic material;
- to facilitate the interchange of healthy germplasm and assist in the establishment and analysis of regional and global trials of new and improved cultivars;
- to promote the gathering and exchange of documentation and information; and
- to support training for researchers and technicians.

INIBAP is an institution supported by the Consultative Group for International Agricultural Research (CGIAR) and comes under the governance of the International Plant Genetic Resources Institute (IPGRI).

Views expressed in articles are those of the authors and do not necessarily reflect those of INIBAP.

INFOMUSA

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INFOMUSA needs you!

INFOMUSA is your magazine as it is the principal information exchange medium of the world 'banana community'. The editors would like more papers, articles and news items of interest in publish in future issues and would also like to hear your comments and suggestions on how INFOMUSA can be improved. Please send your letters, manuscripts, etc. to the address indicated above.

Cover photo: Ines Van den bouwe, Officer-in-Charge of the INIBAP Transit Center tissue culture collection at the Katholieke Universiteit Leuven, poses between banana bunches of Kluii Teparot (ABBB) left and Pitogo (ABB) right on a visit to FHIA's Musa breeding facilities during the IMTP Global Conference sponsored by UNDP. (Photo: David Jones, INIBAP)
First Global Conference of the International *Musa* Testing Program (IMTP)

Report by David Jones,
INIBAP, Montpellier, France

Introduction

IMTP is a link between the world’s *Musa* breeding programs and NARS. It provides a mechanism for new hybrids with good agronomic qualities to be screened against important *Musa* diseases at key locations around the world where pathogen diversity is known to occur. Germplasm which is found to be sufficiently resistant is then released for further evaluation at a local level. The ultimate aim of IMTP is to ensure that improved, healthy *Musa* germplasm becomes available to smallholders in as short a time after development as possible. IMTP is coordinated by INIBAP and sponsored by UNDP.

IMTP Phase I

In IMTP Phase I, 7 new banana and plantain hybrids from the FHIA breeding program were evaluated for resistance to black Sigatoka (*Mycosphaerella fijiensis*) at six sites in Latin America and Africa. Of the 7 hybrids, 3 were released and recommended for further distribution and evaluation because of their high resistance to the disease. To date, INIBAP has

Photos: Nicolás Mateo and David Jones, INIBAP.

Participants of the IMTP Global Conference outside the FHIA Conference Center. (Above)

Ken Shepherd (EMBRAPA-CNPMF, Brazil) advises Ramiro Jaramillo (INIBAP-LACNET) while Aristoteles Pires de Matos (EMBRAPA-CNPMF, Brazil) looks on during a visit to FHIA’s banana breeding plots. (Left)

Chinwe Diké (UNDP, New York) and Paleta Nai (Ministry of Agriculture, Tonga) in FHIA’s banana breeding plots. (Right)
distributed the germplasm, designated FHIA-01, FHIA-02 and FHIA-03, to 23 countries. FHIA-01 is a dessert banana with an apple flavour and is resistant to Fusarium wilt as well as black Sigatoka. It also has many favourable post harvest characteristics which make it suitable for an export industry. FHIA-02 is another black Sigatoka resistant dessert banana, but it has been reported susceptible to Fusarium wilt and the fruit do not have as long a green life as FHIA-01. FHIA-03 is a robust, disease resistant cooking banana which has great potential in many parts of the world including Africa.

**IMTP Phase II**

In this project, 5 hybrids and 1 somaclonal variant from 4 breeding programs (FHIA, EMBRAPA-CNPMF, TBRI and INIVIT/INIFAT) will be evaluated at 11 sites around the world including the Pacific for reaction to both yellow and black Sigatoka. A further 6 hybrids and 3 somaclonal variants from 4 breeding programs (FHIA, EMBRAPA-CNPMF, TBRI and INIVIT/INIFAT) will be tested at 14 sites for reaction to Fusarium wilt.

IMTP Phase II is gathering momentum and a Global Conference for all collaborators was held at FHIA, Honduras on 27-30 April, 1994. Representatives from all the countries where the germplasm is to be evaluated were present. In addition, key speakers on Musa disease and breeding issues were invited to participate.

At the Conference, the technical guidelines for the field evaluation of Sigatoka and Fusarium wilt diseases were finalized and a Steering Committee appointed to oversee the program. An encouraging item of information to emerge was that all the NARS/Institutes participating in IMTP Phase II strongly believe that IMTP has much relevance for their national research programs and, consequently, the majority of NARS are prepared to finance IMTP test sites at their own expense. Germplasm to be evaluated is expected to be dispatched by air to collaborators from the INIBAP Transit Centre at KU Leuven beginning in October 1994.

As well as the evaluation of germplasm, IMTP is to also encompass germplasm collecting in countries where the conservation of Musa species and cultivars is thought essential. Funds are also available to develop rapid, early screening methodologies that will enable hybrids, somaclonal variants and genetically engineered clones to be tested for their reaction to serious pathogens in the glasshouse or laboratory. Training of collaborating scientists is seen as an important component of IMTP Phase II and breeders will also have the opportunity to visit IMTP trial sites to view their material in the field in different regions.

**Future publication**

The proceedings of the Conference are to be published by INIBAP and will contain papers with the latest information on (a) Sigatoka and Fusarium wilt diseases (the two target pathogen groups for IMTP Phase II), (b) FHIA, EMBRAPA-CNPMF, IITA, CIMMYT, CRBP and TNAU conventional breeding programs (c) the IAEA, TBRI, QDRI South African and Malaysian mutation breeding programs and (d) the virus diseases of Musa and the safe movement of Musa germplasm.

*Phil Rowe explains FHIA's breeding strategies during a visit to the Musa breeding facilities.*
Global

First meeting of the Musa breeders’ network

Report by David Jones, INIBAP, Montpellier, France

Introduction
The inaugural meeting of the members of the Musa Breeders’ Network was held at the headquarters of the Fundación Hondureña de Investigación Agrícola (FHIA), Honduras on 2-3 May 1994. Those present at the meeting are listed in Table 1.

In an introductory talk, Dr Nicolás Mateo, Director of INIBAP outlined the theory and practice of the Musa Consortium. He highlighted the differences he perceived between a consortium, which was a formal grouping that had budgetary controls over its members, and a network, which was a looser alliance that did not make or impose binding conditions. Dr Mateo also included the possibility that Musa breeders may not see the need for an alliance at all, but hoped that this was not the case as it was believed that all the programs would benefit from the closer links.

Dr David Jones, Scientific Research Coordinator of INIBAP, presented a paper which identified the different categories of Musa in need of improvement and the desirable characteristics that needed to be incorporated into these different types. A summary of his talk is presented as Table 2.

Following Dr Jones overview of breeding needs, a more detailed analysis of the major breeding issues associated with different Musa types was presented by representatives of the breeding programs involved in their improvement.

East African highland cooking and beer banana (AAA) group
Dr Dirk Vuylsteke led discussions on the East African Highland cultivar group. Farmer surveys in Uganda had revealed that Fusarium wilt was a major concern and was becoming increasingly important in areas over 1400 m. ITA intended to begin work to improve highland cultivars in the near future and proposed crossing fertile highland clones with improved diploids. However, fertile cultivars needed to be identified. Mr Ken Shepherd said that most highland cultivars were mutations from common stock with very low fertility, but there were other cultivars not in this group which should be assessed. It was possible, he continued, that the lack of fertility may significantly limit progress. Dr Phil Rowe thought that people in the region ate highland cultivars because there was nothing else available. He believed that new hybrids being developed had superior taste and could replace traditional cultivars.

Plantains (AAB)
Discussions on plantain improvement were led by Dr Rodomiro Ortiz who first outlined the main production constraints in West Africa. The number one factor limiting production was yield decline and it was possible that this could be tackled by breeding to improve root systems. Black Sigatoka (Mycosphaerella fijiensis) was the next most important factor, but hybrids were now available with resistance and this is not now a top priority with ITA. Other issues, in order of priority, were suckering ability, wind damage in coastal areas and fruit quality (in relation to local consumer preference). Dr Ortiz then outlined the desirable characteristics of the ideal plantain (Table 3). Dr Christophe Jenny followed by explaining that the plantain program of CRBP aimed to improve pest and disease resistance related to sustainable agriculture. Improved diploids were being used as a pollen source in crosses with fertile plantains. Progeny were to be screened against black Sigatoka, yellow Sigatoka (M. musicola), Radopholus similis, Pratylenchus goodeyi and weevil borer (Cosmopolites sordidus).

Photo: Members of the Musa Breeders’ Network who attended the first meeting at FHIA, Honduras on 2-3 May 1994.
Dr Phil Rowe said the emphasis at FHIA was breeding plantain for resistance to black Sigatoka and he was multiplying dwarf French plantain for use in crosses. Dr Rowe emphasized that Maqueno (Maia maoli type) had many good qualities and an ideal cooking plantain type might be a hybrid between this clone and a true plantain.

Mr Hugues Tezenas du Montcel said that CIRAD-FLHOR’s main emphasis was to produce a plantain that had resistance to Sigatoka diseases, weevil borer, nematodes and viruses. Conventional crosses between diploids and plantain to produce tetraploid hybrids was the method being used initially. However, biotechnological methods such as protoplast fusion were envisaged for the future.

Much discussion was generated by the talks outlined above. Dr Sylvio Belalcázar thought that plantains should also be bred for salinity and drought tolerance. Dr Eugene Ostmak, following extensive research, believed that nematodes were the main pest problem on plantain in Latin America and that weevil borers were not important. However, as was pointed out by other participants, this may not be the case in Africa and Asia. Dr Ching-Yan Tang thought that somaclonal variant selection of plantain may solve problems associated with plant height, cycle time and disease resistance, but Dr Ortiz argued that this type of work would not be productive. The importance of information on the genetic origins of diploids used in crosses was deemed by Dr Jean-Pierre Horry to be very important in designing breeding strategies.

Most participants agreed that resistance to black Sigatoka and a good root system were the most desirable characteristics needed in a plantain. An improved root system would help fertility and reduce nematode and wind damage problems. Dr Ronny Swennen thought work on mycorrhizae could compliment breeding work and enhance the efficiency of root systems.

### Table 1. Members of the Musa Breeders’ Network - First meeting at FHIA on 2-3 May 1994

<table>
<thead>
<tr>
<th>Members who attended</th>
<th>Organization</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dr Rownak Afza</td>
<td>International Atomic Energy Agency/Food and Agricultural Organization (IAEA/FAO), Austria</td>
</tr>
<tr>
<td>Dr Jean-Vincent Escalant</td>
<td>Centro Agronómico Tropical de Investigación y Enseñanza (CATIE), Costa Rica</td>
</tr>
<tr>
<td>Dr Jean-Pierre Horry</td>
<td>Centre de Coopération International en Recherche Agronomique pour le Développement - Département de Productions Fruitières et Horticoles (CIRAD-FLHOR), Guadeloupe FWI</td>
</tr>
<tr>
<td>Ir Ramiro Jaramillo</td>
<td>International Network for the Improvement of Banana and Plantain (INIBAP), Costa Rica</td>
</tr>
<tr>
<td>Dr Christophe Jenny</td>
<td>Centre Régional Bananiers et Plantains (CRBP), Cameroon</td>
</tr>
<tr>
<td>Dr David Jones</td>
<td>International Network for the Improvement of Banana and Plantain (INIBAP), France</td>
</tr>
<tr>
<td>Dr Niculás Mateo</td>
<td>International Network for the Improvement of Banana and Plantain (INIBAP), France</td>
</tr>
<tr>
<td>Dr Rodomiro Ortiz</td>
<td>International Institute of Tropical Agriculture (ITA), Nigeria</td>
</tr>
<tr>
<td>Dr Juan Pérez Ponce</td>
<td>Instituto Biotecnología de las Plantas (IBP), Cuba</td>
</tr>
<tr>
<td>Ms Claudine Picq</td>
<td>International Network for the Improvement of Banana and Plantain (INIBAP), France</td>
</tr>
<tr>
<td>Dr Franklin Rosales</td>
<td>Fundación Hondureña de Investigación Agrícola (FHIA), Honduras</td>
</tr>
<tr>
<td>Dr Nicolas Roux</td>
<td>International Atomic Energy Agency/Food and Agricultural Organization (IAEA/FAO), Austria</td>
</tr>
<tr>
<td>Dr Phil Rowe</td>
<td>Fundación Hondureña de Investigación Agrícola (FHIA), Honduras</td>
</tr>
<tr>
<td>Mr Ken Shepherd</td>
<td>Empresa Brasileira de Pesquisa Agropecuária - Centro Nacional de Pesquisa de Mandioca e Fruticultura (EMBRAPA-CNPMF), Brazil</td>
</tr>
<tr>
<td>Dr Sebastiao de Oliveira e Silva</td>
<td>Empresa Brasileira de Pesquisa Agropecuária - Centro Nacional de Pesquisa de Mandioca e Fruticultura (EMBRAPA-CNPMF), Brazil</td>
</tr>
<tr>
<td>Dr Ronny Swennen</td>
<td>Katholieke Universiteit Leuven (KUL), Belgium</td>
</tr>
<tr>
<td>Dr Ching-Yan Tang</td>
<td>Taiwan Banana Research Institute (TBR), Taiwan</td>
</tr>
<tr>
<td>Mr Hugues Tezenas du Montcel</td>
<td>Centre de Coopération International en Recherche Agronomique pour le Développement - Département de Productions Fruitières et Horticoles (CIRAD-FLHOR), France</td>
</tr>
<tr>
<td>Dr Ramon Valmayor</td>
<td>International Network for the Improvement of Banana and Plantain (INIBAP), Philippines</td>
</tr>
<tr>
<td>Dr Dirk Vuylsteke</td>
<td>International Institute of Tropical Agriculture (ITA), Uganda</td>
</tr>
</tbody>
</table>

**Observers**

- Dr Sylvio Belalcázar
- Dr Eric Fourné
- Dr Masa Iwanaga
- Ms Siti Hawa Jamalluddin
- Dr Eugene Ostmak

**Members who were unable to attend**

- Dr Charles Arntzen
- Dr Reynold Gonsalves
- Dr Somasundaram Sathiamoorthy

**Administrative support**

- Ms Lissette Vega

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1 Genetic Engineer  
2 Conventional Breeder  
3 Mutation Breeder

resistance to both Sigatoka diseases and Silk, which was fairly resistant to yellow Sigatoka, should ideally have resistance to black Sigatoka. Resistance to nematodes and weevil borer was not considered a high priority by Mr Shepherd.

Agronomic characters needed to be improved as most cultivars were tall with relatively small bunches and small fruit. Priorities were to develop hybrids with a lower stature, increased numbers of hands (except Mysore), higher numbers of fruits/hands (except Mysore) and an increased fruit size.

Although conventional breeding was possible with Pome, Silk has no useful
Table 2. Improvement of Musa - INIBAP’s perception of needs

<table>
<thead>
<tr>
<th>Musa Type</th>
<th>Region</th>
<th>Desirable traits needed (small stature is ideal trait for all)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plantain (AAB)</td>
<td>West Africa, Latin America,</td>
<td>BLS/BS resistance at low altitude</td>
</tr>
<tr>
<td></td>
<td>Southeast Asia, South Asia (India)</td>
<td>S/Y resistance at high altitude</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Nematode resistance</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Weevil borer resistance</td>
</tr>
<tr>
<td>Silk (AAB)</td>
<td>Latin America (Brazil),</td>
<td>Fusarium wilt resistance</td>
</tr>
<tr>
<td></td>
<td>South Asia (India), Southeast Asia</td>
<td>BLS/BS resistance</td>
</tr>
<tr>
<td>Pome (AAB)</td>
<td>Latin America (Brazil),</td>
<td>Fusarium wilt resistance</td>
</tr>
<tr>
<td></td>
<td>South Asia (India), Australia</td>
<td>BLS/BS resistance</td>
</tr>
<tr>
<td></td>
<td></td>
<td>S/Y resistance</td>
</tr>
<tr>
<td>East African Highland (AAA)</td>
<td>East Africa</td>
<td>Nematode resistance</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Weevil borer resistance</td>
</tr>
<tr>
<td></td>
<td></td>
<td>BLS/BS resistance</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Fusarium wilt resistance</td>
</tr>
<tr>
<td>Pisang Awak (ABB)</td>
<td>Asia and East Africa</td>
<td>Fusarium wilt resistance</td>
</tr>
<tr>
<td>Bluggoe (ABB)</td>
<td>Worldwide in marginal zones</td>
<td>Fusarium wilt resistance</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Nematode resistance</td>
</tr>
<tr>
<td>Maia maoli/Popoulu (ABB)</td>
<td>Pacific (also has potential elsewhere as a plantain replacement)</td>
<td>BLS/BS resistance</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Fusarium wilt resistance</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Nematode resistance</td>
</tr>
<tr>
<td>Cavendish/Gross Michel (AAA)</td>
<td>Asia, Pacific, Latin America, Africa</td>
<td>BLS/BS resistance</td>
</tr>
<tr>
<td></td>
<td></td>
<td>S/Y resistance</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Nematode resistance</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Weevil borer resistance</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Virus resistance</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Delayed ripening (for export)</td>
</tr>
<tr>
<td>Miscellaneous dessert</td>
<td>Southeast Asia, South Asia (India),</td>
<td>BLS/BS resistance</td>
</tr>
<tr>
<td>types such as Pisang mas (AA)</td>
<td>East Africa and Pacific</td>
<td>S/Y resistance</td>
</tr>
<tr>
<td>Ney poovan (AB) and</td>
<td></td>
<td>Nematode resistance</td>
</tr>
<tr>
<td>Pisang berangan (AAA)</td>
<td></td>
<td>Weevil borer resistance</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Fusarium wilt resistance</td>
</tr>
</tbody>
</table>

Key

1. Small stature can be obtained by using a dwarf mother cultivar in conventional breeding or by mutation/somaclonal induced variants.
2. Mono/oligogenic (vertical) resistance may be acceptable in polyclonal production systems, but polygenic (horizontal) resistance may be more durable in monoclonal production systems. Ideally, both types should be incorporated into the genome. Resistances from different sources should be utilized to increase diversity of resistance mechanisms in breeding programs. Conventional breeding may be sufficient.
3. Resistance to *Radopholus similis*, which is spread by Cavendish, has been identified in Pisang jari buaya. More research needs to be undertaken to identify other sources of resistance to *R. similis* and resistance to *Pratylenchus* spp. *P. goodiei* is important over 1,000 m in tropical Africa. Improvement by transformation is a possibility.
4. Little is known about sources of resistance to weevil borer. Mechanical resistance in corn tissue may be important. All available BT toxins should be screened to see if any are effective. Gene(s) coding for effective toxin(s) could be inserted into the *Musa* genome.
5. The pathogenic variability of *Fusarium oxysporum* f. sp. *cubense* needs to be considered. Natural sources of resistance/tolerance exist in wild species, cultivars and synthetic diploids. Conventional breeding may be sufficient.
6. Not much work has been undertaken to screen *Musa* for resistance to virus diseases, but evidence to date suggests most germplasm is susceptible to most viruses so conventional breeding may be of little use. Resistance may be possible through the insertion of genes for virus coat proteins or replicate inhibition into the *Musa* genome.
7. Ripening may be delayed by genetic engineering with gene(s) that code for antisense polycatclorotranses and inhibition of ethylene production.

Table 3. Characteristics of the ideal plantain for West Africa (IITA)

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yield potential</td>
<td>&gt;25 MT ha⁻¹ year</td>
</tr>
<tr>
<td>Plant height</td>
<td>&lt;3 m</td>
</tr>
<tr>
<td>Time to flowering</td>
<td>210-240 days</td>
</tr>
<tr>
<td>Fruit filling time</td>
<td>90-120 days</td>
</tr>
<tr>
<td>Production cycle time</td>
<td>365 days</td>
</tr>
<tr>
<td>Bunch weight</td>
<td>&gt;15 kg</td>
</tr>
<tr>
<td>Number of hands</td>
<td>6-8 bunch</td>
</tr>
<tr>
<td>Number of fingers</td>
<td>75-100 bunch</td>
</tr>
<tr>
<td>Average fruit weight</td>
<td>150-200 g</td>
</tr>
<tr>
<td>Suckering behavior</td>
<td>Follower should be 75% height of mother plant at harvest</td>
</tr>
<tr>
<td>Root system</td>
<td>Vigorous</td>
</tr>
<tr>
<td>Bunch characteristic</td>
<td>Pendulous</td>
</tr>
<tr>
<td>Fruit characteristics</td>
<td>No seeds</td>
</tr>
<tr>
<td></td>
<td>Parthenocarpic development</td>
</tr>
<tr>
<td></td>
<td>&gt;33% of dry matter</td>
</tr>
<tr>
<td></td>
<td>&gt;8 days from harvest to ripe</td>
</tr>
<tr>
<td></td>
<td>&gt;1.5 pulp/peel ratio</td>
</tr>
<tr>
<td></td>
<td>Taste suitable for West African palates</td>
</tr>
<tr>
<td>Disease resistance</td>
<td>Black leaf streak/black</td>
</tr>
<tr>
<td></td>
<td>Sigatoka</td>
</tr>
<tr>
<td></td>
<td>Fusarium wilt</td>
</tr>
<tr>
<td>Pest resistance</td>
<td>Nematode</td>
</tr>
<tr>
<td></td>
<td>Weevil borer</td>
</tr>
<tr>
<td>Abiotic stress factors</td>
<td>Drought tolerance</td>
</tr>
</tbody>
</table>

identify and collect resistant germplasm in the Amazon basin was suggested. Some diploids such as Dorado and Manam had been reported resistant in Honduras. Mr Shepherd also believed more work was needed on *in vitro* fertilization. Pollen tubes often failed to reach ovules and this problem needed to be investigated.

Maia maoli/Popoulu group (ABB)

In Guadeloupe, Mr Tezenas du Montcel said CIRAD-FLHOR were trying to improve the Maia maoli/ Popoulu group of Pacific cooking banana by conventional breeding involving crosses between triploids and diploids to get tetraploids. Maia maoli accessions were found to produce seed, but not Popoulu accessions. Two Maia maoli accessions were routinely used as female parents in Guadeloupe. The main problem with the group was its susceptibility to Fusarium wilt, but this disease was not found in the Pacific where the vast majority of cultivars were grown. Dr Rowe added that Maqueno, the Latin American Maia maoli cultivar used in breeding at FHIA, was slow to ratoon, but could perhaps be cultivated as an annual crop. However, he had produced two hybrids that were fast to ratoon and it was possible these tetraploids could be used in crosses with diploids to produce triploids. The fruit of this type of banana could be used as a substitute for plantain.
Dr Ramon Valmayor urged that measures be taken in the near future to collect, characterize and conserve cultivars in the Maia maoli/Popou group. Banana bunchy top disease was quite widespread in the Pacific and was a threat to this unique germplasm. However, collecting could be undertaken on islands where this disease did not occur. Mr Tezenas du Montcel informed members that collections could be found in Tonga, Fiji, Vanuatu, New Caledonia and elsewhere at the moment and it was important that these collections remain well maintained in the future. He said that Dr Vincent Lebot had studied accessions in several collections in Hawaii and also cultivars growing in French Polynesia (Lebot et al., 1994), but cultivars on islands in Western Polynesia islands needed study.

Cooking banana types (ABB/BBB)
Dr Ortiz notified members that IITA had developed two tetraploids designated BITA I (Bluggoe x Calcutta 4) and BITA II (Pisang awak x Musa balbisiana). Both were resistant to black Sigatoka and Fusarium wilt. Dr Valmayor stated that Saba and Cardaba were resistant to pests and diseases, were drought tolerant and could grow in poor soil conditions. However, they were tall and were long cycling. Fast cycling, dwarf types were needed. Dr Rowe said that FHIA were working in the area of ABB/BBB cooking banana improvement following the scheme below:

3n × 2n → 4n
4n × 2n → 3n (secondary triploid)
3n × 2n → 4n (secondary tetraploid)

Dwarf diploids were being used as pollen sources.

Mr Shepherd pointed out that Bluggoe produced much seed with a 20-25% germination rate. However, the vast majority of progeny had abnormal chromosome numbers when crosses were made with Musa acuminate pollen. This was less pronounced when Musa balbisiana pollen was used. He also said that an analysis of chromosome numbers of Pisang awak accessions at EMBRAPA-CNPMP had shown that all this germplasm had 34 and not 33 chromosomes. Two types of Pisang awak were known to exist and the one known as Pisang awak legor was very female fertile with a high frequency of seeds. The dwarf Pisang awak (Kluai Namwa Khom) was not fertile. Mr Shepherd continued by saying that the suitability of Bluggoe to Moko disease was an important issue. Pelipita, which was used as a replacement for Bluggoe in Latin America because its persistent bracts prevented insect borne infections, was not liked and it was necessary to find an acceptable replacement. It was thought that Brazil and Colombia could cooperate in tests to screen germplasm for Moko resistance.

Cavendish/Gros Michel group (AAA)
Dr Rowe began by saying that the original goal of FHIA was to breed a disease resistant Cavendish type. However, the Cavendish group itself is infertile and breeding began using Highgate, which is a smaller Gros Michel type. Later work utilized Lowgate, which was smaller that Highgate and gave progeny the same height as Grande Naine. Unfortunately, Lowgate gave fewer seeds than Highgate and its bunch qualities were also inferior to Highgate. Consequently, crosses would have to be made with agronomically superior improved diploids. He believed that the disease resistant hybrids developed from dwarf Prata could replace Cavendish if the public accepted a fruit that had a more acidic taste.

Dr Tang followed by explaining that somaclonal variant work at TBRI had allowed the development of Cavendish that was resistant to Fusarium wilt race 4, had high bunch weight, was small in stature and quicker in cycling. He continued by saying that TBRI had no experience in selection for resistance to leaf diseases but he was exploring possibilities in this area. Haploid breeding was also being investigated.

Mr Tezenas du Montcel believed that conventional breeding approaches to improve Cavendish were not possible and unconventional methods must be employed. CIRAD-FLHOR's list of work priorities began with introducing genes for virus resistances into the Cavendish genome, followed by weevil borer resistance and then resistance to black Sigatoka.

Dr Ortiz enquired whether weevil borer resistance was important for Cavendish and Mr Tezenas du Montcel replied that weevil borer was a problem in this group in the Caribbean and Africa. There followed some discussion on whether the BT toxin gene was durable and the desirability of screening BT toxins for

---

**Table 4. Biotechnology to enhance Musa improvement (IITA)**

<table>
<thead>
<tr>
<th>Tissue Culture</th>
<th>Genetic Analysis</th>
<th>Genetic Engineering</th>
</tr>
</thead>
<tbody>
<tr>
<td>Protoplast fusion protocols</td>
<td>DNA fingerprinting</td>
<td>Embryogenic cell suspension protocols</td>
</tr>
<tr>
<td>Rapid in vitro multiplication protocols</td>
<td>Mapping &amp; genetic analysis</td>
<td>Transformation technologies</td>
</tr>
<tr>
<td>Somaclonal variation studies</td>
<td>- Taxonomy</td>
<td>Transgenic plants</td>
</tr>
<tr>
<td>In vitro germination of seeds</td>
<td>- Mapping QTLS</td>
<td></td>
</tr>
<tr>
<td>Embryo rescue technologies</td>
<td>- Maternal inheritance</td>
<td></td>
</tr>
<tr>
<td>Virus diagnostics &amp; elimination</td>
<td>- Chromosomal rearrangements</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Cytological studies</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Marker assisted selection</td>
<td></td>
</tr>
</tbody>
</table>

---

**Table 5. Possible contributions of collaborators in a nematode project**

<table>
<thead>
<tr>
<th>Organization</th>
<th>Technical expertise</th>
<th>Personnel available</th>
</tr>
</thead>
<tbody>
<tr>
<td>CRBP</td>
<td>Field screening for Radopholus similis and Pratylenchus goodeyi resistance</td>
<td>One (1) Nematologist One (1) Breeder</td>
</tr>
<tr>
<td>CIRAD</td>
<td>Early screening for resistance to Radopholus similis</td>
<td></td>
</tr>
<tr>
<td>FHIA</td>
<td>Diagnostic capabilities Biotechnological methods</td>
<td>One (1) Nematologist</td>
</tr>
<tr>
<td></td>
<td>Screening capabilities</td>
<td>Sources of resistance for Radopholus similis (Pisang jari, banyu) Segregating populations for genetic analysis</td>
</tr>
<tr>
<td>IFTA</td>
<td>Diagnostic capabilities</td>
<td>One (1) Nematologist</td>
</tr>
<tr>
<td></td>
<td>Screening capabilities</td>
<td>One (1) PhD student</td>
</tr>
<tr>
<td>CATIE</td>
<td>Segregating progeny for genetic analysis</td>
<td></td>
</tr>
<tr>
<td>IBP</td>
<td>Regeneration techniques</td>
<td>One (1) Biotechnologist</td>
</tr>
<tr>
<td>IAEA</td>
<td>Transformation work</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Propagation</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Evaluation</td>
<td></td>
</tr>
<tr>
<td>QDP/NSWDA*</td>
<td>Mutation breeding</td>
<td>Uncommitted</td>
</tr>
<tr>
<td></td>
<td>Molecular and host range studies</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Distribution and yield loss in Southeast Asia</td>
<td>Unknown</td>
</tr>
<tr>
<td>NRT*</td>
<td>Screening to find sources of resistance to Pratylenchus goodeyi and P. coffeae</td>
<td>Unknown</td>
</tr>
<tr>
<td>Rothamsted*</td>
<td>Pathogenicity of Radopholus similis</td>
<td>Unknown</td>
</tr>
<tr>
<td></td>
<td>Molecular basis of resistance</td>
<td></td>
</tr>
<tr>
<td>IIP*</td>
<td>Radopholus similis collection</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Taxonomy</td>
<td>Unknown</td>
</tr>
</tbody>
</table>

* Representatives of these organizations were not present, but their interest in nematode work was reported by members
resistance. Dr Ortiz thought it important to incorporate resistance to banana bunchy top virus in the Cavendish genome and wondered if others were being considered by CIRAD-FLHOR. He was told that cucumber mosaic virus was a big problem, especially when material derived from tissue cultures was used as planting material. Work to engineer resistance to this virus was being contemplated.

The discussion continued with Mr Shepherd stating that post-harvest problems with hybrids derived from Highgate made them unsuitable for most export markets. He wondered if crosses of dwarf diploids onto Gros Michel had ever been considered. Dr Rowe answered that no dwarf diploids have been produced with qualities good enough to use in crosses with Gros Michel. He went on to say that the large transnational companies had been able to ignore new hybrids for many years because leaf spot could be controlled chemically. However, if fungicide resistance problems increased in the future, it may be impossible to control black Sigatoka by chemical means and hybrids with genetic resistance would have to be grown. Mr Shepherd concluded by saying that he believed that the export companies would find a way to market the tetraploids if Cavendish could not be grown.

Biotechnology

Dr Swennen opened by outlining KUL's plans for Musa improvement. This involved improving cell suspension and protoplast regeneration techniques and transformation work. Genetic engineering research was aimed at inserting genes into the Musa genome that would confer resistance to fungal diseases, but work was envisaged on virus, nematode and weevil borers resistance in the near future.

Dr Jean-Vincent Escalant then talked on CATIE's collaboration with the conventional breeding programs of CIRAD-FLHOR (Guadeloupe), CRBP and FHIA. Work involved helping produce homozygous diploids and haploid plants and studies related to transformation technologies such as somatic embryogenesis. IAEA/FAO's intentions were described by Dr Rownak Afza. She explained that close cooperation with Dr Charles Arntzen's group at Texas A & M University was a key element in plans to further develop transformation technology based on the particle gun and Agrobacterium mediated methods. Mutation breeding and DNA fingerprinting to detect somaclonal variants was also proposed.

All biotechnologists agreed that Musa genomic libraries were essential to locate important genes that could be later isolated and engineered into genotypes lacking these traits. CIRAD in Montpellier in France had probably done more in this area than any other group. However, there was agreement that groups needed to collaborate closely in this work as it was beyond the capacity of any one team to accomplish all that was necessary.

Dr Escalant then asked the conventional breeders if they needed biotechnologists and, if so, what should they try to accomplish. Dr Ortiz's reply is summarized in Table 4. Dr Vuylsteke added that genes needed to be inserted into parental lines that could then be used in conventional breeding. Mr Shepherd suggested that insertion into fertile diploids would be the ideal as this would be more stable than other backgrounds.

Dr Swennen believed that there were many options for engineering resistance to fungi. Genes were available that could code for different antifungal proteins with different modes of action. The best strategy for success may be to insert more than one of these genes into the Musa genome.

Consortium, network or status quo?

Dr Mateo reopened talks on the need to decide how the different breeding programs and biotechnology groups were going to interact in the future. The advantages and disadvantages of each option and the various ways collaborators could associate was discussed at length. In the consortium approach, which was the most formal option, programs and teams would be governed by a decision-making committee that would direct and coordinate breeding goals for the common good of Musa improvement. Members would need to abide by consortium decisions and contribute resources to a common pool. Funds would be needed to operate such an organization which were not available to INIBAP at the moment. It was explained that the CGIAR Task Force on Banana and Plantain thought that a consortium would be a vehicle to attract more funds from donors. Some members voiced the opinion that under this structure, programs not well endowed would not receive much when funds were subdivided. Most members thought that this more structured option may evolve with time and a more informal arrangement would be preferable initially. More liaison between breeders was now likely through IMTP and it was thought Network members should meet every year after the IMTP Global Conference. The majority of members wanted an informal Network based on working groups of breeders/biotechnologists with common interests to be coordinated by INIBAP.

Dr Mateo called for a list of issues/activities for collaboration/discussion. Suggestions included Musa genome mapping, transformation technologies, early screening of germplasm for disease resistance, safe movement of germplasm, characterization of germplasm, embryogenesis for mass propagation, mutation breeding, cryopreservation techniques, fruit quality, cytogenetics and training breeders in new biotechnologies. Dr Escalant thought that a small number of working groups should be established based on Musa types in need of improvement. Working groups were envisaged on:

1. AAB Cooking Bananas (Plantain, Maia maoli/Popopouli),
2. AAB Dessert Bananas (Silk, Pome, Mysore),
3. AAA/ABB/BBB Cooking Bananas (East African Highland types, Pisang awak, Bluggoe, Saba),
4. AAA/AAD Dessert Bananas (Cavendish, Gros Michel, edible diploids).

First collaborative project

As a preliminary step towards developing closer ties, members were asked to discuss possible ways they could collaborate. Areas of interest and expertise were identified. Mr Tezenas du Montcel suggested that members should formulate a joint project through INIBAP that would appeal to donors. Dr Vuylsteke nominated nematode resistance as the subject. Members then indicated how they could contribute to such a project. Their response is summarized in Table 5.

The meeting closed with Dr Mateo confirming INIBAP's willingness to coordinate the activities of the Musa Breeders' Network and to liaise with groups to formulate a proposal on improving the nematode resistance of plantains for submission to donors. There would also be an endeavor to coordinate activities of those interested in mapping the Musa genome.

Future publication

At the meeting, the major breeding programs submitted papers outlining their perceived breeding goals. These papers will be published as a separate document by INIBAP in the near future.

Reference

History and Methods of Banana Breeding

Kenneth Shepherd

Early interest in banana breeding was undoubtedly triggered by Fusarium wilt. Although this was first recorded at the beginning of the century, it did not make immediate catastrophic inroads into the large-scale growing for export of the Gros Michel cultivar in Central America and Jamaica. This banana type is now known not to be the most susceptible to the original pathogen. However, before many years had passed, the economic severity of the disease was to be felt all the more because of the very large scale of planting. Added to this, it was soon clear that the pathogen could survive for long periods in infected soil. Banana growing became shifting cultivation.

First thoughts of breeding go back to the late 1920s and early 1930s and arose in three centers: with the United Fruit Company in Honduras, with the newly inaugurated and UK-funded Imperial College of Tropical Agriculture (ICTA) in Trinidad, and with the Department of Agriculture in Jamaica.

The commercial company was sufficiently alarmed to form a germplasm collection which included some introductions from Asia. Thereafter, United Fruit’s concern soon weakened and died, for reasons not on the public record.

At ICTA and in Jamaica, centers which collaborated practically from the start, work continued in pursuit of a Gros Michel resistant to Fusarium. Both programs formed collections and shared more interesting acquisitions, such as (Pisang) Lilin (also known as Lidil) which came to ICTA in 1932. Various former post-graduate students, scattered throughout the tropics, and national Departments of Agriculture contributed germplasm, via intermediate quarantine at the Royal Botanic Gardens, Kew, where this service was available into the 1960s.

There were some cytological studies in Jamaica in the initial phase, but it was ICTA that adopted the taxonomy, cytology and cytogentic of Musa spp. and cultivars as a major research area. Critical findings were that the relevant basic haploid chromosome number is 11, and that Gros Michel and many other cultivars are triploids with 33, while some other cultivars and the nearest wild relatives are diploids with 22. A vital discovery, first published in the 1930s, was that when a diploid’s pollen (11 chromosomes) was used in crosses on female flowers of Gros Michel, the result was a low or very low incidence of seeds that could yield tetraploid hybrids, with 44 chromosomes. The morphology of these made it clear that the hybrids each possessed the whole chromosome and gene complement of the triploid and could inherit Fusarium resistance through the extra chromosomes of the pollen. A pathway was opened for breeding, but not for all triploids. Clones of the Cavendish sweet banana type were almost invariably seedless, although one hybrid has now been bred in Honduras.

Few tetraploid hybrids of Gros Michel were ever generated at ICTA, for want of land space, and this function became Jamaica’s, while ICTA persevered with more strategic studies. The division of labor was incorporated in 1947 in a Banana Research Scheme, sponsored by the UK but also supported by the then British Cameroons and by the Jamaican All-Island Banana Growers’ Association (AIBGA). Additionally, ICTA started to seek the genetic improvement of diploids, by crossing and selection, on the new universal and logical principle that, with a genetically fixed female parental contribution, the success of hybrids must depend totally on the positive genetic qualities transmitted by the pollen.

The diploids on hand were of limited appeal, mainly related wild forms, but germplasm exploration had been delayed by war and

Ken Shepherd honored

Ken Shepherd, advisor to EMBRAPA-CNPMF (Bahia State, Brazil) on Musa germplasm and breeding, was honored at the IMTP Global Conference in Honduras in April 1994 for his contribution to the science of Musa. Of British nationality, Ken graduated with first Class Honors in Agriculture/Botany from the University of Durham, England in 1947. He worked as a cytogeneticist in the Banana Research Schemes of Trinidad and Jamaica from 1950 to 1964. From 1964 to 1980, he was Director of the banana breeding program in Jamaica. Since December 1981, Ken has worked in Brazil installing a Musa germplasm collection and setting up a breeding program that he still assists. In over 40 years with the same crop, he has made contributions not only to cyrognetics and breeding, but also to taxonomy including co-authorship of the authoritative paper on Musa cultivar classification according to genome composition. A plaque of appreciation was presented to Ken by Nicolas Mateo and Ramiro Jaramillo (NIBAP) on behalf of the world Musa community. (Photo: FHIA)
by the unsettled political situation of postwar Asia. Trips were made to East Africa in 1948 and, finally, to the Pacific area and Southeast Asia in 1954-55. The stocks that reached Trinidad were not great in quantity but, at the end of the 1950s, a few very useful diploids had entered into the process of achieving improvement of pollen parents. At that time also, resistance to yellow Sigatoka was becoming a second major objective, while Jamaica was already making the change from Gros Michel to Fusarium-resistant forms of Cavendish bananas, albeit with nostalgia. Happily, the breeding program was still regarded as an insurance for the future.

By 1960, advantages had been seen in the union of all breeding and allied research in Jamaica, where a Banana Board had come into being with a small but effective research department. The newly named Banana Breeding Research Scheme soon gained autonomy within the Banana Board, partly because of its international funding. The Cameroon participation ceased but new partners entered, so that the scheme was funded by the UK, Jamaica and Trinidad governments, by the AIBGA and by the Windward Islands Banana Growers’ Association (WINBAN). The island group was only then developing banana exports.

The effect of better diploids made an almost immediate impact, in the conversion of the fixed female parent from Gros Michel to its semi-dwarf mutant Highgate and in more promising hybrids. However, the Scheme in Jamaica was short-lived on a banana breeding time scale. In early 1973, WINBAN was obliged to withdraw because of economic stresses and a change in UK policy replaced core budget financing with project aid. Hybrid production virtually ceased, but remaining resources allowed the continued evaluation of already existing ones with the aid of three British scientists on projects. As a sort of swan song, one of the best products of the program was among the last seeds recovered from Highgate.

A new program was mounted by United Fruit in Honduras at the end of the 1950s with a massive collecting effort in Asia, the major contribution to the germplasm now in place there today. As a novelty, the offshore island of Utila was used as an intermediate quarantine site. The motivation for this change of Company policy can be at least guessed at, that fresh land for Gros Michel or its mutants was running out. If this was the reason, then the time left for breeding a resistant cultivar was already too short. The conversion to Cavendish occurred in the middle 1960s.

The scientific community can be thankful that the company was then forward-looking enough to maintain the program when many other Musa research projects were closed. With the switch of varieties there was a lack of intense pressure to produce commercial hybrids so that, for 20 years and more, the breeders, or chiefly one, concentrated on diploid improvement, the results of which are now spectacularly apparent.

Other major events in the history of this program were the appearance and rapid spread of black Sigatoka in Central America, the takeover of United Fruit by United Brands, the latter’s withdrawal from banana growing in Honduras and the Company’s remarkable generosity in donating all the program’s land, facilities and accumulated plant material to the recently founded Fundación Hondureña de Investigación Agrícola (FHIA). With an additional breeder and a revived incentive to produce disease-resistant tetraploid hybrids of plantains and various other banana types, the prestige of FHIA has been enhanced by the quality of the first products. Using the advanced diploids available, some of them have striking resistance to black Sigatoka.

Apart from efforts on a minute scale, in India if not elsewhere, the programs described so far were the only two up to 1980. Brazil launched a program in 1982 when a collection of effective germplasm began to be assembled. After early exploratory crosses, this work has settled down to a primary task of producing tetraploid hybrids from Pome (Prata) forms, since these are very much the most planted bananas in the country today. The breeding philosophy has followed that which evolved in Jamaica, of using tetraploids as a measure of advances in diploid parents and accumulating progressive gains in the former. Prata itself has poor agronomic traits so that these gains should come easily. The immediate resistance objectives are to yellow Sigatoka and to Fusarium wilt, with black Sigatoka testing on the scale that an EMBRAPA/CATIE/INIBAP convention permits. This disease is not yet recorded in Brazil.

Even more recently, CIRAD-IRFA (now CIRAD-FLHOR) started banana genetic research in Guadeloupe, and now apparently Cameroon, based both on traditional and biotechnological methods.

IITA planted its first tetraploid hybrids of plantains and other cooking types at Onne, Nigeria, in 1989, but the IITA diploid parents available did not offer great hopes for the quality of the first products.

To conclude on conventional breeding methods, it should be conceded that there has been a difference of opinion over the strategy of how to use primary tetraploids. Should breeders test them directly as potential cultivars or use them chiefly as parents in tetraploid x diploid combinations in the production of “secondary” triploids?

The main arguments against tetraploids as potential cultivars are of weak leaf petioles, which is not usually a conspicuous defect, and of a theoretical possibility of spontaneous seed setting not possible in triploids; but this too does not seem to occur in practice, or at least when no male-fertile diploid is near.

The case for primary tetraploid production is that a small-to-moderate scale of pollination can give sufficient progeny for useful selection, permitting a relatively cost-effective breeding program. Also, the similarity of the hybrids to their already popular triploid parents could facilitate acceptance by farmers and consumers. A good secondary triploid, by contrast, would be a totally novel combination.

In any case, for now and for the immediate future, the very great majority of hybrid candidates, for global testing and possible adoption as cultivars, will likely be primary tetraploids.

Many years of raising and evaluating tetraploid hybrids of Gros Michel and its mutants did not yield a single new cultivar in commercial production. This has been a cause of criticism of the method but there are unusual reasons for this failure. Bananas for export require special physiological characteristics: of remaining firm and green during ocean transit, at reduced temperatures, and of easily controlled ripening speed on arrival. When ripened, the fruit must not break away easily from its stalk. It was in these requirements that the best-looking hybrids failed, not in their agronomic performance, nor in the disease resistances for which they were selected.

From this evidence, the new tetraploid hybrids now being produced have every chance of succeeding where they may be replacing cultivars of similar type and usage. The best future situation will call for not only a diversity of cultivar types among the hybrids but also genetic variability within types, as a cushion against new or variant pathogens.

This paper was developed in 1992 as a part of the CGIAR External Program and Management Review of INIBAP.
Growing Plantain at High Densities

S. Belalcázar, M. I. Arcila, J.A. Valencia, D.G. Cayon and G. Franco*

Introduction

In Colombia at present more than 400 000 hectares are under plantain cultivation, 280 600 of which are in the central coffee plantation zone. The production volume is 1.7 million tonnes per annum and the average yield 6 tonnes per hectare. These yields are considered low since it is possible to reach a level of 50 tonnes per hectare using new technologies.

The increase in population growth, together with rising food consumption, requires solutions which, while avoiding the destruction of the environment, contribute to greater productivity. Various possibilities include cropping systems with species combinations, intercropping or high density planting (Figure 1a & 1b).

High density planting of banana, cocoa and coffee, for instance, results in higher yields per area without the quality of the harvest being affected, which is to the advantage of the farmer whose plantation profits and income are improved (Franco and Vega, 1987; Israeli and Nameri, 1967; Marcelino and Quintero, 1987).

In the case of coffee, increases of 71 % over 5 harvest periods have been observed, for densities of 10 000 plants per hectare, compared to plantations of 2 500 plants per hectare (Uribe and Mestre, 1980 and 1988).

For cocoa, increases of 60 % have been noted, with 1 333 plants per hectare, compared to normal densities of 625 plants per hectare (Franco and Vega, 1987).

For plantain, Belalcázar et al. (1990) and Cardona et al. (1991) have observed production increases from 270 % to 345 % with densities of 3 000 and 5 000 plants per area. This effect has also been observed for coffee (Uribe and Mestre, 1980 and 1988) and for cocoa (Franco and Vega, 1987).

The findings which are presented here evaluate the effect of high density planting on the parameters of growth, development and production on a commercial scale. The work was carried out by ICA and by CORPOICA in co-operation with the Comité Departamental de Cafeteros del Quindío (Coffee Producers’ Departmental Committee), and supported by the International Development Research Centre (IDRC) of Canada and by the International Network for the Improvement of Banana and Plantain (INIBAP).

Figure 1a & 1b: High planting densities of Plantain results in optimal land use and higher yields per area without the quality of the harvest being affected.
Table 1: Effect of planting at 3 x 2m on growth and production factors.

<table>
<thead>
<tr>
<th>Corms/ha</th>
<th>Number of plants/ha</th>
<th>Height (m)</th>
<th>Circumference of the pseudostema (cm)</th>
<th>Duration of the vegetative cycle (months)</th>
<th>Average weight of bunch (kg)</th>
<th>Yields (tonne/ha)</th>
<th>% of plants harvested</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1 666</td>
<td>3.5</td>
<td>49</td>
<td>15.5</td>
<td>15.0</td>
<td>23.1</td>
<td>92.6</td>
</tr>
<tr>
<td>2</td>
<td>3 332</td>
<td>4.2</td>
<td>50</td>
<td>18.0</td>
<td>14.3</td>
<td>40.5</td>
<td>85.0</td>
</tr>
<tr>
<td>3</td>
<td>5 000</td>
<td>4.3</td>
<td>51</td>
<td>20.0</td>
<td>13.3</td>
<td>51.9</td>
<td>78.0</td>
</tr>
</tbody>
</table>

*a At one metre from the ground.


A new option

The high density technology generated for plantain constitutes a profitable alternative for the producer. Traditionally, the crop has been managed on a perennial basis, with different plantation layouts according to the agroecological zones and the producers' objectives. The new method requires treating the plant as an annual, since once the crop has been harvested the plantation is eliminated.

In studies carried out at a semi-commercial level, results obtained agree with those of previous research (Belalcázar et al., 1990): the increase in the number of plants per hectare has a direct influence on growth factors and on overall production, with an inverse effect on output per unit and on the percentage of plants harvested (Cardona et al., 1991).

The analysis of results shows that the increase in the length of the vegetative cycle is compensated for by higher yields. This, therefore, warrants the farmer waiting an extra 3 to 5 months with densities of 3 332 and 5 000 per hectare, rather than densities of 1 666 plants per hectare. (Table 1)

The same table shows that the reduction in yield is in inverse proportion to density increases. Generally speaking, this is due to pest attacks, diseases and abiotic factors such as storms, or to plants with growth problems. These plants are part of the "residual harvest" and it would be advisable to eliminate them, so as to prevent them competing with plants that are developing normally. However, their elimination is not recommended in plots where plantain is grown continuously.

In spite of the problem explained above, yields from high density farming, two to three plants per section, will still be greater and increases of 2 358 and 1 290 bunches per hectare may be observed for densities of 5 000 and 3 332 plants per hectare respectively, compared to normal densities. This implies additional yields of 28.8 and 17.4 tonnes per hectare for densities of 5 000 and 3 332 plants respectively, over yields from 1 666 plants per hectare.

Technological requirements

For this system to be efficient and profitable, the following recommendations should be put in place:

Corm size: This factor merits special consideration, since the success of the system depends on correct selection of corms. It is very important that the corms be of uniform weight and size.

According to Herrera et al. (1990), it is possible to use suckers of between 0.25 and 1.25 m in height which provide corms between 0.66 and 2.5 kg (Figure 2). Corms should be graded according to size when they are being prepared so as to form homogenous groups. This process makes for uniform growth and development and allows for staggered

Figure 2: The corm size merits special consideration since the success of the system depends on their correct selection.

Figure 3: The size of the hole is 30 to 40 cm in depth while the length and breadth depends on the size grade of the corm as well as on the number of plants intended for sowing in each site.
harvesting, i.e. the first plants to be harvested will be those whose combs were the largest, followed by those whose combs were smaller and so on.

Once the combs have been sorted, it is advisable to apply a preventive chemical treatment, consisting of insecticides and fungicides with an adherent, using a back pack sprayer. Combs should be sprayed thoroughly to ensure complete coverage.

**Hole size:** This should be 30 to 40 cm in depth, while the length and breadth will depend on the size grade of the comb as well as on the number of plants intended for sowing in each site. (Figure 3 p.13).

**Levelling:** Despite the use of graded combs, it has been observed that, among plants of each productive unit, one or two may present marked differences in size and thickness of the pseudostem, which are apparently due to the physiological age of the comb. In this case, it is necessary to resort to "levelling by pruning or cutting back" (Figure 4 , 5a & 5b). This consists of either partly or completely eliminating leaf growth, or completely cutting back the pseudostem of the most developed plant(s) to a minimum of 10 cm above ground level (or to a greater height according to the relative development of the plants to be cut back).

The best time for pruning is the moment when the plants have produced the fifth leaf, which in warm and temperate climates is about 1 to 1.5 months after the appearance of the first leaf. This principle is based on the fact that the first twelve leaves produced have no effect on growth and production factors (Belalcázar et al., 1990).

**Fertilization:** This should be undertaken after preliminary soil analysis. Experiments on soils in temperate climates have shown that fertilisers can be applied in three stages: 30 % after levelling, 50 % three to four months after planting (at the tenth to fifteen leaves stage) and 20 % at the 28 to 32 leaf stage.

**Irrigation:** This is a fundamental requirement for development, growth and productivity of the plant. In the high density system, plants must have sufficient water for their needs. Therefore, in zones where there may be rainfall deficiencies (levels below 1 800 mm per annum), it is necessary to consider installing an irrigation system to meet the needs of the plantation during periods of drought.

**Sanitary controls:** For the control of yellow Sigatoka (*Mycosphaerella musciola*) in coffee-producing zones, it is advisable to practise monthly defoliation of dead leaves, broken green leaves hanging down the pseudostem, and leaves with necrotic lesions covering more than a third of the surface (Merchán and Belalcázar, 1990). High density fields show a lesser incidence of the disease, which agrees with the findings of Israeli and Nameri (1967) and of Marcelino and Quintero (1987) in their studies of black Sigatoka (*M. fijiensis*) on banana and plantain. This factor could be related to the increase in length of the pathogen’s life cycle caused by environmental modifications, such as light and temperature, within the plantation.

**Advantages of the system:** The adoption of the high density system described above constitutes a profitable option for the farmer as it offers the following advantages:

1) Production increases of 125 to 224 %, according to the density of the population, and even greater when compared with traditional populations of 1 000 plant per hectare.
2) Greater ease of plantation planning in order to harvest at different times of the year and thus get a better market price.
3) Optimal land use, since plants hitherto spread over 3 to 5 ha now take up 1 ha only.
4) High production of good quality combs after harvesting, which reduces the cost of this factor for subsequent plantings.
5) Use of low weight combs (0.5 - 1 kilos), which brings about a reduction in installation costs between 60 and 21 % respectively (see Table 2).

6) Rational farming management from the point of view of environmental sustainability and conservation, by savings in the use of products for controlling pests, diseases and weeds. The use of fungicides for controlling yellow Sigatoka and black Sigatoka is considerably reduced.

7) The cost of weed control diminishes with the increase of population density, by 66.7 % and 72 % respectively for densities of 3 332 and 5 000 plants per hectare, when compared with a density of 1 666 plants per hectare.

**Economic efficiency**

Comparison of the rates of return on the investment (RRI) (see Table 3) shows that, for farmers who have to buy land, the best choice is a density of 5 000 plants per hectare, which produces an effective quarterly return of 4.85 % for the duration of the project. On the other hand, for farmers who already own the land, the optimal density would be 3 332 per hectare, with returns of 21.72 %.

**Figure 4:** "Leveling by cutting back" consisting of cutting back the most developed plant(s).

**References**


![Figure 5a](image1.png) "Levelling by pruning" consisting of pruning the plant by partial elimination of the foliage.

![Figure 5b](image2.png) "Levelling by cutting back".

**Table 2: Costs of management based on corm size up to the time of planting / Calculations based on 1,600 corms/ha.**

<table>
<thead>
<tr>
<th>Height of sucker (cm)</th>
<th>Weight of corm (kg)</th>
<th>Number of man days</th>
<th>Total cost ($)</th>
<th>Cost in relation to control (%)</th>
<th>Savings in relation to control (%)</th>
<th>Savings in pesos</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.25</td>
<td>0.66</td>
<td>9.5</td>
<td>11 395</td>
<td>39.8</td>
<td>60.2</td>
<td>17 193</td>
</tr>
<tr>
<td>0.50</td>
<td>1.00</td>
<td>10.2</td>
<td>12 195</td>
<td>42.6</td>
<td>57.4</td>
<td>16 393</td>
</tr>
<tr>
<td>0.75</td>
<td>1.66</td>
<td>10.8</td>
<td>12 994</td>
<td>45.4</td>
<td>54.6</td>
<td>15 594</td>
</tr>
<tr>
<td>1.00</td>
<td>2.13</td>
<td>13.8</td>
<td>16 593</td>
<td>58.0</td>
<td>42.0</td>
<td>11 995</td>
</tr>
<tr>
<td>1.25</td>
<td>2.54</td>
<td>14.8</td>
<td>17 702</td>
<td>62.2</td>
<td>37.8</td>
<td>10 796</td>
</tr>
<tr>
<td>1 leaf stage</td>
<td>3.25</td>
<td>16.2</td>
<td>19 392</td>
<td>67.8</td>
<td>32.2</td>
<td>9 196</td>
</tr>
<tr>
<td>5 leaf stage</td>
<td>4.13</td>
<td>18.5</td>
<td>22 391</td>
<td>78.3</td>
<td>21.7</td>
<td>6 197</td>
</tr>
<tr>
<td>10 leaf stage (control)</td>
<td>6.92</td>
<td>23.8</td>
<td>28 588</td>
<td>100.0</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>


**Table 3: Comparison of quarterly rates of return for three densities of planting. Plantain farming. El Cortijo farm. Quimbaya. 1990.**

<table>
<thead>
<tr>
<th>Density of population (plants/ha)</th>
<th>Duration of the project (months)</th>
<th>Rates of return on the investment (RRI) %</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Including the value of land</td>
</tr>
<tr>
<td>1,666</td>
<td>15</td>
<td>2.4</td>
</tr>
<tr>
<td>3,332</td>
<td>18</td>
<td>4.2</td>
</tr>
<tr>
<td>5,000</td>
<td>21</td>
<td>4.9</td>
</tr>
</tbody>
</table>
Middle East

Banana production in Egypt

Randy C. Ploetz*

Introduction

In June and July 1991, a survey was conducted of major banana-producing areas in Egypt. Plantations in the Kalubia, Dakahlia, New Lands, Menoufia, and Qena governorates were visited; together they accounted for about 65% of the area under banana production in Egypt. Management practices, and the most common diseases and cultural problems which were noted during the survey or communicated by the Ministry of Agriculture (Giza) are summarized below.

Background

Despite its arid climate and high latitude, Egypt is a significant banana producer. Banana is grown in a narrow band along the Nile, the Nile delta, and the New Lands areas (Fig. 1). Most fruit produced in Egypt is consumed locally. In 1981, only 66 tons, about 0.04% of the total estimated production that year, was exported (Anonymous). Production area more than quintupled from 1959 to 1988 (Fig. 2), and much of this increase occurred along the Upper Nile. In the Qena governorate alone, the area of cultivation increased from 950 to 9,300 feddans from 1975 to 1988 (one feddan = one acre).

In 1991, the Cavendish subgroup accounted for 95% of the bananas grown in Egypt. Cultivars grown were:
- Maghrabi and Williams (Giant Cavendish),
- Basrai (Cavendish), and
- Hindi, Indian, and Canary (Dwarf Cavendish).

Paradaiya or Balaliki (Pisang awak) and Pome were much less commonly grown. Paradaiya’s primary use was as a windbreak, but its fruit were also sold in local markets, albeit at 1/2 to 1/3 the price of Cavendish fruit. Although Simmonds (1966) mentioned the presence of French plantain and Mysore in Egypt, neither were noted during the survey.

Production

Soil along the Nile river and in its delta are alluval in origin and very fertile. They are primarily loams and are generally well-structured with a moderate pH (6.5-7.5) and good water-holding capacity. In contrast, soils in the New Lands are either sandy or calcareous, and usually have poor nutritional and water-holding attributes.

Although rhizomes are the most common propagation material used to establish new plantings, tissue culture-derived plantlets are beginning to be used with increasing frequency. Plantlets were recently available from only foreign sources (i.e., tissue culture labs in France and Israel). However, within the last three years, two commercial laboratories (PICO and El-Roda) began domestic production.

Planting densities and mat maintenance differ somewhat from those used in other production areas of the world. Initial densities are commonly 300 plants feddan⁻¹, but because 2-3 suckers are allowed to establish and are maintained in a mat, densities eventually reach those used elsewhere (i.e., 700-800 plants feddan⁻¹).

To avoid producing substandard fruit during the coldest months, production is focussed on an autumn to early winter harvest. Thus, the selection of the suckers which will eventually produce fruit in a given mat is of critical importance and requires considerable skill and knowledge of the crop and its cycling time. In general, the best production managers exhibited an impressive understanding of these management constraints.

Producers on the Nile’s alluvial soils and in the New Lands applied adequate or, in some cases, super-adequate levels of fertilizer. Ratios of N-P-K, were heavily skewed towards N-application (e.g. 8:1:2), reflecting the high native content of K in Egyptian soils. Other elements (usually Zn, Fe, Mg, and Mn) are applied by some, but not all farmers, often as foliar spray applications.

Two major types of irrigation were used: flood (in the Delta and in the Nile valley) and drip, (usually in the New Lands west and east of the Delta). Overhead irrigation is rare. Frequency and duration of irrigation events were determined by the water-holding capacity

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Figure 1. Location of primary banana-producing areas in Egypt.
of the soil and the time of year. In general, fields were either flooded every 10-14 days during the summer and less frequently during the winter, or were irrigated via drip for about an hour in the morning and an hour in the afternoon.

Fertilization occurred often in association with irrigation. For example, prior to every third or fourth flood irrigation, granular fertilizer was applied to the soil surface or soluble fertilizers were applied through drip-irrigation systems.

**Diseases**

Since relative humidity and rainfall (≤5 cm year⁻¹) are very low in Egypt, foliar diseases caused by fungi are rare. In total, few diseases of any sort were observed. The following are listed in descending order of importance.

**Banana bunchy top.** Banana bunchy top disease (BBTD) was first reported in Egypt in 1901 (Dale, 1987). During the survey, it was widespread in the Delta and along the Nile and, although it was not observed in the New Lands, it was assumed that the disease was also present in these areas. It was reported that affected plantations were destroyed in five or fewer years if appropriate control measures were not observed.

In the best plantations, weekly to biweekly surveys were made to identify symptomatic plants (Fig. 3). Many managers were skilled at recognizing the initial symptom of BBTD (discrete, green dashes along the petioles of newly emerging leaves), but there was confusion over the appropriate treatment of infected plants. Ideally, symptomatic plants and others in the same mat should be treated with an aphicide to kill the aphid vector (Pentalonia nigronervosa) of the virus that causes BBTD. Plants should then be removed from the field and burned. However, during the survey growers often felt that only symptomatic plants should be removed, or believed that aphicides alone would sufficiently control the disease. Although no epidemiological data from Egypt could be provided to prove or disprove these assumptions, it was apparent that the healthiest plantations were those which were most efficient in the identification, removal and destruction of infected plants.

**Infectious chlorosis.** Infectious chlorosis, or banana mosaic was widespread, but most prevalent in new plantations along the Nile. Although this disease is usually most conspicuous during the cooler months of the year, very severe leaf narrowing and distortion symptoms were noted during the survey on young plants in several plantations. Producers either confused these symptoms with those of BBTD or recognized them as infectious chlorosis and were not concerned. In the latter cases, the source of the causal agent, cucumber mosaic virus, was often known. Control of the broad-leaf weeds and cucurbitaceous hosts of this virus was rarely practiced in plantations.

**Pseudostem heart rot.** Infrequent cases of what appeared to be pseudostem heart rot, presumably caused by Fusarium monoliforme, were observed sporadically in new plantings. Death of the unfurling new leaf and a wet necrosis of the pseudo-

c
tem center was seen in replanted suckers. Rhizomes were unaffected, distinguishing the symptoms from those of Erwinia rhizome rot.

**Erwinia rhizome rot.** Also known as head rot, Erwinia rhizome rot was not observed, but was reported by producers in the New Lands south of Alexandria. Above-ground symptoms included yellowing or death of the plant and those below ground included significant decay of the rhizome which had a putrid, disagreeable odour. This is an unimportant disease in Egypt.

**Nematodes.** During the survey, several banana producers indicated that they used nematicides. However, neither these growers nor the professional staff with the Ministry of Agriculture could indicate what nematode species were being

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**Figure 2.** Total area in Egypt devoted to banana production from 1959 to 1988 (information from: Horticultural Research Institute, Department of Tropical Fruits, Giza, and Volunteers in Overseas Cooperative Assistance, Washington, D.C.).

**Figure 3.** Plantation manager (right) answering questions about identifying symptoms of banana bunchy top disease.
controlled and whether the use of nematicides was warranted.

Although the spiral nematode, Helicotylenchus multicinctus, has been reported from nearby Cyprus, Israel, and Tunisia, as well as from other subtropical production areas around the world, this nematode has not been reported in Egypt (McSorley and Parrado, 1986). Likewise, other nematodes which are more commonly found in tropical production areas, such as Radopholus similis and Pratylenchus spp., have not been reported from Egypt. Thus, the presence and importance of plant-parasitic nematodes on banana in Egypt is not clear.

Fusarium wilt (Panama disease). Although the Ministry of Agriculture had received reports of Fusarium wilt, the disease was not observed during the survey. A disease resembling Fusarium wilt was observed by Ministry of Agriculture plant pathologists in the Fayyum area. It was apparently caused by Fusarium moniliforme, not F. oxysporum, and its symptoms, which included the death of young suckers, were not consistent with those caused by Fusarium wilt.

Miscellaneous problems

Environmental stress. High winds cause physical damage and physiological stress in the New Lands. In these desert areas, wind blown sand abrades and tears leaves and unprotected leaf surfaces become desiccated. Wind damage is most severe during the winter, when freezing temperatures can also injure plants. Wind breaks are often utilized in the New Lands (Fig. 4).

Desiccation and heat stress occurs in the Qena governatorate where summer temperatures can approach 50°C. High sunlight and excessive evapotranspiration in this area can cause leaves to overheat, and patchy, necrotic and yellow areas were observed on exposed leaf surfaces in several plantations during the survey.

Loss of soil in the Nile basin. Although annual floods historically replenished soil along the banks of the Nile, this has not occurred beneath Lake Nasser since the completion of the Aswan dam. Thus, flood deposition of soil no longer occurs and erosion of previously deposited soil has now begun. Soil is also being lost due to its removal for brick making. This is an ancient activity that has recently increased to meet the demands of Egypt's increasing population (now over 60 million). Although removal of soil along the Nile is illegal, laws against this practice are seldom enforced.

In the long term, the combined effects of soil removal, erosion, and the absence of annual floods will make farming along the Nile increasingly difficult, if not impossible. In the short term, high water tables will impact an increasing number of banana-production areas. Banana does best in deep, well-drained soil and is quite sensitive to waterlogging (Stover and Simmonds, 1987). During the survey, water tables were already within 1m of the soil surface in some areas and growers had already noted a reduction in plant vigor and yield.

Floating. "Floating" was noted in several production areas. The syndrome is characterized by suckers in mats growing progressively higher in the soil until, three or four years after planting, most of the mats is on the soil surface. Plants are then quite vulnerable to "tip over", especially if they are bearing fruit. Floating often makes replanting necessary.

The cause of floating was not known. Since it was noted on calcareous and sandy soils under drip irrigation, as well as in alluvial soils that were flood irrigated, a common edaphic factor in the affected areas was not apparent.

Fruit prices. Cooperatives of banana producers did not exist in Egypt in 1991. However, Mr. Baby El-sin Hozaien, Deputy with the Ministry of Agriculture in Luxor, was attempting to start a banana cooperative in the Qena governorate. Its primary aim was to provide a strong, unified voice when the wholesale prices of fruit were determined. Prices varied in the Qena governorate from 300 to 1,200 Egyptian pounds per ton (ca. US$116 to 467). Much of this variation resulted not from fluctuations in retail prices, but from the bargaining ability of the wholesaler. The creation of cooperatives as marketing units and groups, through which fertilizers and other supplies could be purchased in quantity, were viewed as a good, future goal.

Conclusion

Considering the extreme environmental conditions that confront banana producers in Egypt, the quantity and quality of fruit that are produced was high. In general, production standards were high and the means by which certain production constraints, such as diseases, could be managed were known and well-executed. In short, banana growers have adapted well to this harsh, desert climate. However, continued production will rely on the availability of cheap water from the Nile and the conservation of alluvial soils along the Nile.

Acknowledgements

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West Africa

Banana and plantain pests in Cameroon

Roger Fogain*

Introduction

The staple foods in 7 of the 10 provinces of Cameroon include banana and plantain. They are cultivated throughout the southern part of the country. Production totals some 1,700,000 tonnes with 700,000 tonnes of dessert bananas and 1,000,000 tonnes of plantains. In parallel, dessert bananas have become the main export crop, having drawn ahead of cocoa and coffee. The large plantations are in the Mounigo and Fako departments and total about 5,000 hectares.

Banana and plantain are attacked by two main pest groups - insects and nematodes.

Insects

Banana weevil borer (Cosmopolitanes sordidus)

The banana borer is the most harmful insect for banana and plantain in Cameroon and causes serious damage (Lavabre, 1950; Vilardebo, 1960). The insect, whose apodous larval tunnel through rhizomes, is found in all bananas and plantain production areas in Cameroon (CRBP survey, 1993). The adult borer is some 1.1 to 1.5 cm long.

The banana borer is particularly harmful to plantain sub-group cultivars. Damage to Cavendish sub-cultivars does not seem to be as serious (Fogain and Price, 1993).

Two other weevils, Metamasius sericeus and Polytus mellebergi, are observed in Cameroon banana plantations, but the damage caused has not yet been defined. M. sericeus is a large brownish-black weevil. Adults are 1.0 to 1.1 cm long (excluding the rostrum) with a shoulder width of approximately 4 mm (Lavabre, 1950). It has been observed (CRBP survey, 1993) in the Mounigo and Fako regions and in the Nyombé germplasm collection.

M. sericeus and C. sordidus were reported by Lavabre (1950) as being the main banana pests. Clément (1944) reported that M. sericeus was to be found along the coast of West Africa where it was considered to be an insect of secondary importance.

P. mellebergi is another member of the Curculionidae family found in banana plantations in Cameroon. It is a small, black weevil about 5 mm long (including the rostrum) when adult. Farmers tend to confuse it with weevil storage pests. This weevil is reported in Cameroon for the first time (CRBP survey, 1993).

Weevils populations are currently well-controlled on commercial plantations by use of Croulane (Chlordecone), whose registration has unfortunately been withdrawn. Other insecticides with low persistence have been tested and can be used three times a year. No chemical spraying is carried out on smallholdings, which accounts for the strong pressure from weevils observed in these systems. Only paring and cutting of pseudostem are performed when the bunches have been cut. Breeding programs should in time develop plantain varieties tolerant to weevil attack which can be supplied to smallholders.

A local strain of Beauvaria bassiana has also been isolated (CRBP survey, 1993) from Metamasius sericeus in Cameroon and might prove to be of interest as a biological control agent.

Nematodes.

Nematodes are the other major pest on banana and plantain in Cameroon. The importance of individual species varies according to the ecological conditions and cropping systems.

Radopholus similis is dominant in the Mounigo and Fako industrial banana plantations where it can cause yield losses of over 50% in the third and fourth cycles. Populations vary considerably during the year and can reach 200,000 R. similis per 100 grams of root. This species is also dominant in the smallholdings near commercial plantations. R. similis does not appear to be present in highland banana zones. Gowen and Quéhérvé (1990) reported that R. similis was not observed in highland zones in East Africa.

Pratylenchus goodeyi is a nematode mainly found in zones with elevation of over 700 m. It was reported for the first time in Cameroon in 1989 (Bridge and Price, 1989). It is the main nematode on plantain on the slopes of Mount Cameroon (Buea), Koupe and Nlonako (Mbourou-Melon) and on the high plateaux in the west (Dschang, Djupitsa, Bafou, etc.). Sarah (1989) reported that P. goodeyi was the dominant species in highland areas in Africa. The damage caused by this migratory endoparasite is similar to that inflicted by R. similis.

Helicotylenchus multicinctus is present in all the banana production zones in Cameroon. Populations rarely exceed 2,500 specimens per 100 grams of root in commercial plantations. However, the density may exceed 50,000 specimens per 100 g in some smallholdings where the pest is dominant.

Root knot nematodes (Meloidogyne spp.) are observed almost everywhere but population levels are low. However, strong attacks have been observed on tissue cultured plants (Fogain, 1993). This type of plant material thus appears to be extremely sensitive to attack by Meloidogyne.

Hoplolaimus spp. are also found throughout the banana and plantain production zones in Cameroon. They are generally considered to be of secondary importance.

Nematode control on commercial banana plantations is undertaken using a combination of preventive and curative methods including cultivation techniques (fallow, cropping pattern, paring of cords) and chemical methods (nematicide application to cords before planting and to the soil during cultivation). This crop management program should in the future take into account the existence of a fungus-nematode interaction (Cylindrocladium-R. similis) which has been demonstrated in commercial plantations in Cameroon (Castaing et al., 1994).

No control is carried out in smallholdings because of the extremely high cost of nematicides; in any case, most farmers are not aware of the problems caused by these pests.

References


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Global

Plot technique studies on yield trials of plantain propagated by in vitro methods

Rodomiro Ortiz*
and Dirk Vuylstke**

In vitro techniques have become standard procedures for the conservation, distribution and rapid multiplication of plantain (Musa spp. AAB group) (Vuylstke, 1989; Vuylstke and De Langhe, 1985; Vuylstke et al., 1990). However, phenotypic or somaclonal variation among micropropagated plants of Musa is a common phenomenon and this may adversely bias results from yield trials (Vuylstke and Swennen, 1990; Vuylstke et al., 1988, 1991). This study was aimed to determine whether somaclonal variation should be considered in the determination of yield potential of plantain (which had undergone rapid in vitro multiplication) by using appropriate field plot techniques.

The cultivars in the trial represented the major plantain taxonomic groups: Ntanga 2 (Giant French), Bobby Tnnap and Obino L’Ewai (Medium French), Big Ebanga (Giant False Horn), Agbagba (Medium False Horn) and Ubok Iba (True Horn). A total of 120 true-to-type plants, initially in vitro propagated, were sampled and their bunches weighed for each cultivar. No data transformations were required because both the variance and the standard deviation were unrelated to the means and the variances of the six plantain cultivars were homogenous according to Box’s test (Milliken and Johnson, 1989).

Analyses showed that, for each clone, the intra-clonal variance of bunch weight was not affected by the rate of somaclonal variation (Table 1). However, a negative trend was observed for intraclonal variance with somaclonal variation, which suggests that selection against phenotypic somaclonal variants effectively reduced within clone variation for bunch weight.

The coefficient of soil heterogeneity (b) was estimated by the variation of bunch weight within each cultivar as determined by solving the following equation: $V_r = V_i / x^2; \text{ where } V_r$ is the variance (calculated on a per unit basis) of bunch weight per unit area among plots of x units in size, $V_i$ is the variance among plots of one unit in size and x is the number of basic units per plot. Soil heterogeneity was smaller in the French

<table>
<thead>
<tr>
<th>Plantain Cultivar</th>
<th>Bunch Weight</th>
<th>Somaclonal Variation</th>
<th>No. plants</th>
<th>Soil heterogeneity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type</td>
<td>Mean</td>
<td>sd</td>
<td>CV (%)</td>
<td>plot</td>
</tr>
<tr>
<td>Ntanga 2</td>
<td>FG</td>
<td>20.99</td>
<td>3.57</td>
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</tr>
<tr>
<td>Bobby Tnnap</td>
<td>FM</td>
<td>14.01</td>
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<tr>
<td>Obino L'Ewai</td>
<td>FM</td>
<td>12.48</td>
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<td>Big Ebanga</td>
<td>FGH</td>
<td>11.90</td>
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<td>Agbagba</td>
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<td>Ubok Iba</td>
<td>H</td>
<td>7.80</td>
<td>2.53</td>
<td>32.40</td>
</tr>
</tbody>
</table>

1 Data from 120 random plants.
2 From Vuylstke and Swennen (1990)
3 $FG =\text{French giant, } FM =\text{French medium, } FGH =\text{False Horn giant, } FHMM =\text{False Horn medium, } H =\text{True Horn}$
were enough to detect a significant mean bunch weight difference of 2.5 kg between 2 plantain cultivars. The detection of significant mean differences larger than 4 kg between plantain bunch weights requires only 2 reps of 15 competing plants.

References


Trisomic segregation ratios and genome differentiation in AAB plantain

Rodomino Ortiz* and Dirk Vuyisileke**

Plantains (Musa spp. AAB group) are triploid giant perennial herbs derived from interspecific crosses between the diploid species M. acuminate and M. balbisiana, which contributed the A and B genomes respectively (Simmonds and Shepherd, 1955). Consequently, the AAB genome designation was given to plantain due to its interspecific origin and based on a putative differentiation between the A and B genomes.

We investigated whether these genomes were different with the aid of genetic marker segregation in diploid populations, derived from 3x (plantain) × 2x (wild banana) crosses (Vuyisileke et al., 1993). The markers analysed were P1 (fruit parthenocarpy), b5 (major gene for black Sigatoka resistance) and dw (dwarfism due to short internodes).

The diploid progenies were considered as test-crosses because the diploid wild banana “Calcutta 4” (Musa acuminate ssp. burmannicoides) is a homozygous line (Simmonds, 1953) and the triploid plantains were found to be dominant duplex for the P1 locus (Ortiz and Vuyisileke, 1992a), and dominant simplex for the b5 and dw loci (Ortiz and Vuyisileke, 1992b). The 1:1 (diploidy) and 2:1 (trisomic) critical ratios were tested to determine the pattern of inheritance of the morphological markers.

Segregation at the P1 and dw loci did not fit a diploidy but a trisomic ratio whereas segregation at the b5 loci fitted both ratios (Table 1). However, the co-segregation of b5 and P1 loci, which are linked in repulsion phase in plantain (Ortiz, 1993), deviated significantly from the expected disomic inheritance (data not shown).

In conclusion, plantains have a trisomic pattern of inheritance because each linkage group occurs three times instead of twice. Furthermore, there was no preferential pairing between the homologous chromosomes of the A genome, but random distribution of the paired chromosomes to the cell poles occurred during anaphase I of the first meiotic division. This might imply that there is no genome differentiation between M. acuminate and M. balbisiana and, therefore, the AAB genomic designation for plantain should be discontinued or replaced with a more specific genetic characterization when necessary.

References


Table 1: Segregation in diploid test-crosses derived from matings between heterozygous triploid plantain and a homozygous diploid wild banana

<table>
<thead>
<tr>
<th>Trait</th>
<th>Observed</th>
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<tr>
<td></td>
<td>Yes</td>
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</tr>
<tr>
<td>Black Sigatoka Resistance (b5)</td>
<td>46</td>
<td>32</td>
</tr>
<tr>
<td>Dwarfism (dw)</td>
<td>24</td>
<td>41</td>
</tr>
<tr>
<td>Fruit Parthenocarpy (P1)</td>
<td>54</td>
<td>16</td>
</tr>
</tbody>
</table>

* ** Deviated significantly from expected 1:1 test cross ratio for disomic inheritance

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* Plantain and Banana Improvement Program, the International Institute of Tropical Agriculture, Ibadan, Nigeria

** IITA Station for Eastern and Southern Africa, Kampala, Uganda
improving the resistance of Musa to nematodes. Musa nematodes were the subject of a global conference organized by INIBAP-ASPNET in Malaysia on 18-21 April, 1994, and financially supported by ACIAR. Nematodes, in addition to Sigatoka and Fusarium wilt diseases, are being considered for inclusion in IMTP Phase III.

The breeders felt that an informal Network would be a more appropriate forum than a Consortium at this stage of the group's development. However, it could well be that a more formal body would emerge in future years.

A comprehensive account of the Breeders' Network Meeting is included as the second paper in this issue of INFOMUSA.

Headquarters' agreement with France

Three major advances have been achieved on this issue early in 1994. These were the approval of the Headquarters' Agreement by all the interested French Ministries, the Conseil d'Etat and the Conseil des Ministres (the Cabinet). The text of the HQ Agreement is now to be passed on to the Senate and National Assembly where it is expected to be approved and adopted during the present Spring Session.

Regional networks

INIBAP's model has been successfully implemented in Asia and in Latin America where collaborative activities, training, definition of priorities, germplasm conservation, enhancement and evaluation, and information and documentation systems are now in place. However, this is not the case in Africa where only a few elements of INIBAP's programme have been effective, i.e. evaluation and distribution of improved and natural germplasm and information documentation systems.

Considering past experience in Africa and the actual limited resources available, INIBAP believes its involvement in this region should follow a different approach. Instead of a coordinating role to generate collaboration and funding, INIBAP should be a direct and active participant in the Musa research and development process and should selectively deliver its program activities and services through key national, regional and international partners. In other words, "focusing on specific activities" becomes the key element.

During the last two years, INIBAP's staffing has been severely reduced and the following senior positions have either been lost or not replaced: Assistant Director, Germplasm Research Coordinator, Communications' Specialist, East Africa Coordinator and, as of June 1994, the West Africa Coordinator. However, INIBAP is recruiting Jean-Pierre Horry, a highly experienced Musa Breeder and Taxonomist, to fulfill the critical role of Germplasm Officer in August 1994.

Under the above scenario, and in the foreseeable future, INIBAP will not have a staff member based in Africa. In order to provide the desired focus and services to Sub-Saharan Africa, INIBAP is convinced that this position should be the number one priority if and when resources become available. Until such time, HQ's staff will continue key research activities in this region by interacting with CRBP, IITA, NARO, IRAZ and other partners and donors.

Information Documentation

Publications

Last year was very productive with the publication and the dissemination of 2 issues of INFOMUSA, 3 trilingual issues of Musarama (the bibliographic abstract journal on banana and plantain), and their related trilingual indexes, INIBAP's 1992 Annual Report, the proceedings of 1 international and 4 regional meetings, the UPEB/INIBAP co-publication of a bibliography on plantain, and 2 Musa Disease Fact Sheets.

Databases

In order to update the Banana Research Information System (BRIS), to prepare the second issue of the Directory of Researchers Working on Banana and Plantain and to initiate work on the first issue of the Directory of Research in Progress on Banana and Plantain, a survey was carried out with banana researchers early in 1994. To date, BRIS contains 567 researchers' records of which 133 are new records and 280 have been updated.

The trilingual INIBAP Database Package will be soon available to NARS. It was finalized in 1993 and is now being tested with partners in Africa (IITA, Nigeria ; CRBP, Cameroon), Latin America (UPEB, Panama), Caribbean (Ministry of Agriculture, Cuba; WINBAN, St Lucia) and Asia (PCARRD, Philippines). It includes two databases: MUSALIT (the bibliographic database), and BRIS, and two manuals for installation and use.

Once the testing period is completed and final improvements made, the database package will be available to national and regional institutions that have already participated or demonstrated their willingness to participate in INIBAP's Info/Doc network activities.

It is hoped that this new user-friendly tool will encourage, consolidate and improve the flow of information on Musa at regional and national levels, particularly in Asia and Africa where the regional Info/Doc networks have not been formally established.

Musa Germplasm Information System (MGIS)

The general objective of MGIS is to develop a reliable information system, based on a network of researchers and curators from regional and national Musa collections, to facilitate the identification of biodiversity of the genus Musa and the conservation of Musa germplasm. Data on Musa biodiversity will be recorded in the International Musa Germplasm Database (IMGD). After a feasibility study and the approval by IDRC in 1993 of a 3-year project proposal, the first phase of the MGIS project has now been initiated with the development of the database software. It is expected that CIRAD will be a close partner in this endeavor.

Future Activities

- Consolidation of the regionalization process.
- Development of a bibliographic CD-ROM on Musa literature in collaboration with CIRAD / FLHOR. Collaboration with NRI and UPEB is also under discussion to incorporate all past information.
- Updating and standardization of UPEB's "Tesaurlo del Banano" (Banana Thesaurus) to make it available in English, French and Spanish.
- Regular updating of INIBAP's data on global production and consumption of the major types of bananas and plantains.
- Further collaboration with IPGRI's Program particularly within the framework of MGIS.
To be published:

The second edition of the directory of researchers working on banana and plantain

Results of the survey of January 1994

INIBAP thanks all the researchers that have responded to the second survey sent with Musarama vol.6, no.3, in January 1994.

Today, the Banana Research Information System (BRIS) database contains records of 567 Researchers. Since the last issue, 280 records have been updated of which 133 are new names. Figures 1 and 2 compare regions as a percentage of the total number of records. Figure 3 shows the increase of recorded names between 1992 and 1994.

The increase in number of researchers in the BRIS database is global, but the highest increase has been in Asia. INIBAP's visibility and impact in Asia increased thanks to the activities of the Regional Network and visits by the Scientific Research Coordinator to the region. Numerous projects have also been developed, such as germplasm collecting, characterization, duplication of the Asian germplasm accessions in the INIBAP Transit Center at Taiwan Banana Research Institute (TBRI), International Musa Testing Program (IMTP), etc. The updated mailing list is now more complete and accurate for Asia. Responses from the Pacific stay low and did not increase significantly. The activity of the ASPNET Regional Network is not completely developed in the Pacific because of the high number of small countries scattered over a vast area of

Figure 1: BRIS, 1992: Origin of the researchers' records in the first edition of the directory

Figure 2: BRIS, 1994: Origin of the researchers' records for the second edition of the directory

Figure 3: BRIS Updating Comparison between the 1992 issue of the Directory and the contents of BRIS in April 1994
The response from Africa was low, but it has increased since the survey for the first issue. Although, at present, there is no Regional Network for East & South Africa, numerous contacts that INIBAP has made over the last two years, as well as the development of projects (IMTP, training, etc.) has improved its impact in this region.

Around 180 BRIS records are from Latin America. This high number is explained by the fact that the Union of Banana Exporting Countries (UPEB) transferred its database on researchers to INIBAP Headquarters in 1992. This illustrates the important role that Regional Networks play in the collection and dissemination of information.

We have also received replies from countries that were not listed in the first edition of the Directory: Gabon, Morocco, Netherlands, New Zealand, Oman, Pakistan, Portugal, Sri Lanka and Vietnam.

The publishing of the first edition of the Directory has certainly encouraged researchers to reply to the second survey. INIBAP still receives replies on a daily basis. However, in order to prepare the new edition of the Directory, data updating closed at the end of May. The latest replies will be recorded into the database, but will be published in the 1996 edition.

INIBAP. It includes 1944 bibliographic abstracts of documents published between 1911 and 1992. The bibliography covers all aspects of cooking banana and plantain cultivation, such as anatomy, genetics, breeding, physiology, cultural practices, pests and diseases, soils, irrigation, post-harvest technologies and also agroindustry, trade and socio-economic issues. The bibliography is available on request at INIBAP Headquarters.

Compendium of Tropical Fruit Diseases
This year, the American Phytopathological Society released a 88-page publication which provides up-to-date information on diseases of important tropical fruits including banana, coconut, mango, pineapple, papaya and avocado. Part 1 includes comprehensive information on banana diseases caused by fungi, bacteria, viruses and nematodes. Color plates illustrate the symptoms of each banana disease described. The book was edited by R.C. Ploetz, G.A. Zentmyer, W.T. Nishijima, K.G. Rohrbach and H.D. Ohn. For more information, please contact: The American Phytopathological Society, 3340 Pilot Knob Road, St Paul, Minnesota 55121-2097, USA.

Special Banana Issues of Fruits
A special issue on banana (Fruits Vol. 48 n°1, 1993) summarizes work by CIRAD-FLHOR and others in areas of genetic improvement, crop protection and physiology.

New banana improvement project
A new international research program on banana improvement, which is being co-sponsored by the Common Fund for Commodities (CFC), the FAO Inter-Governmental Group on Bananas (FAO/IGB) and the World Bank, is now underway. The executing agency for the Banana Improvement Project (BIP) is the World Bank and Dr Gabrielle Persley is the Program Manager. The objectives of BIP are to develop (1) new, more productive and higher quality banana varieties with export potential and (2) better integrated disease management practices in order to reduce pesticide use on banana. Further information can be obtained from Dr Persley at the following address:


Dr Persley is calling for the submission of projects for funding under BIP. The first round of applications closed on 8 April 1994, but a second round, which will close on 15 August 1994, is now open.
INIBAP co-sponsors with ACIAR and MARDI:

Conference/workshop on nematodes and weevil borers affecting bananas in Asia and the Pacific

Representatives of 7 ASPNET member countries/institutions namely: Australia, China, Indonesia, Malaysia, Philippines, Thailand and the South Pacific Commission presented status reports of the nematode and weevil borer problems in their respective countries. Likewise, there were also participants from national, regional, international/foreign agencies who presented their control strategies/program for the above mentioned pests. These were from MARDI (Malaysian Agricultural Research and Development Institute), UPM (Universiti Pertanian Malaysia), UP at Los Baños (Philippines), QDPI (Queensland Department of Primary Industries), NSW-Agriculture (New South Wales), IITA (International Institute of Tropical Agriculture), NRI/UK (Natural Resources Institute), CIRAD-FLHOR (France), Catholic University of Leuven (Belgium) and ASEAN-PLANTI (Plant Quarantine Centre and Training Institute).

The country reports indicated that both nematodes and weevil borers are common problems in the Asia and Pacific region. The nematode Radopholus similis was rated as serious in Australia, the Pacific Island countries, the Philippines and Indonesia. This nematode species attacks Cavendish clones primarily. Meloidogyne incognita and Helicotylenchus multi-

*cinctus were commonly observed affecting local cultivars in the region. The corn weevil, Cosmopolites sordidus, was observed as a serious pest in all countries in ASPNET while China reported

Versalynn N. Roa*

KARI wishes to announce the hosting of the 4th KARI Scientific Conference from 25th to 28th October 1994. The venue will be the Conference Room, KARI Headquarters, Kaptagat road, Loresho, Nairobi, Kenya. The conference will focus on agricultural research for intensifying rural and industrial research.

The objectives are:

(i) To sensitize policy makers and agricultural researchers on the role of new methodologies and the relevance of current research methodologies; and

(ii) To assess the role of new technologies in agro-based industries.

For more information, please contact:
The Secretary – 4th KARI Scientific Conference
KARI Headquarters – PO Box 57811 – Nairobi Kenya – Tel: (254-2) 444144/444029/32
Fax: (254-2) 444144 – Telex: 25287 KARI HQ KE

The 3rd International Conference on Tropical Entomology will be held in Nairobi from 30th October to 4th November 1994, to coincide with the 25th anniversary celebrations of the International Center of Insect Physiology and Ecology (ICIPE). This series of conference on tropical entomology provides a forum for effective communication between insect scientists and technologists in the tropics thus promoting excellence in the science of entomology.

For more information, please contact:
Dr R. K. Saini – Secretary General
3rd International Conference on Tropical Entomology – PO Box 30772 – Nairobi – Kenya
Tel: (254-2) 803501 – Fax: (254-2) 803360
Telex: 22053 ICIPE

The University of the West Indies (UWI), Faculty of Agriculture plans to celebrate 70 years of publishing of its International Journal «Tropical Agriculture» with a conference on the theme: Advances in Tropical Agriculture in the 20th Century and Prospects for the 21 st: TA 2000 scheduled for September 4-9, 1994 in Port of Spain, Trinidad.

The following themes will be included in the conference:
Cropping and utilization, livestock production, utilization and health; land and soil management, economic and social issues in agricultural development; food and nutrition security, women and development, agricultural sustainability and diversification, biotechnology and agricultural productivity; plant genetic resources and breeding; rural development; international trade and competitiveness; ecotourism; technical strategies for crop diversification.

For more information, please contact:
The Secretariat, TA 2000
Office of the University Dean
Faculty of Agriculture
University of the West Indies – St Augustine
TRINIDAD, W. I. – Tel: (809) 662-2868
(809) 662-1182 – (809) 663-1364/49 ext 3327
Fax:(809) 662-1182 – (809) 663-9386
Telex: 24520 UW1 WG – Cable: Stomata
Port-of-Spain – Trinidad
Views from our readers

I have just received Vol. 2 no. 2 of INFO-MUSA. Congratulations! The contents reflect the vast increase in Musa knowledge and research that has taken place in the last three years (breeding, banana viruses, especially BSV, Fusarium wilt, etc.).


The INFOMUSA magazine is a real treasure for all banana people – covering all aspects of the industry and thus invaluable for any one interested in banana and plantain, whether in research or in production.

However, I do miss information about future events, e.g. congresses, seminars, etc. Such a list including data about dates, venues and general topics, has great importance – expanding the circle of participants and enabling more people, from all over the world, to contribute their own experience.

A. M. Davedevani (Dubon), R&D Dpt, Rahan Meristem, Propagation Nurseries, Israel.

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Publications from INIBAP

For more information about INIBAP, the following publications are available from headquarters:


