inibap

Networking Banana and Plantain

Annual Report 1998

The mission of the **International Network for the Improvement of Banana and Plantain** is to sustainably increase the productivity of banana and plantain grown on smallholdings for domestic consumption and for local and export markets.
The Programme has four specific objectives:

- To organize and coordinate a global research effort on banana and plantain, aimed at the development, evaluation and dissemination of improved cultivars and at the conservation and use of *Musa* diversity
- To promote and strengthen collaboration and partnerships in banana-related research activities at the national, regional and global levels
- To strengthen the ability of NARS to conduct research and development activities on bananas and plantains
- To coordinate, facilitate and support the production, collection and exchange of information and documentation related to banana and plantain.

Since May 1994, INIBAP is a programme of the International Plant Genetic Resources Institute (IPGRI).

The **International Plant Genetic Resources Institute** (IPGRI) is an autonomous international scientific organization, supported by the Consultative Group on International Agricultural Research (CGIAR). IPGRI's mandate is to advance the conservation and use of plant genetic resources for the well-being of present and future generations. IPGRI's headquarters is based in Rome, Italy, with offices in another 14 countries worldwide. It operates through three programmes: (1) the Plant Genetic Resources Programme, (2) the CGIAR Genetic Resources Support Programme, and (3) the International Network for the Improvement of Banana and Plantain (INIBAP).
The international status of IPGRI is conferred under an Establishment Agreement which, by January 1998, had been signed and ratified by the Governments of Algeria, Australia, Belgium, Benin, Bolivia, Brazil, Burkina Faso, Cameroon, Chile, China, Congo, Costa Rica, Côte d'Ivoire, Cyprus, Czech Republic, Denmark, Ecuador, Egypt, Greece, Guinea, Hungary, India, Indonesia, Iran, Israel, Italy, Jordan, Kenya, Malaysia, Mauritania, Morocco, Pakistan, Panama, Peru, Poland, Portugal, Romania, Russia, Senegal, Slovakia, Sudan, Switzerland, Syria, Tunisia, Turkey, Uganda and Ukraine.
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Foreword

The fact that bananas and plantains are essential for the food and income security for hundreds of million people in the developing world is still insufficiently known. During 1999, INIBAP therefore took advantage of several opportunities to raise public awareness about the crop. As a partner with CIRAD at the Paris International Agricultural Fair, INIBAP mounted an eye-catching exhibit featuring *Musa*. The display, visited by thousands of people, showed the diversity of the crop, both biologically and as a plant with a multitude of uses. On that occasion a series of colourful posters were produced by INIBAP and have been widely distributed. A Conference organised by a consortium of NGO's in Brussels in May 1998 gave INIBAP another opportunity to highlight the important role that research can play in developing sustainable banana production systems.

In Africa, a major task of the two regional *Musa* networks in 1998 was to develop their respective research strategies. The strategic plan of BARNESA was well received by donors at a meeting organised by ASARECA in June and will form the basis for the implementation of a number of projects in the region. In West and Central Africa a draft strategy was discussed by the Steering Committee in November 1998 and will be finalised in 1999. Africa was also the location for the first symposium devoted to socio-economic aspects of non-export banana production, entitled "Bananas and Food Security". This meeting highlighted the significant role a wide range of banana and plantain varieties play as basic staples as well as generators of income for millions of rural poor.

For PRO*MUSA*, 1998 was a turning point; from a concept, it became a reality. Several activities were undertaken by partners in the programme and a number of new collaborative initiatives were launched. It is now clear that PRO*MUSA* will have a significant impact on the genetic improvement of the crop. Furthermore, the programme has been cited as a model for collaboration on other crops by the International Conference on Horticultural Research and by the Steering Committee of the Global Forum for Agricultural Research for Development.

Significant breakthroughs in research were made during the year. For the first time *Agrobacterium* transformation has been successful using embryogenic cell suspensions, opening the way for the introduction of larger gene constructs and better control over gene expression. In cryopreservation, a combination of three techniques now allows the successful regeneration of cryopreserved meristems from all genomic groups of bananas.

During 1998, the INIBAP programme was further strengthened by the addition of several staff in the different regions. With continued support from its donors, INIBAP is gradually building up the critical mass that will allow it to deliver the results expected by its partners.

Geoffrey Hawtin
Director General, IPGRI

Emile Frison
Director, INIBAP

Supporting *Musa* research and development through conserving and sharing diversity

Methods are being developed for the long-term storage of Musa *varieties using liquid nitrogen (cryopreservation).*
(Photo: KUL)

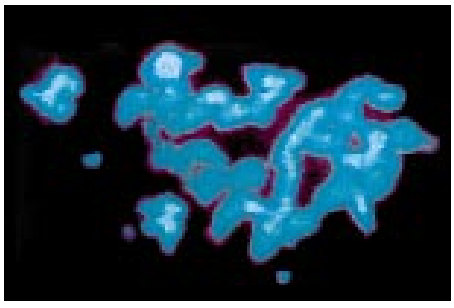
Banana plants are maintained in vitro *(literally 'in glass') at the INIBAP genebank. Here they are protected from pest and diseases and kept in a healthy state ready for distribution.*
(Photo: KUL)

Information about different varieties is collected and entered into a specially developed computerised database, the 'Musa *Germplasm Information System'.*
(Photo: A. Molina, INIBAP)

The wide diversity in the genus *Musa* is the basic element that sustains production of this important crop. Diversity is used by breeders to produce improved varieties. It also allows the crop to be grown in a wide range of environments and to meet the varied needs of the millions of people who depend on it for food and income.

INIBAP has been entrusted by FAO to conserve this diversity for the benefit of present and future generations. But for diversity to be useful, it must also be available. INIBAP takes its role as the major provider of *Musa* germplasm seriously. Every day accessions are shipped to users, who may be researchers developing improved varieties, or extension workers wishing to introduce

Research on Musa *viruses forms an important part of INIBAP's work. This includes using the latest technologies to study the very DNA of the plant.* (Photo: John Innes Centre)



Before distribution plants are inspected in quarantine greenhouses at the INIBAP Virus Indexing Centres. Here a virus-infected plant has been identified. (Photo: M.L. Iskra, CIRAD)

alternative varieties to farmers in their villages. All material is carefully checked to ensure that it is healthy before being distributed, and state-of-the-art techniques are used at all stages.

Plant material ready for distribution by INIBAP. (Photo: KUL)

Musa germplasm management

Objectives: to conserve germplasm representative of *Musa* diversity, including improved material from breeding programmes as well as naturally occurring varieties and wild species and to distribute this material, as well as information related to it, for research and development activities worldwide.

This work is largely supported with funding provided by the Belgian Agency for Development Cooperation (BADC).

Germplasm conservation

The germplasm collection maintained at the INIBAP Transit Centre (ITC) consisted of 1,119 accessions at the end of 1998. Accessions are maintained under medium-term storage conditions (16°C and 2000 lux 24/24hr). Subculture frequency ranges from 121 to 773 days depending on clone, with an average of 314 days.

Introduction of new germplasm

During the year, 28 new accessions were received. These consisted of: 12 bred hydrids donated by breeding programmes at the International Institute of Tropical Agriculture (IITA, Nigeria), *Fundación Hondureña de Investigación Agrícola* (FHIA, Honduras), and *Centre de coopération internationale en recherche agronomique pour le développement* (CIRAD, Guadeloupe), one somaclonal variant from the Taiwan Banana Research Institute (TBRI) and 15 natural accessions collected in Vietnam during prospecting missions in 1994-95.

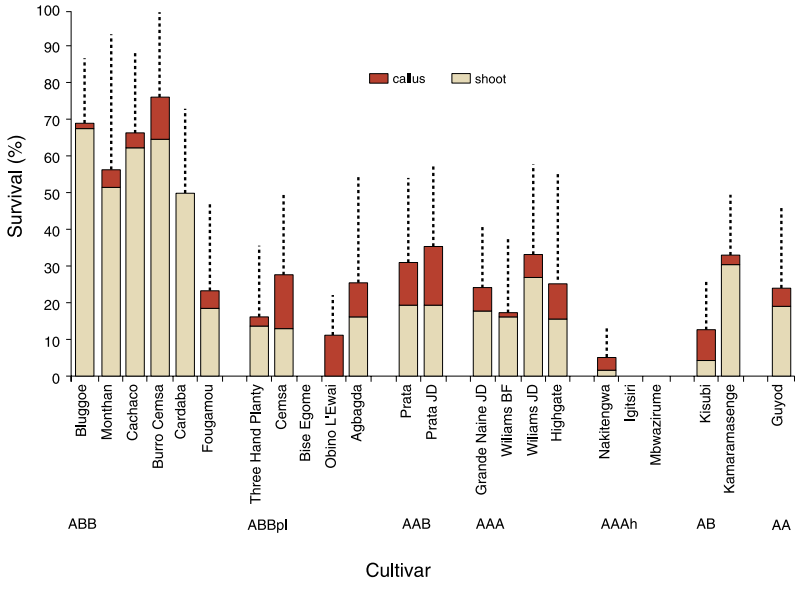
Germplasm collecting

INIBAP supports targeted collecting of *Musa* germplasm in order to fill identified gaps in its collection. In 1998, collecting work took place in India, supported by funding provided by the Department for International Development (DFID, UK). Thirty-six accessions were collected in Assam and Meghalaya States. A preliminary survey carried out in the region has identified a great deal of variability in ABB clones and possibly in the wild species, *Musa balbisiana*. As little diversity has previously been found in this species, future collecting missions are expected to reveal interesting results.

Germplasm monitoring in storage

Accessions continued to be routinely screened for endogenous bacterial contamination during 1998 and infected material was cleaned as reported in the INIBAP Annual Report 1997 (p. 12). A selective medium is being used for the isolation of slow-growing mycobacteria, which have been difficult to grow in the past. One hundred and fifty-eight accessions were screened in 1998 bringing to 672 the number of accessions (60% of the collection) have now been screened. Of the 36 found to be contaminated, 15 have been cleaned and 21 are undergoing treatment. Testing for Moko disease (bacterial wilt) has also been

Figure 1. Survival rates, indicated by callus and shoot regeneration, of precultured proliferating meristems of 23 different banana cultivars after cryopreservation through simple freezing. (Courtesy of KULeuven)



introduced during 1998 and, although this bacteria has not been known to pass unnoticed through tissue culture, this is carried out as a routine for samples destined for countries requiring Moko-free certified material.

In order to minimise the risk of accidental loss of accessions, individual cultures of all clones in storage are systematically evaluated every month for contamination, blackening, vigour and possible somaclonal variation. Abnormal growth was identified in two accessions, and shoots were regenerated from each of these for greenhouse observations. Abnormalities observed *in vitro* continued *in vivo*. These accessions will be removed from the ITC collection and the clones involved replaced with new material.

In order to study the *in vitro* behaviour of accessions belonging to different genomic groups, individual tissue cultures of accessions stored under slow growth conditions are being morphologically evaluated. Morphological characterisation is carried out over four successive generations on 4-5 month old (fully-grown) cultures in storage, using 20 replicates for each clone. Criteria used for characterisation include:

- the type of proliferation,
- extent of blackening,
- amount of corm formation,
- hyperhydricity (glassiness) of tissues.

Observations are currently being made for the 4th cycle. Results of these evaluations should enable a relationship between the performance of cultures, the genotypic constitution and the storage capacity to be determined.

Long-term conservation

Cryopreservation has been identified as the preferred method for the long-term storage of *Musa* germplasm. In the INIBAP Annual Report of 1997, information was provided on two cryopreservation methods being developed at KUL, Belgium. During 1998, a third method was also introduced and emphasis was placed on the comparison and optimisation of the three protocols, which are described below.

Method 1

This simple freezing method results in viability rates between 0 - 76% depending on the cultivar. A number of parameters were tested during 1998 in an attempt to further optimise the protocol – see Table 1. Most of the experiments carried out did not result in any viability improvement over the standard method. The only exception was preculturing in darkness, which in one case gave significantly improved post-thaw regeneration, and will thus be further evaluated. Survival rates of 23 different cultivars cryopreserved by this method are shown in Figure 1.

Method 2

This method was developed by Dr Nguyen Tien Thinh during PhD research carried out at the Japanese International Research Centre for

Table 1. Description of the three cryopreservation methods being investigated at KUL.

Method type	Starting material	Steps required	Parameters being tested
1. Simple freezing Recommended for ABB cultivars	Proliferating, cauliflower-like meristems	Preculture for 2 weeks on high sucrose (0.4M) Rapid freezing	Varying BA (benzyladenine) concentrations in preculture medium; Cold treatment (15°C) during preculture; Preculture in darkness; Duration of thawing in water bath at 40°C; Gradual decrease of sugar concentration in regeneration medium.
2. Vitrification of apical meristems Recommended for recalcitrant cultivars (e.g. AAA highland bananas)	Rooted *in vitro* plants	Vitrification of apical meristems (PVS2 solution)	Use of smaller cryotubes Decrease in the amount of PVS2 in cryotube
3. Vitrification of proliferating meristems Recommended for AAB and some AAA cultivars	Proliferating, cauliflower-like meristems	Preculture for 2 weeks on high sucrose Vitrification of meristems (PVS2 solution)	BA concentration in the preculture medium Preculture period Length of PVS2 treatment Preculture in darkness Subculture period before preculture

Figure 2. Survival rates, indicated by callus and shoot regeneration, of non-precultured proliferating meristems of 23 different banana cultivars after cryopreservation through vitrification (same cultivars as in Figure 1). (Courtesy of KULeuven)

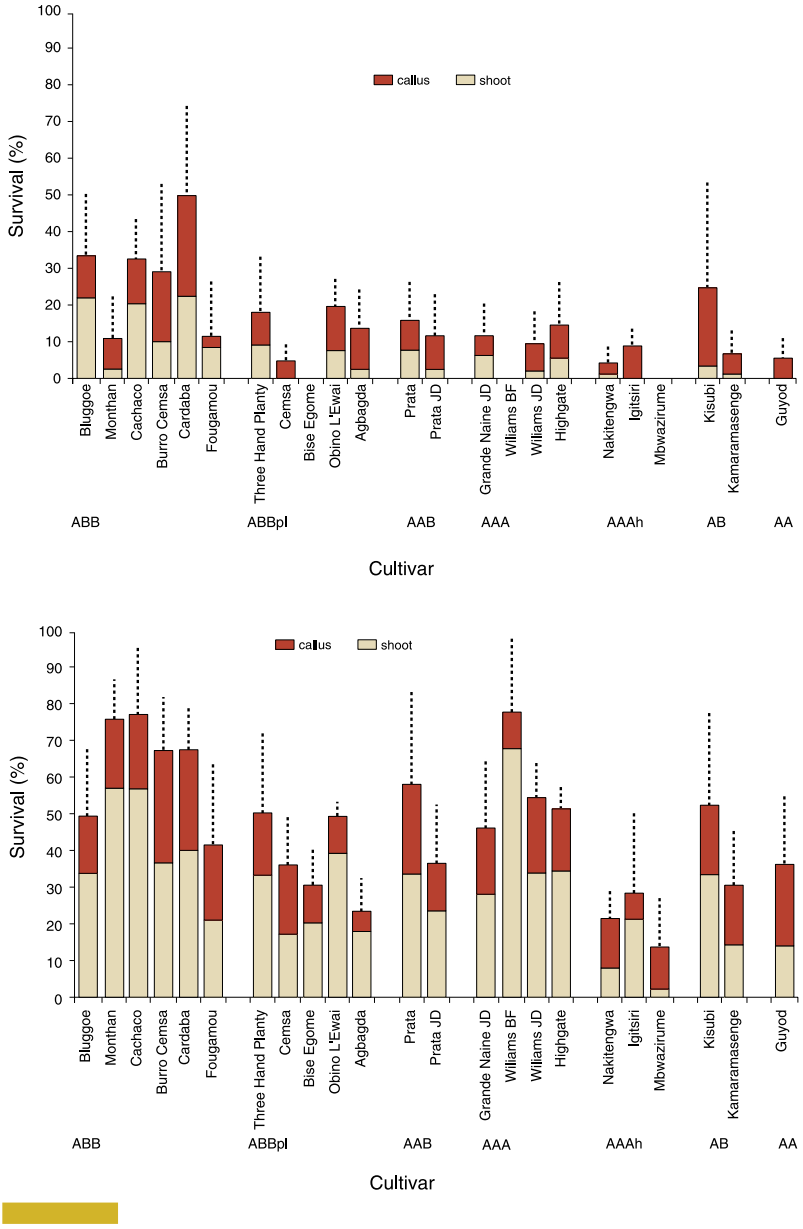


Figure 3. Survival rates, indicated by callus and shoot regeneration, of sucrose precultured proliferating meristems of 23 different banana cultivars after cryopreservation through vitrification (same cultivars as in Figure 1). (Courtesy of KULeuven)

Agricultural Sciences (JIRCAS) and was introduced to KUL through a post doctoral fellowship. The method relies on the vitrification of tiny meristems excised from rooted *in vitro* plants with a highly concentrated and sometimes very toxic solution PVS2. This PVS2 solution consists of 30% glycerol, 15% ethylene glycol, 15% dimethyl-sulphoxide (DMSO) and 0.4M sucrose. The toxicity can be overcome by (1) plant culture for 1 month on 6% sucrose, (2) a loading phase prior to PVS2 treatment and (3) the application of the vitrification solution at 0°C. The most essential but also most difficult step in that protocol is the selection and excision of tiny meristem tips with a base diameter of 0.5 -1 mm and apical domes only covered for 2/3rd by the youngest leaf primordia. If this severe selection is applied, post-thaw regeneration frequencies increase considerably, ranging up to about 80% depending on the level of experience of the operator, the cultivar and the type of cryotube.

Neither the use of smaller cryotubes (0.5 ml instead of 2 ml tube) or a decrease in the amount of PVS2 solution (0.5 ml instead of 1 ml) resulted in higher viability rates. Higher post-thaw viability rates are however expected through a further improvement of the quality of the shoot-tip donor plants, an increased experience in excising 'ideal' meristems and an adjustment of parameters such as loading temperature and recovery conditions.

Method 3

The third method consists of a combination of Methods 1 and 2. Vitrification solutions were applied to non-precultured and sucrose precultured highly meristematic 'cauliflower-like' meristem cultures. The positive effect of the sucrose preculture on post-thaw viability and regeneration after vitrification can be seen by comparing Figures 2 and 3. Results of Figure 3 compared to those of Figure 1 (simple freezing method) show an increase in post thaw viability for most cultivars under investigation. The average viability for all cultivars is 28.9% for the simple freezing method and 47.4% for the vitrification of precultured meristem cultures, but regeneration frequencies are 23.3 and 30.8%, respectively. It is very important to stress that cultivars such as the plantain Bise Egome and the highland bananas Igitsiri and Mbwazirume which were so far totally recalcitrant towards freezing,

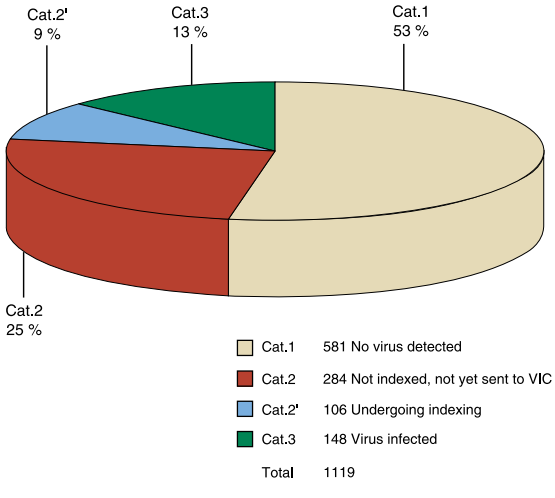


Figure 4. INIBAP germplasm collection at ITC: Summary of health status.

can now be regenerated after cryopreservation with this third method. The manipulation of parameters like BA concentration in the preculture medium, the preculture period and the amount of PVS2 solution in the cryotube did not significantly improve survival rates. Parameters that will be subject to further investigation are length of PVS2 treatment, influence of preculture in darkness and subculture period before preculture.

Comparison of the three different cryopreservation protocols

Each of the three methods has its advantages and disadvantages (Table 2). For example, one person can only excise and cryopreserve 20 meristem tips per day using Method 2, while one day of work using Methods 1 and 3 will result in about 600 and 400 cryopreserved meristem clumps, respectively. However, Method 2 can be applied earlier after reception of new material.

Taking the three methods together, any tested accession can be cryopreserved. The choice of which method to use depends on the genome of the accession. Accessions belonging to the ABB group can be stored through simple freezing (Method 1) but Method 3 is more appropriate for plantains and other accessions with an AAB genome as well as AAA cultivars. More recalcitrant cultivars, like AAA highland bananas from which 'cauliflower-like' meristem cultures are difficult to obtain, should be cryopreserved through vitrification of apical meristems (Method 2) provided that higher post-thaw regeneration rates are achieved.

Table 2. Comparison of three cryopreservation protocols for meristematic tissue.

	Simple freezing Method 1	Vitrification of apical meristems Method 2[a]	Vitrification of proliferating culture Method 3
Time needed before cryopreservation can take place[b]	5-16 months	5-7 months	5-16 months
Preparation of starting material[c]	+ to ++[d]	+++	+ to ++
Preparation of meristems for freezing[e]	++++	+	+++
N°. of explants which can be cryopreserved per person per day	600	20	400
User-friendliness of protocol	+++	+	++
Post-thaw regeneration frequencies (%)	0 to 68	0 to 43	3 to 69

[a] Results obtained at KU Leuven — [b] Time between an accession is received from the ITC and preparation for cryopreservation — [c] Methods 1 and 3: scalps; Method 2: rooted in vitro plants — [d] + difficult; ++ intermediate; +++ easy — [e] Method 1 and 3: precultured scalps; Method 2: tiny meristems excised from rooted plants.

Table 3. Shipments of ITC germplasm for research and development activities in 1998.

Country	Number of institutes	Number of accessions
Austria	1	4
Belgium	8	41
Bolivia	1	3
Côte d'Ivoire	1	9
Czech Republic	1	9
Democratic Republic of Congo	1	15
Dominican Republic	1	4
Eritrea	1	4
France	3	27
Germany	2	31
Guadeloupe	1	182
India	2	41
Israel	1	3
Jamaica	1	3
Mayotte	1	2
Netherlands	1	2
Nicaragua	1	10
Nigeria	1	1
Papua New Guinea	1	10
Spain	1	1
Tanzania	1	3
Thailand	1	7
United Arab Emirates	1	1
United Kingdom	3	20
USA	2	9
Venezuela	2	23
Vietnam	2	17

Health status of ITC genebank accessions

One hundred and forty accessions were sent for virus indexing in 1998 and results were received for 83 accessions. Of the 724 accessions (66% of the collection) that have now completed indexing, virus particles have not been found in 580 accessions (80% of those tested) and these are therefore available for distribution (Figure 4).
In order to increase INIBAP's virus indexing capacity, a new Virus Indexing Centre was opened at the Plant Protection Research Institute (PPRI) in South Africa and this became operational in November.

Distribution of germplasm

On average, 3.2 accessions were distributed daily from the ITC during 1998. The shipment procedure for multiple shoots in plastic culture vials and rooted plantlets in cultusaks ®, which has been routinely used since 1995, is obviously suitable and does not result in any appreciable problems of contamination or loss.

In 1998, a total of 55 requests for banana germplasm were processed by the ITC providing samples of 482 accessions to recipients in 27 countries worldwide (Table 3).

Two hundred and sixty-seven different accessions were disseminated, with the most popular being indicated in Table 4. These accessions account for approximately 20% of the germplasm distributed in 1998. Requests for proliferating tissue cultures and rooted plantlets were supplied on average 57 days and 84 days respectively, after the signing of the Material Transfer Agreement by the client.

Table 4. The most frequently supplied accessions in the ITC collection.

Name	ITC code	Number of shipments
Yangambi Km 5	ITC1123	11
FHIA-01	ITC0504	10
Calcutta 4	ITC0249	8
FHIA-02	ITC0505	8
Cachaco	ITC0643	8
Pisang Mas	ITC0653	8
FHIA-23	ITC1265	8
Gran Enano	ITC1256	7
Tani	ITC1120	7
Williams	ITC0365	6
AAcv Rose	ITC0712	6
FHIA-03	ITC0506	6

Research on viruses

Banana streak virus

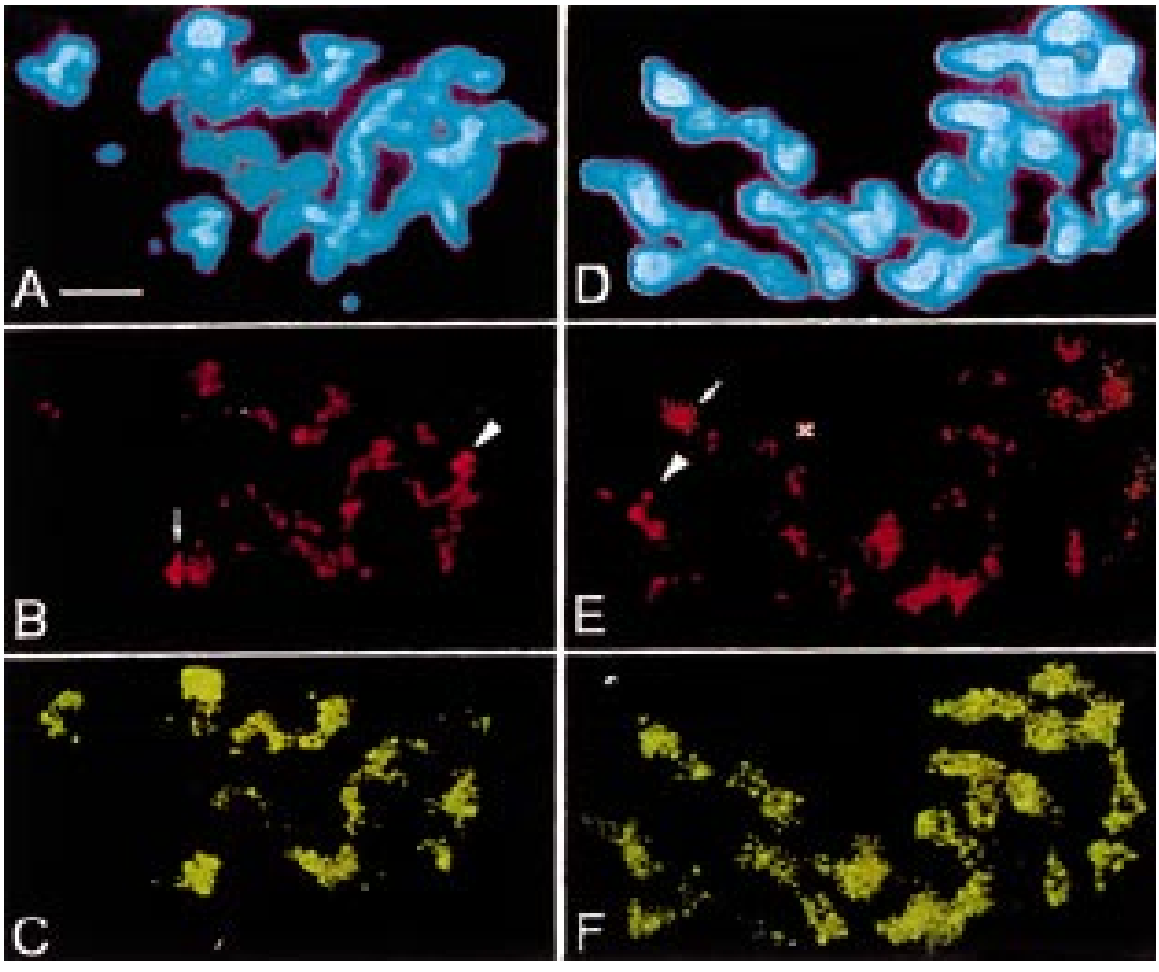
Banana streak virus (BSV) is the most widely spread virus of *Musa*, being found wherever *Musa* is grown worldwide. This virus is a major constraint, not only to *Musa* production worldwide, but also to the international movement of germplasm. BSV belongs to the badnavirus group and like other badnaviruses, is serologically very variable. BSV is unique among known plant viruses as viral sequences are integrated into the host genome, and it is apparent that BSV-like sequences can be found in all *Musa* lines tested. In some *Musa* cultivars, it seems that these can be activated by the stresses associated with tissue culture and/or crossing to give episomal infection (INIBAP Annual Report 1997, p. 11). A further feature of BSV infections is that symptoms can be transient with symptom suppression at higher temperatures. This resembles the situation with another pararetrovirus, cauliflower mosaic virus, in which symptom suppression is associated with perturbation of the virus replication cycle. On current evidence, there appears to be three forms of BSV associated with infection or potential infection, the encapsidated episomal form giving the symptoms (and sometimes symptomless infection), the unencapsidated episomal form and the integrated form.

INIBAP has been supporting research at the John Innes Centre (JIC), UK and the University of Minnesota, USA on the integrated sequences found in the plantain cultivar Obino L'Ewai, in order to provide information which could be used in the development of a diagnostic. There are now adequate techniques for the detection of the encapsidated episomal form of the virus based on immune specific electron microscopy or immune-capture polymerase chain reaction (IC-PCR). Thus of immediate importance is the development of diagnostic techniques for the active integrated and unencapsidated episomal forms.

Techniques used at JIC include polymerase chain reaction (PCR) and *in situ* hybridisation (See Focus paper 1). It was found that there are two loci of BSV sequences in Obino L'Ewai chromosomes and both have a complex structure. The integrated BSV sequence itself is not a straightforward viral genome, but it has many inverted and rearranged sequences. Activation of this integrated sequence would require recombination (probably two recombinations) and it is probably only a subset of the complex integrant that is activated. There is no information as yet on how the simple episomal form is derived from the complex integrants. This information is currently being sought as it is necessary for the development of a diagnostic for active integrants and for the development of approaches to suppressing activation of integrants.

Screening of the Obino L'Ewai genomic library is also being carried out at the University of Minnesota. Using a BSV-specific probe, two types of bacteriophage clones were revealed, one with only BSV sequences (type A) and one with both BSV and non-BSV sequences (type B). Additional screening of the libraries using other portions of the BSV genome also revealed the presence of 15 clones, of which six were type B and remaining nine were type A. Further screening of two additional Obino L'Ewai libraries is in progress.

Symptoms of banana streak virus (left) and cucumber mosaic virus (right) on the same banana leaf
(Photo: Ben Lockhart, University of Minnesota)



In situ *hybridisation to chromosomes of metaphase spreads of Obino L'Ewai.* *A and D: Chromosomes stained with DAPI; B and E: Hybridisation with BSV probe showing one major (arrowhead) and one minor (arrow) site; X is overstain precipitate not associated with a chromosome; C and F: Hybridisation of* Musa*OL probe. Bar = 5µm.*
(Photo: John Innes Centre)

It has been found that integrated BSV sequences similar to those in Obino L'Ewai are also found in cultivars which do not have a history of BSV activation. Thus it is likely that the difference between the activatable and non-activatable situation lies in the detail of the integrant, or in the presence of an unknown activator. This finding is of great use to the unravelling of the mechanism of activation as it provides a "null" system, which can be compared with the positive system in Obino L'Ewai and its tetraploid hybrids. In an attempt to specifically detect the functional BSV integrant, PCR primers that amplify the region encompassing the junction between BSV and *Musa* sequences in Obino L'Ewai were designed. These primers specifically amplified a 1.4 kb DNA fragment from several plantain genotypes (AAAB hybrids and AAB genome) but not from Cavendish bananas (AAA) obtained from Asia, Africa and tropical America. The plantain cultivars have a history of BSV infection after a few generations of micropropagation, while Cavendish bananas remain BSV-free, even after many generations of tissue culture.

Comparative DNA sequence analysis of BSV-integrant clones and episomal viral clones revealed a highly polymorphic region on the BSV genome. To further characterise this region, clones were prepared from episomal virus of 10 different *Musa* genotypes. Analysis of the sequences from this region showed that all the 10 episomal clones had the full 9 bp deletion, while the 12 bp deletion region was highly variable and fell into seven families. Obino L'Ewai genomic DNA was then PCR amplified using the same primer pairs. Some of the PCR products had the 9 bp deletion, identical to the episomal clones. Interestingly, none of the PCR products had the 12 bp deletion, suggesting it occurred post-excision. Comparison of the PCR product identified four distinct sequences indicating that there are at least four copies of the BSV integrant in the Obino L'Ewai genome. Further detailed analysis of this region is currently in progress.

Related work is being carried out at the University of Gembloux, Belgium on FHIA-21, a hybrid that is known to exhibit symptoms of BSV following tissue culture. Suckers taken from plants which have never been in tissue culture and in which BSV symptoms had never been reported, have been introduced by the University. Plants derived from these suckers will be established *in vitro* using various techniques in an attempt to identify the specific tissue culture stress which causes BSV activation. Unfortunately of the 26 suckers that were established in pots at Gembloux, seven are now showing BSV symptoms, perhaps indicating that some other stress during transport to Belgium has resulted in activation of the virus.

Other viruses

As reported in the INIBAP Annual Report 1997 (p. 13), a new banana virus has been isolated from cultivar Ducasse (Pisang Awak – ABB). During 1998 research on this virus continued in the framework of a collaborative project involving the Queensland Department of Primary Industry (QDPI, Australia), CIRAD-FLHOR, France and the Bureau of Plant Industry (BPI, Philippines). The genome of this virus has been totally sequenced and the genome organisation indicates that it is a unique, novel virus and most likely a member of the potexvirus group. A polyclonal antiserum has been produced and PCR and IC-PCR tests also developed for its detection. Monoclonal antibodies have been prepared to a Philippine isolate of the virus. Using these tests and an antiserum developed by Dr Lockhart at the University of Minnesota, the virus was shown to be widely distributed in international germplasm. The virus is frequently found as a mixed infection with other viruses, and at this stage the symptomatology is uncertain.

Participants in the MGIS training course in Cuba.
(Photo: E. Arnaud, INIBAP)

Providing information on ITC germplasm – characterisation activities

Characterisation of *Musa* germplasm is being carried out at both the morphological and molecular level in order to obtain and make available accurate information regarding the classification and morphology of accessions distributed by the ITC.

Morphological characterisation
INIBAP's involvement in the collection of morphological characterisation and evaluation data of *Musa* germplasm is based on the use of the *Musa* Germplasm Information System (MGIS). This system allows genebank curators to collect data using a standard format and to share this data with INIBAP as well as with other curators. INIBAP, with funding from IDRC, provided two training courses on the use of the MGIS during 1998. These courses were held in Australia and Cuba and brought the total number of genebank curators trained in the use of MGIS to 32. The global database now contains records of 2,453 accessions provided by six partner institutes, *Centre de recherches régionales sur bananiers et plantains* (CRBP), CIRAD-FLHOR, BPI, FHIA, ITC and South China Agricultural University (SCAU). Characterisation information is available for 647 accessions, data resulting from agronomic evaluations for 956 accessions and from stress evaluations for 183 accessions. The database, which also includes photographs of over 400 accessions, is available on CD-ROM and is distributed free-of-charge to all collaborating institutes.

Molecular characterisation
Molecular characterisation of over 320 selected accessions from the ITC collection was completed in 1998. This work was carried out by CIRAD-FLHOR, using sequence-tagged microsatellite (STMS) markers. Ten STMS markers were chosen for their high discrimination potential. Alleles specific to the *balbisiana* and Australimusa genomes were identified, thus allowing the identification of interspecific clones. The accessions tested had previously been classified according to morphological characteristics. This work thus allowed existing classifications to be confirmed, and in some cases reclassifications at the group or sub-group level were suggested. See Box 1.

Molecular characterisation of *Musa* germplasm

A molecular characterisation of a subset of Musa *germplasm held at the INIBAP Transit Centre was undertaken in order to facilitate the classification of the accessions at least at the sub-group level. Among the different methods available, microsatellites or sequence-tagged microsatellite site (STMS) markers that are simple sequence repeats (SSRs) were chosen.*

STMS markers were chosen because they are locus specific and codominant, thus can be interpreted in terms of genotypes. They are highly polymorphic and reveal alleles specific of species. In addition, the PCR procedure requires little DNA and can thus be used with in vitro *plantlets and a large number of samples can be handled daily. The markers were assayed with a non-radioactive urea-polyacrylamide gel electrophoresis (PAGE), a simple and transferable method which is less expensive than most other molecular techniques.*

Nine STMS markers were used which are localised separately on the different linkages groups of the banana core molecular map. These markers were also chosen because of their good staining with silver nitrate and high level of polymorphism.

Results

Specific alleles for balbisiana *(B) and Australimusa (T) genomes could be detected, thus allowing the identification of interspecific clones. Most clones produced profiles which allowed classification at least to the sub-group level.*

Fe'i

In the case of four Fe'i cultivars examined, three gave similar profiles, while one accession 'Asupina', PNG 361 *(ITC1027) appeared to possess an* acuminata *allele. Flow cytometry has confirmed that this accession is a triploid, and it has a different profile to four AAT clones also tested. It is therefore proposed that Asupina could be ATT, but this should be further confirmed using genomic* in situ *hybridisation (GISH) – See Focus Paper 1.*

Cultivars

Most of the accessions tested provided results that confirmed previous classifications based on morphology. Some exceptions where reclassification was recommended include the following:

ITC code	Name	ITC classification	STMS proposed group/subgroup
ITC0443	Inabaca	AA	AAA-Cavendish*
ITC0827	Kerua	AAB	AA
ITC0347	Mattui	AAA	AA*
ITC1251	Vietnam No. 5	AAw	AAA-Cavendish
ITC0445	Morong Principe	AA	AAA-Cavendish*
ITC1223	Mshale	AA	AAA-Cavendish*
ITC1250	Tien (Than -Hua)	AAw	AAB-Pisang Kelat
ITC1226 type	Bata bata	AA	AAB-Plantain-
ITC0990 type*	Vunapope	AB	AAB-cooking
ITC0924	Samoa	ABB	AAB-Popoulou – Maia Maoli
ITC1062	Pisang nangka	AAA/AAB	AAB-dessert type*

** = ploidy level not confirmed*

Variability among AA cultivars

Several of the AA cultivars have been studied with restriction fragment length polymorphism (RFLP) markers as well as STMS. The cultivars fall into 10 sub-groups, with clones within each sub-group appearing to be very similar:

Group 1:	ITC0312 Pisang Jari Buaya ITC1308 Pisang Sipulu ITC0792 Niukin	ITC 0314 Pisang Sipulu ITC0307 Gabah Gabah
Group 2:	ITC0279 Bie Yeng ITC0939 Fu Des ITC1004 To'o	ITC0471 Bebek ITC0942 Yendisi
Group 3:	ITC1187 Tomolo ITC0782 Agul	ITC0776 Kekiau
Group 4	ITC0653 Pisang Mas ITC1230 Senorita	ITC0714 Kirun ITC0774 Yenai
Group 5	ITC0663 Khai Nai On	ITC0673 Sa
Group 6:	ITC0603 Somani ITC0849 Sepi	ITC0899 Tamat
Group 7:	ITC0779 Tangamor ITC0770 Navaradam	ITC1186 Tangamor ITC0904 Papat Wung
Group 8:	ITC0778 Gorop	ITC0771 Lalalur
Group 9:	ITC0996 Manameg red	ITC0773 Mpiajhap
Group 10:	ITC0258 Pisang Madu	ITC0891 Igua

Improving production through the development and evaluation of new varieties

Scientists carry out detailed studies on the effects of pests and diseases on plant growth in the field. (Photo: J. Daniells, QDPI)

Fungus diseases can cause severe damage to banana leaves. This banana breeder is working to produce fungus-resistant varieties and a bunch of a promising new variety can be seen. (Photo: R. Jaramillo, INIBAP)

Research on developing new varieties also involves working with plant cells. New plants can be regenerated from these somatic embryos produced in the laboratory. (Photo: KUL)

Bananas and plantains are predominantly small-holder crops, and most growers cannot afford costly chemicals to control pests and diseases. As diseases such as the devastating black Sigatoka continue to spread, there is a growing demand for new varieties, especially those with in-built resistance. Bananas and plantains are difficult crops to breed because most of the important and popular varieties are highly sterile and do not produce seeds. Despite this, breeding programmes have made good progress in recent years and new varieties are starting to appear. However, considering its importance as a staple food, *Musa* remains an under-researched crop. INIBAP believes that through building collaboration and developing synergistic partnerships,

Musa *scientists meet to discuss recent progress and develop new ideas. Field visits allow the performance of new varieties to be observed first-hand.*
(Photo: S. Sharrock, INIBAP)

research output can be maximised and the impact of ongoing efforts will be accelerated. This focus on working together underpins INIBAP's efforts in *Musa* genetic improvement and has culminated in the establishment of PRO*MUSA*, a global programme for *Musa* improvement.

Musa germplasm improvement

Objectives: To make available to NARS a wide range of tested, improved *Musa* varieties through supporting, co-ordinating and carrying-out appropriate *Musa* improvement research.

Second global meeting

Excellent progress in PRO*MUSA* was evident at the second global meeting, which was held in Douala, Cameroon in November 1998. This meeting was attended by some 70 researchers and included meetings of the Genetic improvement, Sigatoka, Nematology and Virology working groups. Each group focused on reviewing priorities set in Guadeloupe and identifying work plans and opportunities for collaboration in the coming years. In addition to the individual group discussions, time was set aside for interactions between groups, and this was considered to be particularly useful.

This second global meeting also provided an opportunity for the PRO*MUSA* steering committee to meet for the first time. This committee is made up of representatives of NARS, ARIs and IARCs and is responsible for providing direction and oversight to the programme. At this meeting the Steering Committee endorsed the strategy and Medium Term Plan of PRO*MUSA*, as described in the Proceedings of the PRO*MUSA* meeting held in Guadeloupe in 1997.

Working group activities

Genetic improvement working group

In order to facilitate collaboration in specific areas, two subgroups were formed in 1998. These will address issues related to *Musa* karyology and *Musa* genetic mapping.

Musa *karyology*

In the framework of PRO*MUSA*, a novel method for the preparation of slides to allow high resolution chromosome studies has recently been developed (Doležel *et al.* 1998). This method results in chromosome spreads of a much higher quality than those previously used for karyological studies in *Musa*. The method thus allows chromosome numbers to be unambiguously determined and has been successfully used to confirm the reclassification of 'Kluai Tiparot' as a triploid clone. In addition to reliable chromosome counting, the method can also be used for high resolution studies of chromosome morphology and for physical mapping using *in situ* hybridisation methods. The development of this and other new methods and procedures has stimulated recent progress in plant cytogenetics. The *Musa* karyology subgroup will work together to develop collaborative projects in this area.

Ref.: Doležel, J. M. Doleželová, N. Roux and I Van Den Houwe. 1998. A novel method to prepare slides for high resolution chromosome studies in *Musa*. INFO*MUSA* 7(1):3-4.

PROMUSA
A Global Programme for *Musa* Improvement

FHIA-01 (Goldfinger) is resistant to Fusarium wilt (left), a fungal disease which causes devastating damage (right).
(Photo S. Sharrock INIBAP)

Genetic mapping
Although different genetic maps of *Musa* have been developed, during discussions in Douala, this sub-group agreed that existing banana genetic maps lack co-dominant, locus-specific and polymorphic markers easily transferable to all laboratories. The members of the group will therefore collaborate in the development of a saturated genetic map of *Musa,* which will be useful to:

- gain a true understanding of the genetic basis of the inheritance of agronomic and resistance characters despite distorted segregation frequently observed on bananas partially due to translocations,
- localize the main genes involved in the agronomic and resistance characters of interest in order to use them in marker-assisted selection (MAS) and ultimately to isolate them and use them in transformation,
- localize the break-point of translocations to increase the efficiency of improvement strategies based on MAS.

Segregating populations
An agreement has been signed between the *Corporación Bananera Nacional* (CORBANA, Costa Rica) and INIBAP to establish a number of segregating populations. These populations will be used in the identification of molecular markers for specific traits. Initial crosses have been made by the *Empresa Brasiliera de Pesquisa Agropecuaria* (EMBRAPA, Brazil) and the resulting populations will be established at CORBANA. Assuming good segregation is obtained, the populations will be evaluated for parthenocarpy, bunch orientation, resistance to black Sigatoka and *Radopholus similis* as well as various agronomic traits.

Virology working group

Banana streak virus (BSV)
Progress in the understanding of BSV was achieved during a meeting of the Virology working group, which was held in Montpellier, France in January 1998. The meeting focused on recent advances in research on the virus and resulted in a better understanding of the significance of integrated viral sequences in the *Musa* genome. Research needs were analysed and prioritised and current BSV indexing procedures reassessed in the light of research results. It was agreed that the existing indexing methods are still the most reliable for detecting a wide range of BSV isolates and revisions to the FAO/IPGRI Technical Guidelines for the Safe Movement of *Musa* Germplasm were not considered necessary. The proceedings of the meeting have been published by INIBAP providing important information on the state of the art of research on this unique virus.

Regarding the effects of BSV on yield, work in Australia has shown that in intensive well-managed plantations on cv. Williams, the effect of BSV appears to be only significant on crop cycle length (1-week delay) with a 7% loss in yield per annum. A similar but additive loss is reported for the ratoon crop. However, in poor agricultural conditions or under temperature fluctuations, the effect on yield is likely to be much greater.

Potex virus
Filamentous virus particles, which are serologically related to the potex virus found in the

ABB cultivar Pisang awak (Ducasse) in Australia have been identified in various cultivars. No, or only mild, visual symptoms are associated with these potexvirus-like particles. The same types of viral particles are also encountered in co-infection with cucumber mosaic virus (CMV) and BSV related to severe attacks and damage caused by the latter viruses. In the case of CMV infection they are strongly related to an additional symptom of necrosis. These different potexvirus-like particles are serologically related. Alone, they are propagated only vegetatively and the fact that they are in mixed infection would facilitate their dissemination in the same way as CMV, banana bract mosaic virus (BBrMV) or BSV.

Virus resistance

In Australia, Bluggoe and Cavendish have been transformed with genes for banana bunchy top virus (BBTV) resistance and are currently being tested. BBrMV resistance trials are also being planned. Similarly, in Hawaii, transgenic plants for BBTV resistance have been produced and a small proportion (6%) were apparently resistant to the first challenge of BBTV. PRO*MUSA* will facilitate the further testing of transgenic plants in countries where the relevant biosafety guidelines are in place.

Figure 1: Effect of seven Radopholus similis *isolates from different geographical locations on banana roots* (Musa *AAA cv. Poyo), 12 weeks after inoculation.* *(Photo: M. Boisseau, CIRAD).*

Douala meeting

During the meeting of the Virology working group in Douala, future research activities were identified and the work was divided between the various members of the group. These activities fall into three main areas:

- Development of reliable virus detection methods – to differentiate integrated and episomal BSV sequences and to detect the virus in plants with few or no symptoms,
- Further work on BSV – mechanisms of activation, differences between *Musa* varieties,
- Further development of transgenic virus resistance in order to eliminate particular viruses as a constraint to production.

Nematology working group

Evaluation

Evaluation trials to identify sources of resistance to the major nematode species affecting *Musa* are being carried out in the framework of PRO*MUSA* by INIBAP/VVOB Associate Experts in Vietnam (Vietnam Agricultural Sciences Institute, VASI) as part of an ACIAR-funded project and in Costa Rica (CORBANA). In addition, early screening is being carried out at the *Katholieke Universiteit Leuven* (KUL, Belgium). The work at KUL has identified two Fe'i varieties from Papua New Guinea with increased levels of resistance to *Radopholus similis*. No sources of resistance to other nematodes have been identified so far.

A proposal to enlarge the "*Musa* Nematologists Consortium" was presented to the Nematology working group during the meeting in Douala. This Consortium would focus on screening/evaluation experiments and trials and could be carried out by different partners as individual modules of a worldwide project. In order for results to be comparable from site to site, all evaluations would include standard/reference cultivars.

Breeding for nematode resistance

It is estimated that there might be 15-20 currently identified sources of resistance to *R. similis*, but only two are considered reliable (PJB and Yangambi Km 5). Further work is required on the 'usefulness' of the others.

Diversity studies

In work being carried out at CIRAD-FLHOR, France, the diversity within *R. similis* is being studied. There appears to be a direct relationship between reproductive fitness of nematode populations and resulting root damage. Virulence (the intrinsic ability to cause damage) in *R. similis* seems to be relatively uniform across populations of this nematode species, but aggressiveness (ability to multiply in plant tissues) varies widely from one population to another. The extent of plant damage is most likely linked to the latter trait (Figure 1). Moreover, there is no simple relationship between ecological conditions in any given area and aggressiveness of nematode populations.

Availability of information

The Nematology working group recognises that much information on *Musa* nematology is available, but is not always readily accessible. It has therefore been agreed that, within the framework of PRO*MUSA*, three special publications will be prepared on the following themes:

- A review of *Musa* nematode distributions worldwide,
- A review of work conducted on yield losses caused by nematodes to *Musa*,
- A review of studies of nematode resistance in *Musa*.

Sigatoka working group

Durability of resistance

The pathogen, *Mycosphaerella fijiensis,* is a highly variable organism with a high rate of genetic recombination and, as a result, a high capacity for change. Occurrence of resistance breakdown in previously resistant varieties, e.g. Paka and TU8 has been reported from Rarotonga and Tonga.

A key issue for this working group is therefore the durability of the resistance to the pathogens *M. fijiensis* and *M. musicola* in newly developed hybrids, and the detection and utilisation of alternative resistance sources in breeding programmes to reduce dependence on a relatively narrow resistance base.

During the meeting in Douala, the members of this group were able to clearly define their aims, which are to:

- develop a detailed understanding of population structures of the pathogens *M. fijiensis* and *M. musicola* in the different geographical areas,
- develop methods to determine the rate of change of pathogen structure in response to selection pressure from new banana genotypes,
- develop a better understanding of the mechanisms and inheritance of resistance in the host, in particular the genetic control of quantitatively and qualitatively inherited resistance,
- identify sources of resistance.

New leaf spot disease

A 'new' leaf spot disease has recently been reported from the South East Asian region. Leaf specimens were sent to CIRAD from collections in Asia between 1992 and 1995 to determine whether they were black or yellow Sigatoka. Diagnosis showed that there was a previously unrecorded fungus associated with the spots. There was no evidence of either the yellow Sigatoka or black Sigatoka pathogens. The new fungus had a *Septoria* anamorph stage, and a *Mycosphaerella* teleomorph stage. Isolation of the organism and reinoculation to banana reproduced the original symptoms and confirmed pathogenicity of the new fungus. Molecular analysis confirmed the identification of a new species and a molecular diagnostic method confirmed that the new fungus, isolated from all the localities sampled, belonged to the same species. The fungus has been confirmed from India, Sri Lanka, Thailand, Vietnam, Malaysia and Mauritius. It has been proposed that the fungus be classified as *Septoria eumusae* (asexual phase) and *Mycosphaerella eumusae* (sexual phase). The importance of this pathogen both as the cause of disease in Asia and as a potential threat to other areas has yet to be determined.

PRO*MUSA* publications

A number of publications were produced in the framework of PRO*MUSA* during 1998. These include:

- "Evaluation of *Musa* germplasm for resistance to Sigatoka diseases and Fusarium wilt" which was published as Guidelines No. 3 in the INIBAP Technical Guidelines series and produced in English, French and Spanish,
- The proceedings of the meeting of the PRO*MUSA* Virology working group on banana streak virus were published as "Banana streak virus: a unique virus-*Musa* interaction?"
- Two issues of PRO*MUSA* News have been published as special sections in INFO*MUSA.*

International *Musa* Testing Programme

Phase II of the UNDP-funded International *Musa* Testing Programme (IMTP) was completed in 1998. In addition to the results received from three countries during 1997, the results of the majority of participating countries: Australia, Brazil, Cameroon, Costa Rica, Honduras, Indonesia, Malaysia, Philippines, South Africa, Spain, Tonga and Uganda were received in 1998. In some places a complete analysis was not possible due to much missing data following natural catastrophes or other unforeseen circumstances (Colombia, India and Malaysia). Data is still outstanding from a few countries, including Thailand, St. Lucia and Cuba. The analysis of the results is well underway and will be finalised and available for distribution early in 1999. The analysis of the data includes the agronomic and disease evaluations and comparisons of means to the local and reference clones. The report will include graphics and charts to accompany the tables of results.

Initial results show that FHIA-23, a dessert banana hybrid produced by FHIA, has a very good level of resistance to black Sigatoka, even under high levels of disease pressure and produces good yields across a range of environments. FHIA-23 also seems to be tolerant to races 1 and 4 of Fusarium wilt. A number of other clones including materials from Taiwan (TBRI) and Brazil (EMBRAPA) also show promising results in terms of disease resistance.

A new phase of IMTP has begun with the publication of the Technical guidelines for

evaluation of resistance and tolerance to Sigatoka diseases and Fusarium. The guidelines include explanations of the pathological evaluations and suggest various possibilities for field designs. They also incorporate forms that can be photocopied for collecting data in the field. Each field form is accompanied by a database structure to be used to input data in a computer for further statistical analyses. The new phase of IMTP does not have a common planting date, instead each institute is encouraged to request material according to the most appropriate planting dates in their area. Several countries have expressed a desire to participate in this next phase of IMTP and have already requested material to evaluate.

An IMTP database has been developed containing information on the IMTP hybrids and reference cultivars. Data on agronomic and resistance traits, together with general performance information and photographs of the different clones is included. This database has already been made available to participants in IMTP phase II, as well as 20 other interested countries.

New accessions received from FHIA during 1998 were FHIA-25 and FHIA-26. FHIA-25 (Figure 2) was described in the INIBAP Annual Report 1997 (p. 29). FHIA-26, which resulted from a cross between Pisang awak and SH-3437, is very vigorous and is fast to flower and ratoon. This hybrid is highly resistant to black Sigatoka, and the green and ripe fruit characteristics are very similar to those of Pisang awak. It is not yet known if FHIA-26 has the Fusarium wilt resistance of its SH-3437 diploid parent, but if it does, it could be a very valuable beer banana in the regions of East Africa where Pisang awak is being destroyed by this disease.

Figure 2: FHIA-25 can be harvested hand-by-hand. *(Photo: P. Rowe, FHIA)*

Genetic transformation

Starting material for transformation

The starting materials for the genetic transformation of bananas and plantains are embryogenic cell suspensions. These are derived from scalps taken from proliferating shoot meristem cultures. Before high quality scalps can be prepared, most cultivars have to pass through several cycles on a proliferation medium with high levels of cytokinin (100 µM 6-benzyladenine (BAP), see INIBAP Annual Report 1997, p. 24). Despite continuous selection for groups of tiny white meristems at each subculture, meristem cultures on the proliferation medium are still very heterogeneous. Tiny white meristems, corm and leaf tissues are present in varying proportions depending on the cultivar and subculture. To obtain a better insight into the proliferation process and to determine whether these cultures can be more rapidly improved and homogenized, pictures of proliferating cultures are being taken weekly using the computer program MIROTelevision® (Figure 3). These archives will allow the full history of an ideal scalp, which has led to a suspension, to be traced back and examined.

The effect of the growth retardant Paclobutrazol (naphtaleneacetic acid ethyl ester) on proliferation was also tested since this compound strongly enhances the shoot inducing effect of BAP in some *Araceae*. Paclobutrazol was added at concentrations of 10, 20, 30 and 50 µM to regeneration (1 µM IAA and 1 µM BAP) and proliferation media (1 µM IAA and 10 µM BAP). The effects were tested on the cultivars Bluggoe and Cachaco, (good *in vitro* proliferation) and Grande Naine and Nakitengwa, (bad *in vitro* proliferation). Stunted shoots were obtained, but there was no increase in proliferation rates compared to the control. Therefore it was concluded that the proliferation rate of banana shoot tips, unlike those of the *Araceae*, is not influenced by Paclobutrazol.

Research is underway on the search for homogenous and transformation-competent cultures other than embryogenic cell suspensions. As meristems are readily available, research efforts were focused on the development of an *in vitro* system which produces transformation-competent meristem cultures similar to the proven transformation-competent multiple shoot clumps of maize. However initial results showed that *in vitro* procedures applied on corn shoot tips excised from seedlings grown *in vitro*, are not promising for banana if applied unmodified. To develop an *in vitro* system which produces homogeneous and transformation-competent meristem cultures in banana, parameters such as type and size of

Figure 3: Computer equipment used to monitor the development of proliferating cultures.
(Photo: KUL)

explant, age of donor plant, medium composition and environmental parameters need further investigation.

Establishment of embryogenic cell suspensions
In 1998, 3,336 scalps of 13 cultivars were inoculated. Results for 1,560 scalps that were incubated more than 3.5 months ago are presented (Table 1). In general, embryogenic responses were never higher than 2.1%. The only exception is Three Hand Planty with 12.5% of the total scalp number producing embryogenic complexes. This response is lower than normal, which is over 30%. However the Three Hand Planty meristem culture is getting old and was not always kept under optimal conditions. This confirms earlier findings that the embryogenic response drops in old cultures (Schoofs H., Ph.D. thesis, 1997). For the first time, calluses of the cultivars Grande Naine FHIA, Grande Naine JD and Williams JD were obtained.

No embryogenic response has been obtained so far for Calcutta 4, Burro CEMSA or Mbwazirume, though the blackening problems of Mbwazirume and other highland bananas are now under control. It was found that for cultivars such as highland bananas, most plantains and Calcutta 4, culturing in the dark for 2-3 weeks immediately after inoculation, is effective in controlling excessive blackening (Table 2).

The effects of gelling agent, container size and temperature fluctuations on the embryogenic response continue to be evaluated. Work has also been initiated on the use of male flowers as a source of embryogenic cultures.

Plant regeneration from cell suspensions
Somaclonal variation poses a serious limitation on the *in vitro* storage and multiplication of bananas and plantains. Several research groups have made comprehensive field studies on the frequency of somaclonal variation of meristem-derived plants. Similar field studies of cell-suspension derived plants are now also warranted as suspensions offer much promise for rapid multiplication and are routinely used for genetic engineering of bananas and plantains. Since somaclonal variation is linked to the genotype, preliminary evaluation should include varieties belonging to different genomic configurations. Therefore KUL is supplying cell suspension derived plants or suspensions for plant production of the following varieties: the plantains Three Hand Planty and Bise Egome-1 (AAB); the cooking banana Burro CEMSA (ABB); the highland banana Nakitengwa (AAA); the Cavendish variety Williams (AAA); and the dessert banana Kamaramasenge (AB) (Table 3). Control plants consist usually of meristem-derived

Table 1. Number of scalps inoculated in 1998 and preliminary embryogenesis responses.

Cultivar	ITC code	Medium	NS	NS3	RS	FREQ	FREQi
Agbagba	0111	ZZ	192	168	3	1.8	8.3
Agbagba	011	Zzag[a]	96	96	1	1.0	4.2
Burro CEMSA	1259	ZZ	96	96	0	0.0	0.0
Cachaco	0643	ZZ	24	24	0	0.0	0.0
Cachaco	0643	ZZag	24	24	0	0.0	0.0
Calcutta A[b]	-	ZZ	144	24	0	0.0	0.0
GN FHIA[c]	-	ZZ	360	120	2	1.7	8.3
GN FHIA	-	ZZag	72	72	0	0.0	0.0
GN JD[d]	-	ZZ	504	144	1	0.7	2.1
GN JD	-	ZZag	72	72	0	0.0	0.0
Gran Enano	1256	ZZ	240	96	2	2.1	2.1
Mbwazirume	0084	ZZ	96	48	1	0.0	0.0
Natiktengwa	1180	ZZ	408	120	1	0.8	0.8
Obino L'Ewai	0109	ZZ	120	48	3	2.1	2.1
Three Hand Planty	0185	ZZ	24	24	0	12.5	12.5
Three Hand Planty	0185	ZZag	24	24	0	0.0	0.0
Williams BSJ	0570	ZZ	48	0	0	0.0	4.2
Williams JD[d]	-	ZZ	696	264	9	1.1	4.2
Williams JD	-	ZZag	96	96	0	0.0	0.0
Total			**3336**	**1560**	**23**		
Mean						1.3	2.6

[a] *ZZ medium solidified with 7 g/l agarose instead of 2 g/l gelrite*
[b] *Derived via zygotic embryo rescue. Seeds obtained from IITA, Nigeria*
[c] *Hand-carried from FHIA*
[d] *Supplied from QDPI*
NS Total number of scalps inoculated in 1998
NS3 Total number of scalps longer than 3.5 months in culture (long enough for first embryogenic complexes to form)
RS Responsive scalps i.e. number of scalps forming embryogenic complexes
*FREQ Frequency (%) of scalps forming embryogenic complexes (RS/NS3*100)*
FREQi Highest frequency (%) in a single experiment.

Table 2. Effect of culture in the dark on scalp blackening.

Cultivar	ITC code	Medium	Light conditions	NS	BS
Agbagba	0111	ZZ	light	48	48
Agbagba	0111	ZZ	light	48	48
Agbagba	0111	ZZag	light	72	35
Agbagba	0111	ZZ	3 weeks dark	24	0
Agbagba	0111	ZZ	2 weeks dark	24	0
Nakitengwa	1180	ZZ	2 weeks dark	72	3
Obino L'Ewai	0109	ZZ	2 weeks dark	48	10

NS total number of scalps grown under these conditions (per experiment)
BS percentage (%) of scalps completely turning black and not forming meristematic globules.

plants grown on normal proliferation medium and on medium containing high BAP levels, as this is the medium used to obtain ideal scalps.

***Agrobacterium* mediated transformation**

Progress has been made at KUL on the *Agrobacterium*-mediated transformation of bananas and plantains. This technique is being developed as an alternative to particle bombardment as it allows the manipulation of larger pieces of DNA comprising several genes. As traits such as pest and disease resistance are generally controlled by several genes, the technique is considered to hold great potential. Initial trials have been carried out on cultured suspension cells of the plantain cultivar Three Hand Planty. Shoot induction has now occurred on selected putative transgenic colonies. The transgenic nature of the plants has been confirmed by histochemical staining of the β- glucuronidase enzyme expressed by the *gusA* foreign gene. The *gusA* gene construct had a plant intron inserted in the coding sequence eliminating the expression of the gene in the bacterium itself. Thus, positive staining indicates stable integration of the transgene in the banana genome. In total, 174 out of the 188 plants (92.5%) showed expression of the *gusA* gene in their leaf tissue. In another experiment, selection and shoot induction was performed on solid medium to allow individual handling of independent plants. So far, 40 plants have been regenerated of which 37 (92.5% again) showed positive histochemical staining. All transgenic plants are being micropropagated, maintained *in vitro* and subjected to molecular analysis such as PCR and Southern hybridization. The work has been able to demonstrate that *Agrobacterium tumefaciens* is not only compatible with various banana tissues in the early steps of their interaction, but it is able to deliver and integrate T-DNA into cultured banana cells.

Table 3. Important events in the establishment of embryogenic cell suspensions from scalps and the generation of transformed banana plants (Financing by KUL, BADC, EU, FC, the World Bank and INIBAP).

Year	Event	First cultivar	Number	SV (%)	Institute	Country
1978	Start *in vitro* meristem culture	several				
January 1984	Start work on somatic embryogenesis	several				
March 1989	First embryogenic cell suspension (ECS)	Bluggoe				
June 1989	First successfully cryopreserved ECS	Bluggoe				
July 1989	First plants regenerated from ECSs	Bluggoe				
End of 1991	First flowering plants in the field obtained via ECSs	Bluggoe	140	<1	IITA	Nigeria
1991	First plants in the field regenerated from a cryopreserved ECS	Bluggoe		96[a]	IITA	Nigeria
1992	First cell cultures showing transient expression	Bluggoe				
1993	First transformed banana plants[b] in the glasshouse	Bluggoe				
1994	First Cavendish ECS	Williams				
1996	First transformed Cavendish	Williams				
1997	Third cycle harvested of Cardaba plants regenerated from an ECS	Cardaba	36	0	CORBANA	Costa Rica
1997	First flowering transformed Cavendish plant in the glasshouse	Williams				
1997	Supply of plants regenerated from ECSs for field testing of SV	Three Hand Planty Bise Egome-1	750 250		IITA	Nigeria
1997	Supply of plants regenerated from ECSs for field testing of SV	Williams	400		Rahan Meristem	Israel
1998	First inoculation tests under controlled conditions with *Mycosphaerella fijiensis* of transgenic plants	Three Hand Planty Williams				
1998	Supply of plants regenerated from ECSs for field testing of SV	Williams	600		Rahan Meristem	Israel
1998	Supply of plants regenerated from ECSs for field testing of SV	Nakitengwa	300		IITA-ESARC	Uganda

[a] *74% of the controls (plants regenerated from non-frozen cell suspensions) were found to be off-types as well*

[b] *Insertion of genes encoding antifungal proteins*

BADC : Belgian Administration for Development Cooperation

EU : European Union

FC : Flemish Community

SV : Somaclonal variation

ECSs : Embryogenic cell suspensions

Gene expression

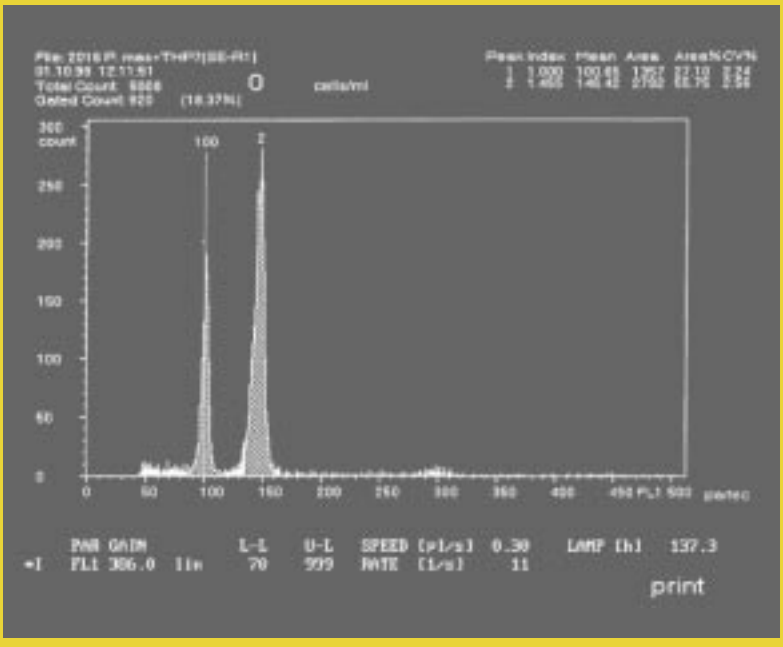
Besides alternative and more efficient transformation systems, novel tools are also required for high expression of foreign genes in banana and other tropical crops. To this end, as part of a collaboration with the Cooperative Research Centre of Tropical Plant Pathology in Brisbane (Australia) the expression characteristics of a new viral promoter in transgenic banana have been studied.

A putative promoter region was isolated from sugarcane bacilliform badnavirus that is able to infect banana. This 1369 bp DNA fragment (Sc) was inserted into a plant gene expression vector containing the *gusA* reporter gene and the resulting vector (pScGUS) bombarded into cultured suspension cells of the dessert banana Grande Naine or of the plantain Three Hand Planty. For comparison, transgenic plants were also produced with the *gusA* gene fused to the promoter and first intron of the maize ubiquitin gene *Ubi1* (pUbiGUS) or the enhanced cauliflower mosaic virus 35S (eCaMV35S) promoter. These two promoters are regarded as standards for strong constitutive gene expression in monocotyledonous or dicotyledonous plants, respectively.

Flow cytometry analysis of cell suspensions

Cell suspensions offer promise for rapid multiplication and are routinely used for genetic engineering of bananas and plantains. Flow cytometry, which is a powerful technique for ploidy assessment, offers prospects for quality monitoring of banana cell suspensions. This technique facilitates the verification of euploidy/aneuploidy of cells, conditions which result in somaclonal variation in cell-suspension derived plants. As part of this work, a four-year old embryogenic suspension culture of the cultivar Three Hand Planty was analysed and the results showed a normal triploid peak (Figure 1). Plants derived from this highly regenerable suspension have been planted in the field for evaluation of somaclonal variation, and preliminary observations on 50 glasshouse plants showed no variation during vegetative development. By contrast in another test, the peak of a suspension culture of cells for the cultivar Bluggoe exhibited a shift to the left, indicating a loss of chromosomes (Figure 2). The peak for this suspension lies in between the diploid control banana (Pisang mas, 2n=22) and the triploid leaves of Bluggoe in vitro *plants. Assuming a linear relation, this Bluggoe suspension seems to consist of cells with 28-29 chromosomes, but conclusive proof awaits chromosome counting. Since the peak is narrow, it seems the entire suspension has become 100% aneuploid during the extended period of subculturing (nine years). This suspension produced numerous off-types in the early years of culture, but its regeneration potential has now been completely lost. While the technique requires further testing on a wider range of genotypes, it would appear at this stage that flow cytometry analysis holds potential as a means to quickly identify poor quality suspension cultures. This work was carried out in the framework of the FAO/IAEA/BADC Co-ordinated Research Programme in which IAEA, INIBAP, FUSAGx and KUL collaborate.*

Figure 1. Flow cytometry analysis of leaves of the diploid banana Pisang Mas (Peak 1: 2n=22) and of Three Hand Planty somatic embryos regenerated from a 4-year old suspension (Peak 2: 2n=33). (Figure courtesy of IAEA).



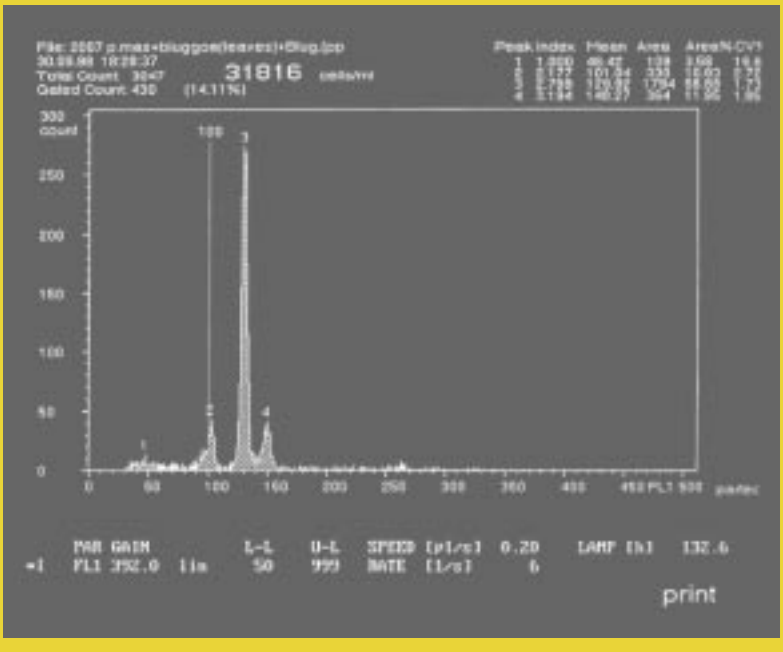


Figure 2. Flow cytometry analysis of leaves of the diploid banana Pisang Mas (Peak 2: 2n=22) and of protoplasts derived from the 9-year old Bluggoe suspension (Peak 3: 2n=28-29?) and of leaves of the triploid cooking banana Bluggoe (Peak 4: 2n=33). (Figure courtesy of IAEA).

Transient expression of the *gusA* gene was observed two days after transformation by histochemical staining. The number of blue foci, which refers to the number of transformed cells, was comparable or higher with the Sc promoter than those obtained with the ubiquitin promoter. Furthermore, in transgenic banana plants, the new promoter drove *gusA* expression in different vegetative tissues and cell types including the leaf, pseudostem, corm and root. Quantitative measurements of ß-glucuronidase enzymatic activity in 25 independent transgenic lines revealed that the Sc promoter expressed in the greenhouse and under *in vitro* conditions at a similar level as the eCaMV35S promoter and the ubiquitin promoter, respectively. These results demonstrate that the new Sc promoter could be an important tool to obtain strong constitutive expression of transgenes in banana.

Research on genetic transformation at KUL is funded by the Belgian Agency for Development Cooperation (BADC).

Focus paper 1

Fluorescent *in situ* hybridization of plant chromosomes: illuminating the *Musa* genome

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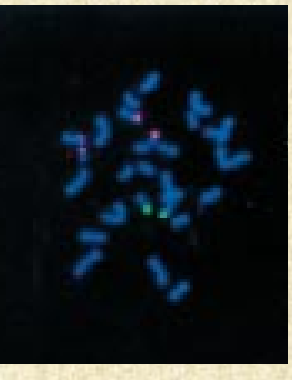
Introduction

Characterisation of banana and plantain germplasm has until now, been largely based on the use of phenotypic characters and more recently on molecular markers such as RFLP and RAPD (see INIBAP Annual Report 1996, p. 24-28). Cytogenetic studies have proved difficult in the genus *Musa* because of the small size of the genome (550 Mbp, Doležel *et al.* 1994), just 10% of the barley genome for example, and the large number of chromosomes (2n=3x=33 in most banana cultivars, compared to 2n=2x=14 in barley). Molecular cytogenetic studies, which link data about the molecular composition and organisation of the genome with the chromosomes, offer greater understanding of phylogenetic relationships and improved clarity of taxonomic discrimination, allowing the identification of aneuploids and assisting selection. In recent years, there have been rapid advances in the direct observation and analysis of banana chromosomes using molecular cytogenetic methods. This focus paper provides some information on the applications of such techniques in relation to banana and plantain research.

Figure 1. Double FISH showing the rDNA sites on somatic metaphase chromosomes of Narenga. The 18-25S rDNA site are visualized in green (FITC) and the 5S rDNA sites are visualized in red (Texas Red). The chromosomes are counterstained with DAPI (blue). (Courtesy of CIRAD)



In Situ hybridisation

The *in situ* hybridisation (ISH) technique, developed more than 30 years ago (Gall and Pardue 1969, John *et al.* 1969) allows genes or DNA sequences to be directly localised on chromosomes in cytological preparations. The development of user-friendly fluorescent techniques (Langer-Safer *et al.* 1982, Pinkel *et al.* 1986) has greatly increased the application of this technique during the last 15 years. Fluorescent *in situ* hybridisation (FISH) allows hybridisation sites to be visualised directly and moreover, several probes can be simultaneously detected with different fluorochrome, allowing the physical order on the chromosomes to be determined.

For the FISH technique, DNA sequences to be localised are first labelled to produce the probe. The probe is coated on the target chromosome which is spread in a hybridisation buffer. After treatment to denature the DNA into single strands, the probe and target are allowed to re-anneal. The probe will bind specifically to the complementary site on the chromosome. After washing and detection with a fluorescent reporter, a discrete fluorescent signal is visible at the site of probe hybridisation, which can be visualised using a fluorescent microscope (Figure 1).

One of the important modifications of the ISH technique is genomic *in situ* hybridization (GISH) (Schwarzacher *et al.* 1992). GISH is a genomic painting technique which allows parental genomes in interspecific hybrids to be distinguished (Figure 2). Total genomic DNA from one parent is labelled as a probe and unlabelled total DNA of the other parent is used as a block. Alternatively, total DNA from both parents is labelled and these are both used as probes, each one revealed with a different fluorochrome. This technique is based on the rapid evolution during speciation of repeated sequences, which represent the major part of plant DNA. If the species are distant enough, the repeat sequences allow the chromosomes from the two parental species to be differentiated.

Applications

Untangling the A, B, S and T genomes by genomic *in situ* hybridization

The classification of *Musa* cultivars into genomic groups has so far been based on chromosome numbers and morphological traits (Cheesmann 1947, Simmonds and Shepherd 1955) as well as

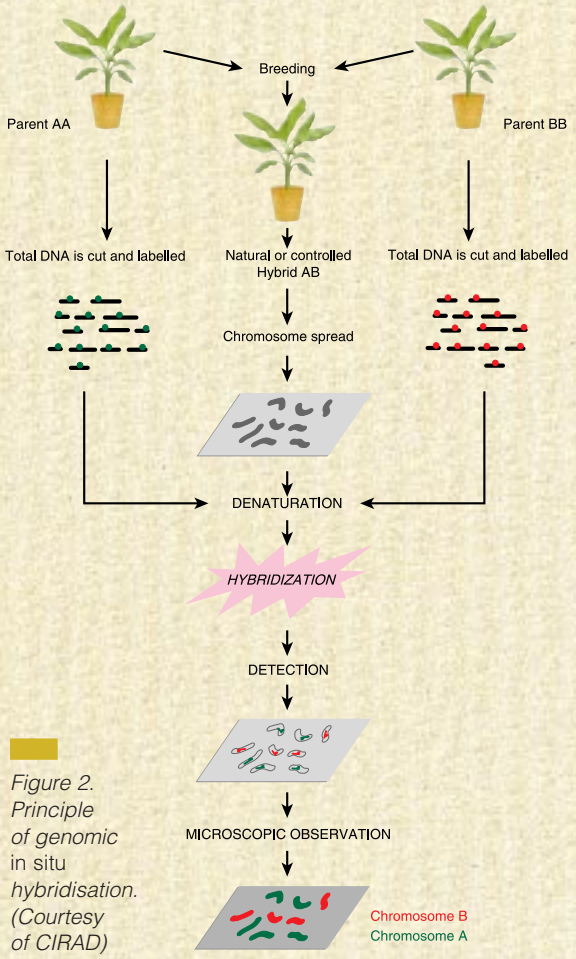


Figure 2. Principle of genomic in situ *hybridisation. (Courtesy of CIRAD)*

more recently, on molecular markers. GISH however provides a powerful complementary tool to molecular markers, enabling the portion of the genome contributed by each parental species in interspecific hybrids and their derivatives to be visualised (Figure 3). This technique has allowed the chromosomes from the four wild *Musa* species, *M. acuminata*, *M. balbisiana*, *M. schizocarpa* and the *Australimusa* species, involved in the origins of cultivated bananas to be differentiated (Osuji *et al.* 1997, D'Hont *et al. in press*).

The exact genome structure of several interspecific cultivars has been examined using GISH. The results were in most cases consistent with the chromosome constitution estimated through phenotypic descriptors, with one notable exception. The clone 'Pelipita', was found to contain 8A and 25 B chromosomes, instead of the 11A and 22 B predicted (Figure 4).

Using molecular markers, it was recently confirmed that the species *M. schizocarpa* (S genome) and species of the *Australimusa* section (T genome) have contributed to the origin of some cultivars (Carreel 1994). However, it was not possible to determine what proportion of these species are present in the genome. Using GISH it was possible to demonstrate for example, that the S genome contributed a full set of S chromosomes to the cultivar Wompa. Similarly, GISH showed that one basic set of T chromosomes are present in the cultivars 'Karoina'and 'Yawa 2'and established their genome constitution as AAT and ABBT, respectively (Figure 5).

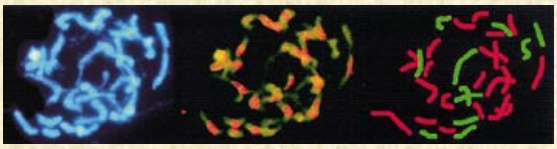


Figure 3. Metaphase of triploid plantain Mbi Egome (AAB): a. The 33 chromosomes stained blue with the DNA stain DAPI; b. In situ *hybridisation of genomic A DNA (red) and B genomic DNA (green); c. Interpretation shows the red labelled regions on 22 chromosomes; the other 11 chromosomes are labelled only with green. (Courtesy of John Innes Center)*

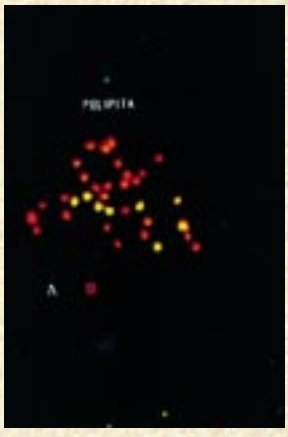


Figure 4. GISH on somatic metaphase chromosomes of 'Pelipita'using total DNA from a BB clone revealed in red with Texas Red and total DNA from an AA clone revealed in green with FITC. (Courtesy of CIRAD)

Identifying individual *Musa* chromosomes and visualising DNA sequences

Individual chromosomes are difficult to identify conventionally because they are so similar. However individual chromosomes can be defined by the hybridisation of specific cloned or synthetic repetitive DNA sequences (Osuji *et al.* 1998, Doleželová *et al.* 1998). For example the 18S-25S rDNA is present at a single site in each genome and can be used to define that chromosome. This has a further significant use as this single site in each genome enables easy assessment of basic ploidy levels in hybrid or tissue culture material. The hybridisation pattern obtained can also provide indicators of recent and evolutionary rearrangements in the genomes (Figure 6).

The development of similar markers (repeated sequences, BAC, etc.) for the various linkage groups will enable the different chromosomes to be assigned to respective linkage groups and will thus efficiently complement genetic mapping efforts. This would also open the way for the investigation of structural rearrangements which are reported to be frequent in bananas (Faure *et al.* 1993). These rearrangements result in important irregularities in meiosis and irregular chromosome transmission and may have been involved in the development of sterility, a prerequisite for edible fruit.

Understanding BSV

FISH can be used to analyse the numbers and loci of other chromosomal sequences and it has been used to analyse the integration of banana streak

Figure 5. GISH on somatic metaphase chromosomes of 'Yawa 2' using total DNA from a AA clone revealed in green with FITC, total DNA from a BB clone revealed in red with Texas Red and DAPI counterstaining (blue). (Courtesy of CIRAD)

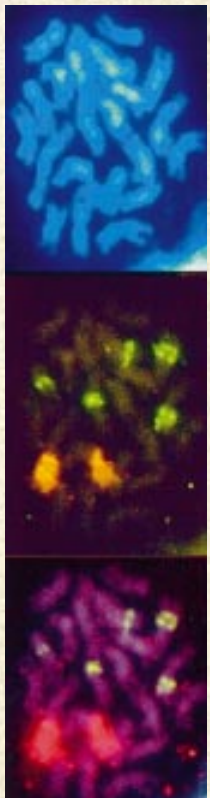


Figure 6. In situ *hybridisation to chromosomes of an AA* Musa *hybrid: a. The 22 chromosomes stained blue with DNA stain DAPI; b. Five sites of hybridisation to 5S rDNA probe (green); c. Single site hybridisation to 18S-25S rDNA probe on each of the two genomes. (Courtesy of John Innes Center)*

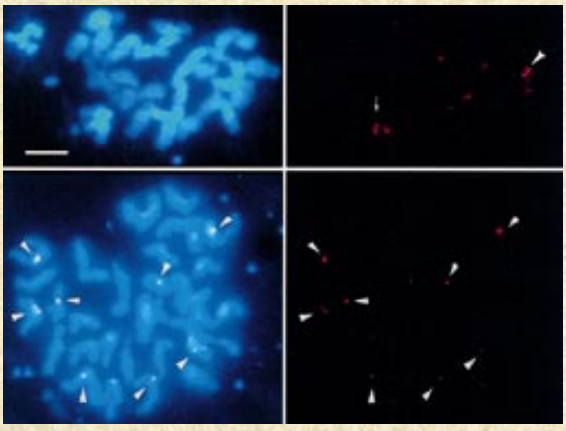


Figure 7. Musa *genotypes Cavendish (AAA) and Obino L'Ewai (AAB) showing hybridising (integrated) BSV sequences.*
In situ *hybridisation to metaphase spreads of Obino L'Ewai:*
a. The 33 chromosomes stained blue with the DNA stain DAPI.
b. Hybridisation sites of BSV (red) showing one major site in each metaphase (arrowhead) and at least one minor site (arrow).
In situ *hybridisation to metaphase spreads of Dward Cavendish:*
c. The 33 chromosomes stained blue with the DNA stain DAPI.
d. Hybridisation sites of BSV (red) showing at least eight major site in each metaphase (arrowhead).
(Courtesy of John Innes Center)
Bar = 5 µm

virus (BSV) DNA into the *Musa* genome. Numerous lines of evidence including PCR and genomic Southern analysis pointed to the possible integration of BSV sequences (LaFleur *et al.* 1996, Ndowora *et al.* 1997, Harper and Hull 1998). To examine whether these BSV sequences in high molecular weight DNA were actually in the *Musa* nuclear chromosomes, double target *in situ* hybridisation was conducted on chromosomes from the plantain cultivar Obino L'Ewai, using a probe specific to BSV and a probe specific to a *Musa* sequence. Both probes gave hybridisation signals on chromosomes of Obino L'Ewai. A major hybridisation site to BSV was detected on both chromatids of one chromosome in each metaphase and at least one weaker hybridisation site was regularly seen. This clearly demonstrates that viral sequences are integrated in the nuclear genome. The *Musa* probe showed hybridisation to multiple sites throughout the genome, including near the major BSV site, but was not uniformly dispersed.

Representatives of AA, AAA and BB genome *Musa* were analysed by FISH and all showed clear hybridisation of BSV sequences. The strength of the signals indicates that multiple copies of the target sequence were integrated at most of the observed sites (Figure 7.) This is further compelling evidence that BSV sequences are integrated into the *Musa* genome and that this integration must have been an ancient event.

Visualisation of fine scale DNA structure

The organisation of gene and DNA structures can be visualised by a relatively new method, that of *in*

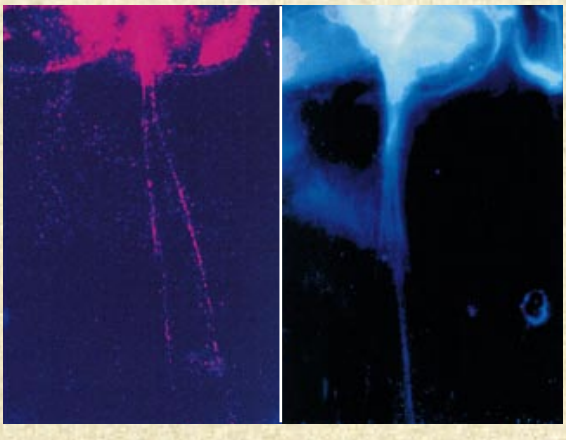


Figure 9.
Rye interphase nucleus:
a. DAPI staining shows the strechted DNA as blue fibres running downwards.
b. A highly repetitive ribosomal DNA probe labels multiple sites on some but not all of the fibres. Here, the fibres are too bundled for detailed analysis of the gene structure, but the relationship between nucleus, the fibres and the probe is evident.
(Courtesy of John Innes Center)

Figure 8. Cartoon of an interphase nucleus fixed to a slide: a. The blue chromatin labelled at eight sites by a red in situ *hybridisation probe; b. After lysis of the nucleus and tilting of the slide the DNA fibres are stretched to their full molecular length. They can hybridise with the same probe and now clearly show the relationship between probe and fibre. (Courtesy of John Innes Center)*

situ hybridisation of probes to DNA fibres extended to their full molecular length (Fransz *et al.* 1996, Brandes *et al.* 1997, see also Schwarzacher *et al. in press*). Theoretical considerations of the length of the extended DNA molecule and calibration from hybridisation with probes of known length and interspersion pattern (Fransz *et al.* 1996, Sjöberg *et al.* 1997) can relate the lengths of observed fibres to the numbers of bases (Figures 8 and 9).

This technique was used to investigate the structure of the integrated BSV sequence. A genomic clone (Ndowora *et al. in press*) and PCR-based methods (Harper *et al. in press*) had shown that the integrated sequence adjacent to a *Musa* interspersed sequence was complex, containing an inverted region and some very highly rearranged stretches. Stretched DNA fibres were prepared on slides from Obino L'Ewai nuclei. Double-target hybridisation with the genomic *Musa* sequence and BSV showed long rows of hybridisation sites ('dots') along stretched DNA fibres. The *Musa* sequence was present at sites associated with the BSV hybridisation sites and also independently as variable lengths of rows of dots (Figure 10). It was apparent that there were two different lengths of *Musa*-BSV chains of dots present in approximately equal numbers. Some were 50 µm long, representing structures containing multiple copies of BSV sequences (150 kb long) and others were 17 µm long (about 50 kb structures). Each group of fibres, long and short, showed common patterns of red and green signal sites and gaps, with repeating units of BSV sequence adjacent to *Musa* sequence. The longer structure is considered to correspond to the major hybridising site seen on metaphase chromosomes while the shorter structure, corresponded to the minor hybridisation site.

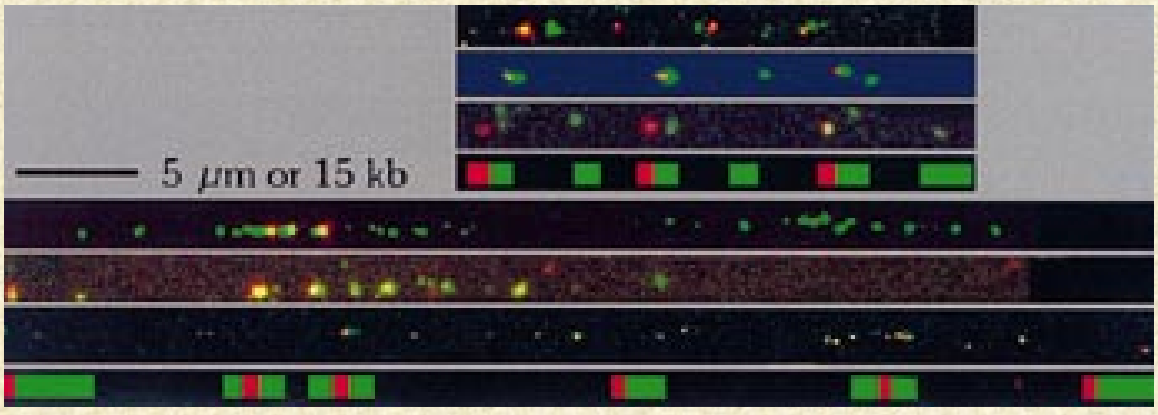


Figure 10. Fibre stretches of Musa *Obino L'Ewai AAB showing hybridising BSV and associated* Musa *sequences. In situ hybridisation to extended DNA fibres from Obino L'Ewai nuclei. Green and red dots represent probe hybridisation sites to BSV sequences and associated* Musa *sequences respectively. Two different patterns of chains of dots were detected:*
a. Three independent and aligned long fibres above a consensus diagram of hybridisation pattern showing red sites and chains of green signals. Both the Musa *and BSV sequences are present in multiple copies in the structure of 150 kb, in at least two different relative orientations, and are separated by gaps with no hybridisation (no homology to probes).*
b. Three aligned short fibres above consensus diagram, showing a pattern that can be interpreted as three sub-repeats. Under the hybridisation, detection and imaging procedures used, individual signals are larger than expected from the probe length, may be slightly displaced from the axis, and some supposed target sites may not have a detectable signal. (Courtesy of John Innes Center)
Bar = 5 µm*, corresponding the 15 kb DNA fibre length.*

Conclusion

Molecular cytogenetic methods are adding a powerful set of tools to those already available to study genome organisation, evolution and recombination. GISH has immense potential for identification of chromosome origin and can be used to characterise cultivars and hybrids produced by *Musa* breeding programmes. Repetitive and single copy DNA probes are yielding insights into the relationship between genetic and physical maps of *Musa* and genome evolution. Finally, fibre *in situ* hybridisation can be used to examine the organisation of genes and DNA sequences. Together, these techniques provide data for *Musa* breeders, which can be used to tackle the challenges caused by banana streak virus, tissue culture and somaclonal variation, the use of wild germplasm in breeding and the irregular transmission of chromosomes during meiosis. *In situ* hybridisation therefore holds great potential to help scientists develop optimum breeding strategies in order to create high quality and disease resistant bananas.

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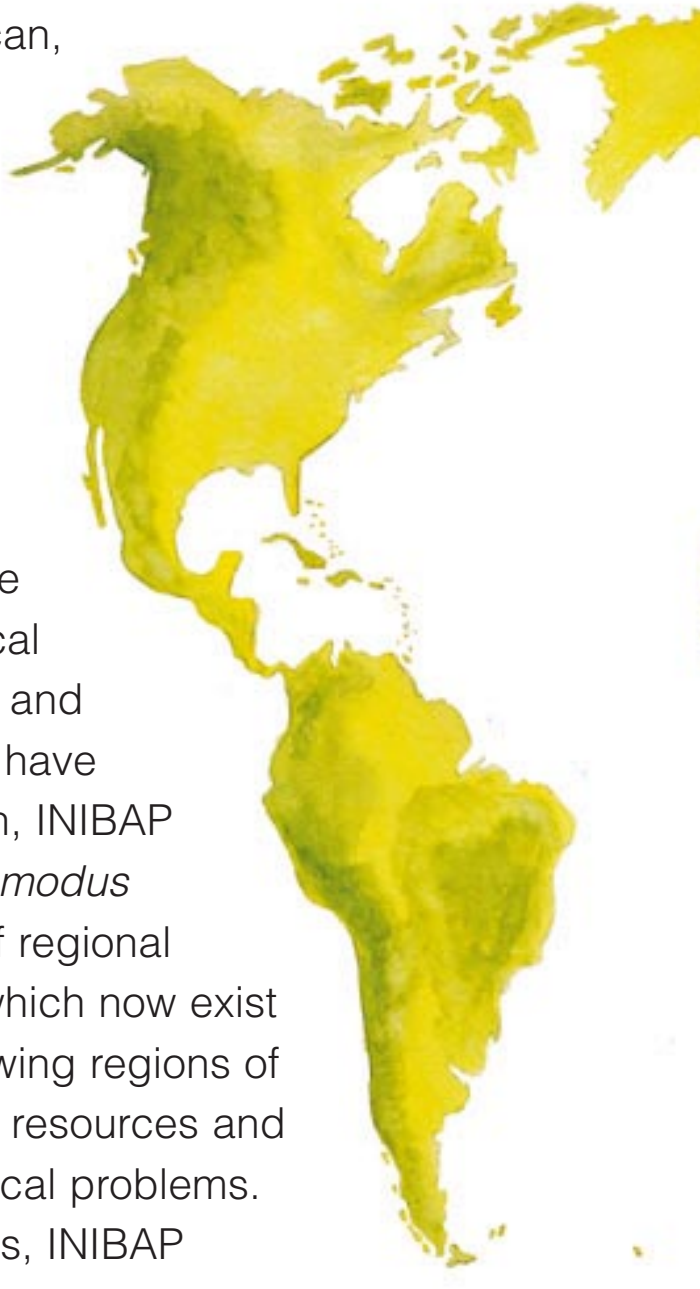
Strengthening national programmes through networking

Bananas and plantains are important throughout the developing countries of the tropics and sub-tropics. About a third of global production is produced in each of the African, Asia-Pacific, and Latin America and Caribbean regions. While some production problems are common across regions, and can be addressed globally, this is not always the case. Each region also has its own very distinct needs, and these are best addressed at the local level. Because many banana and plantain-producing countries have limited resources for research, INIBAP encourages networking as a *modus operandi*. In the framework of regional banana research networks, which now exist in the four major banana growing regions of the world, countries can pool resources and work together to overcome local problems. Through the regional networks, INIBAP



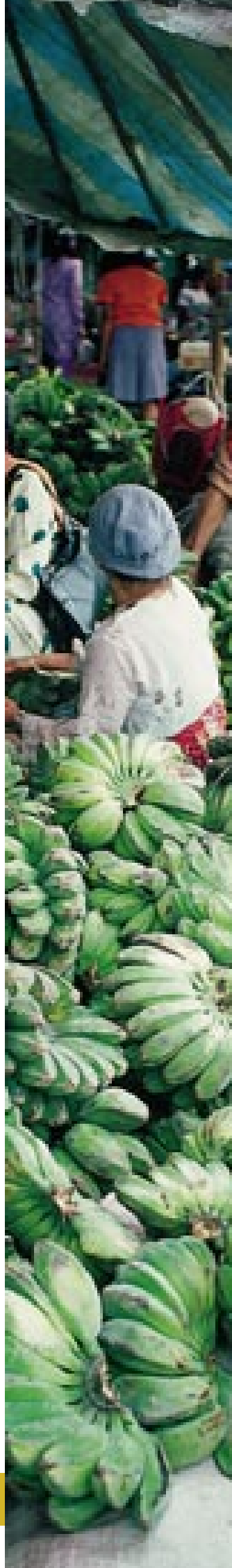
Bananas are transported to market by canoe in Peru.
(Photo: T. Lescot, CIRAD-FLHOR)

In west Africa, plantain markets are lively and colourful events.
(Photo: E. Akyeampong, INIBAP)

Bicycles are frequently used to carry bananas from production areas to central collection points in Uganda.
(Photo: S. Sharrock, INIBAP)

In Asia, it is not only the fruit that is eaten. Immature male buds are also popular.
(Photo: S. Uma, NRCB)

focuses on supporting capacity building activities, and encourages collaborative research initiatives.



INIBAP around the world

Objective: To work with NARS on research and development activities for bananas and plantains in order to strengthen NARS ability to conduct such research and to develop appropriate technologies and facilitate their adoption by farmers.

Latin America and the Caribbean

Hurricane damage
Banana and plantain producers in Central America and the Caribbean suffered considerable losses during 1998 as a result of Hurricanes 'Georges' and 'Mitch'. Puerto Rico, Dominican Republic, Haiti and Cuba were badly affected by 'Georges' which swept away practically all the plantations in the first three countries and caused damage in 70% of Cuba's production areas. Hurricane 'Mitch' devastated almost the whole banana and plantain production area in Honduras, and Nicaragua and Guatemala were also badly affected.

Improved hybrids in Cuba
Cuba continues its efforts to multiply and distribute black Sigatoka resistant improved germplasm, which consists mainly of hybrids developed by FHIA. By October of this year, more than 8,000 hectares were cultivated with FHIA hybrids. Following the damage caused by Hurricane 'Georges', it is clear that the FHIA hybrids are better able to withstand strong winds than other cultivars. This is especially the case with FHIA-18, which is the hybrid preferred by farmers due to its high yields. Only 5% of the areas cultivated with FHIA-18 suffered losses as a result of hurricane winds. FHIA-23 showed less resistance than FHIA-18 towards the hurricane winds, but was highly superior to Cavendish. Damages reported for Cavendish were more than 70% while FHIA-23 losses were around 20%. FHIA-03 losses ranged around 15% mainly due to up-rooting and not to pseudostem breakage, thanks to the very vigorous nature of this plant.

Spread of black Sigatoka to Brazil
Following confirmation of this devastating disease in Brazil in the early part of 1998, INIBAP-LACNET supported the activities of EMBRAPA in its efforts to develop a strategy to minimise the damage caused by this disease. An expert team including the INIBAP Regional Coordinator for Asia and the Pacific and an INIBAP-hired consultant visited the affected area (along the banks of the Amazon River near the border with Colombia) in order to assess the situation and develop measures for preventing further spread of the disease. Management practices for controlling the disease, which threatens nearly half a million hectares of *Musa* in Brazil, were also discussed.

IDB project
The project "*Musa* research and technology transfer network" for Latin America and the

Transporting bananas and plantains on the Amazon river in Brazil.
(Photo: A. Molina, INIBAP)

Caribbean, financed by the Inter-American Development Bank (IDB) and executed by INIBAP, came to an end in August this year. This project lasted for two years and included the participation of six research institutions: FHIA, Honduras; CORBANA, Costa Rica; EMBRAPA, Brazil; *Corporación Colombiana de Investigación Agropecuaria* (CORPOICA, Colombia); Windward Islands Banana Development and Exporting Company (WIBDECO, St. Lucia); and *Centro Agronómico Tropical de Investigación y Enseñanza* (CATIE, Costa Rica). The breeding programmes from the region received considerable support for banana and plantain improvement activities and their germplasm collections, where more than 1000 accessions are maintained, were also strengthened.

The major contribution of this project to the local banana and plantain sector has been the generation of new hybrids resistant to the pests and diseases of greatest economical importance in the region: black Sigatoka, Moko and nematodes. At FHIA, 300 new diploid hybrid plants were produced by cross pollination, with potential resistance to both black Sigatoka and nematodes. In addition, a number of improved hybrids, including FHIA-25 were developed. At EMBRAPA, 72 diploid hybrid plants are undergoing testing for Moko resistance. Generated diploids will be used as improved parents for further development of new cultivars.

Musa variety testing for black/yellow Sigatoka and Fusarium was implemented in five countries and 33 different cultivars were evaluated for Sigatoka and Fusarium resistance. A Regional Centre for multiplication and distribution of elite cultivars was established at CATIE, Costa Rica. Here eight black Sigatoka (virus tested) resistant hybrids are being mass-propagated for distribution to countries in Latin America and the Caribbean. One thousand plants of each variety are awaiting distribution as “seed bed” material for local propagation and distribution to farmers. Training and documentation activities also formed an important part of the project.

Organic banana production workshop

INIBAP-LACNET, together with the Agricultural School for the Humid Tropical Region (EARTH), Costa Rica, organised an international workshop on Organic/Environmentally friendly banana production, with funding provided by IDB. The objective of this workshop was to analyze the current knowledge regarding organic banana and plantain production and to identify the requirements for sustainable and economically profitable organic production of this crop. Twenty-five banana, plantain and organic production experts from ten countries attended this meeting and shared their experiences on this topic. The important role that pest and disease resistant varieties can play in organic production was noted. It was recommended that an information centre on *Musa* organic production be established together with an organic production network to evaluate the impact of production alternatives chosen for validation.

Regional Advisory Committee meeting

The 7th meeting of INIBAP’s Regional Advisory Committee (LACNET-RAC) was held from July 4-7, 1998 in Manzanillo, Colima, Mexico. This event was co-sponsored by the Inter-American Development Bank and by the *Instituto Nacional de Investigaciones Forestales, Agrícolas y Pecuarias* (INIFAP) from México. Seventeen scientists from 13 countries of the region participated in this meeting.

INIBAP LACNET and INIFAP coordinated efforts so that the 7th RAC meeting would coincide with the Black Sigatoka International Workshop co-sponsored by both institutions. Seventeen Regional Advisory Committee (RAC) members and two INIBAP scientists participated in this event.

In Colombia, donkeys are useful to transport plantains.
(Photo: T. Lescot, CIRAD-FLHOR)

Musa Germplasm Information System
A regional MGIS training course was held at *the Instituto Nacional de Investigación Fundamental en Agricultura Tropical* (INIFAT), Cuba from September 21-26. Twelve *Musa* genebank curators from LACNET countries participated in the training. The hands-on training included the use of computer software to manage germplasm characterisation data as well as a field exercise in collecting such data.

ICIA/INIBAP-LACNET co-operation
Reciprocal scientific exchange visits between scientists from the Canary Islands and LAC continues, and the programme for a second phase was agreed upon by INIBAP for implementation in 1998/1999. Under this agreement, four scientists from the *Instituto Canario de Investigaciones Agrarias* (ICIA, Spain) were able to visit CORBANA and FHIA and two of them participated on the international workshop on organic banana production at EARTH. One scientist from CATIE and one from CORBANA also visited ICIA. Production practices, biotechnology, breeding, mycorrhizae, and root/soil interactions, were among the subjects discussed.

Caribbean banana network
The Ministers of Agriculture of the Caribbean have mandated the Caribbean Agricultural Research and Development Institute (CARDI) and the *Instituto Interamericano de Cooperación para la Agricultura* (IICA, Costa Rica) to stimulate networking on banana and plantain, to provide the industry with state of the art technology relevant to the Caribbean situation and to promote systems that contribute to food security and natural resource management. INIBAP-LACNET has been contacted by the organisers to discuss co-operation between this new initiative and INIBAP.

Banana and plantain development in Ecuador
The LACNET Regional Coordinator assisted a Belgian team in a two-week mission to Ecuador to identify research and production constraints in *Musa* in order to finalize a document for the project “Banana and plantain production development in Ecuador”. This programme will have a strong technology transfer component and a focus on small to medium scale farmers. It also involves a component of applied research directed towards solving problems related to fertiliser application, drainage and fruit quality for export. One aim of the project is the creation of a national banana and plantain research and extension institute for Ecuador.

INIBAP-LACNET Biotechnology working group
This year the INIBAP-LACNET Biotechnology working group met at La Havana, Cuba, in parallel with the Third Latin American Biotechnology Meeting-“REDBIO 98”, organised by FAO. A *Musa* workshop was organised by INIBAP within REDBIO 98 and more than 80 scientists participated. REDBIO 98 itself attracted around 700 participants. The *Musa* workshop was co-sponsored by the *Instituto de Biotecnología de Plantas* (IBP) from Cuba. The speakers included: Juan Pérez Ponce and Rafael Gómez Kosky from IBP, Kazumitsu Matsumoto from EMBRAPA-CENARGEN, Brazil, François Côte from CATIE, Costa Rica; Miguel Gómez Lim from the *Centro de Investigaciones y de Estudios Avanzados de Irapuato* (CINVESTAV, Mexico); and Françoise Carreel from CIRAD-FLHOR, Guadeloupe. This group was joined by Carmen Ponz from the *Instituto de Investigaciones en Viandas Tropicales* (INIVIT, Cuba) and María del Carmen Vidal and Eva de Garcia from the Central University of Venezuela, who also presented their most recent advances in biotechnology.

Agreement with Peru
A co-operation agreement between the Government of Peru and INIBAP was signed this year. Even though Peru is not known as a banana producing country its acreage of bananas and plantains has increased dramatically in the last 10 years. By 1997, more than 100,000 hectares were reported. The Ministry of Agriculture has launched a significant banana project in the Tumbes region, in the north of Peru. The main goal of this project is to help small-scale banana producers to recover from crop losses caused by the “El Niño” phenomenon. A total of 800 families in this area will benefit from the project, which is planning to rehabilitate 1,000 hectares of banana. INIBAP-LACNET provided assistance in the planning of the project and is co-ordinating the training component for the technicians involved in managing the project. So far two Peruvians have been trained in production practices at CORBANA and two others attended the international symposium on black Sigatoka organised by INIFAP in Manzanillo, Mexico.

Agreement with CORBANA
INIBAP signed a special agreement with CORBANA, Costa Rica to develop three segregating populations to conduct genetic studies on black Sigatoka, nematodes and Fusarium. A complementary agreement was also made by which an INIBAP/VVOB Associate Expert is now working with CORBANA in the area of plant nematology. Ir. Thomas Moens, a Belgian citizen, joined CORBANA in June 1998 to take up the post.

Banana market at Trichy, India
(Photo: S. Uma, NRCB)

Asia and the Pacific

Many of INIBAP-ASPNET's activities during 1998 were carried out with support provided by the UK's Department for International Development (DFID).

Partnership with APAARI
To enhance collaboration between INIBAP-ASPNET and relevant partners in the region, an important Memorandum of Understanding (MoU) was signed by the Director General of the International Plant Genetic Resources Institute (IPGRI) and the Executive Secretary of the Asia Pacific Association of Agricultural Research Institutions (APAARI). This MoU provides a framework for collaboration and partnership between IPGRI-INIBAP and APAARI and places ASPNET under the auspices of APAARI.

Germplasm collecting and characterisation in India
In accordance with the provisions of the MoU for Scientific and Technical Co-operation between the Indian Council for Agricultural Research (ICAR) and IPGRI, INIBAP entered into a collaboration with two ICAR agencies, namely the National Research Centre on Banana (NRCB) and the National Bureau of Plant Genetic Resources (NBPGR).

As part of this agreement, NBPGR is acting as an active *in vitro* banana genebank, providing virus-tested accessions received from the ITC to the Indian sub-continent. Fifty-two accessions have been received from the ITC and these are being multiplied *in vitro*. A set of 37 accessions has also been supplied to NRCB, Trichy for multiplication in the field for characterization and evaluation.

Also under this co-operation, INIBAP also provided assistance to NRCB to explore and collect the *Musa* genepool in the north-eastern region of India. So far, 36 accessions have been collected from the states of Assam and Meghalaya. A more extensive mission was conducted in December 1998, including other states. The preliminary survey indicated much variability in ABB and *balbisiana* clones.

Characterisation in China
Exploration and collecting missions in China were concluded in 1997. The material collected was established in field genebanks at the South China Agricultural University in Guangzhou. In 1998, characterisation and identification of synonyms were the main activities. Twenty-three accessions have been characterised completely using the IPGRI/INIBAP *Musa* descriptor list. The data has been recorded in the MGIS database, including photos of each accession and has been submitted to INIBAP for future exchange with other genebank curators.

***Musa* Germplasm Information System**
The first regional MGIS training course took place from July 6-11 at the Centre for Wet Tropics Agriculture in Queensland, Australia. Banana genebank curators from 10 ASPNET countries participated in the training. The hands-on training included the operation of computer software designed to allow curators to input, manage and share germplasm characterisation data. The Philippines and China have so far submitted new characterisation data using the system.

The MGIS database software is also being used as a teaching aid at the College of Agriculture, University of the Philippines at Los Baños. Dr Espino recently introduced the MGIS software for teaching a taxonomy course to horticulture students. The MGIS *Musa* Descriptors allow students to learn the key characteristics of bananas used in taxonomic differentiation. The subsequent input and management of data using the MGIS software gives the students the opportunity to appreciate the use of computers in data management and analysis. Dr Espino was a participant in the first regional MGIS training given by INIBAP.

Collecting and transportation yard in Khasi hills, north-east India
(Photo: S. Uma, NRCB)

Regional Advisory Committee (RAC) meeting
The 8th ASPNET-RAC meeting was held in Brisbane, Australia from October 21-23, 1998. This was hosted by the Queensland Horticulture Institute of the Department of Primary Industries. The meeting included reports of RAC members of relevant national activities on banana and plantain research and development. Australian researchers updated RAC members on significant banana research activities in Queensland, with emphasis on developments in banana biotechnology, Fusarium and virus diseases. A planning discussion was held to identify issues to be addressed within the region in 1999. These included: characterisation of germplasm to update the MGIS database; continuation of targeted collecting missions; resolving banana synonyms; further research on Fusarium, Sigatoka and viral diseases; development of a regional multiplication centre; and information activities in the framework of the Regional Information System for Banana and Plantain - Asia and the Pacific (RISBAP).

Workshops/training
INIBAP-ASPNET was involved in organising and co-sponsoring a number of workshops and training courses in 1998. A regional workshop on "Disease Management of Banana and Citrus: the use of and management of disease free planting materials" organised with the Food and Fertilizer Technology Centre for Asia and the Pacific (FFTC-ASPAC) with BPI and the Philippines Council for Agriculture, Forestry and Resources Research and Development (PCARRD) as co-sponsors, brought together 17 speakers from the region and beyond. A number of virologists from the USA, Australia and Taiwan were among the invited speakers. The outputs of the workshop included recommendations regarding research priorities, development activities and policy recommendations to improve the control of virus diseases in both banana and citrus production throughout the region.

Taking advantage of the presence of experienced virologists, the workshop was followed by a training course in virus indexing held at the University of the Philippines at Los Baños. Seventeen researchers and technicians coming from state colleges and private laboratories working directly on tissue culture production of banana planting materials attended the training. They were trained on how to detect banana virus infection using ELISA and PCR-based techniques. This training was relevant since banana bunchy top and banana bract mosaic viruses are serious banana diseases in the Philippines. Providing training to properly detect banana virus infection will help to ensure the production of disease-free planting materials. The use of clean planting materials by small-scale farmers will play an important role, not only in reducing the effects and spread of virus diseases, but also in reducing losses caused by nematodes and weevils.

First national banana seminar in Malaysia
INIBAP was a cosponsor of this workshop, which brought together, for the first time, all the stakeholders in banana research and production in Malaysia. The meeting focused on the promotion of banana as a sustainable industry for Malaysia and the need to integrate the wide range of existing activities being carried out on this crop in Malaysia. A major output of the workshop was the recommendation to create a national banana coordination secretariat, which would serve as the focus for networking between the various players in banana research, development and production.

Support for Asian participation in the international symposium "Bananas and food security"
In November 1998 the international symposium "Bananas and food security" was held in Douala, Cameroon (See page 41). In preparation for the meeting, INIBAP-ASPNET sponsored a marketing study on the smallholder banana industry in the Philippines, the results of which were presented at the symposium. In addition, three Asian scientists were sponsored to participate in the symposium.

The participation of Asian scientists was particularly welcome at the symposium as small-scale, entrepreneurial activities, involving a diversity of banana-derived products are much more developed in this region than elsewhere. Participants from Africa and Latin America agreed that there was much to learn from the Asian experience and there is a great need for exchange of information and expertise between the different regions.

Rehabilitation of cooking bananas from "blood disease": Commercial demonstration trials in Sumatra island
"Blood disease", a destructive banana bacterial disease, is traditionally serious in the Sulawesi area of Indonesia and has devastated the cooking banana Kepok (Saba) in this region. In recent years severe outbreaks of this disease have also been seen on the southern tip of Sumatra, in the region of Lampung, where it is now seriously threatening the smallholder banana crop. Banana sales provide an important source of revenue for small-scale farmers in this region and production losses therefore hit the poorest farmers hardest. INIBAP-ASPNET has entered into an agreement with the Research Institute for Fruits in Indonesia,

to conduct demonstration trials on the management of this disease. A disease management programme, that has proven effective in previous studies in the Philippines, is being adapted in "blood disease" ravaged farms in Sumatra Island. The strategy being developed is simple and practical and is expected to control this disease that is presently seriously affecting small-scale banana farms.

Banana research and development at the Bureau of Plant Industry, Philippines

INIBAP-ASPNET is working with the Philippines government on a three-year project for the maintenance, characterisation and evaluation of the Southeast Asian banana germplasm collection at Davao National Crop Research and Development Centre, Bureau of Plant Industry, Philippines. The collection includes a field genebank of 179 accessions from the Philippines, Papua New Guinea, Malaysia, Thailand, and Indonesia. One hundred and fifty-two of these accessions are duplicated *in vitro*. The major problem of the collections is virus infection. As of April 1998, all of the accessions were indexed and found free from BBTV and CMV. However, some were positive to BBrMV and BSV. One of the major efforts in maintaining the germplasm is keeping the accessions free from virus infection. A new field genebank site has been established this year, using clean planting materials. Passport data for 153 accessions has been entered into the MGIS database and sent to INIBAP.

RISBAP and publications

The ASPNET secretariat distributed 251 publications during 1998. In addition, the Minutes of the 7th Regional Advisory Committee meeting, Asia and Pacific Network held in Hanoi, Vietnam on October 21-23, 1997 were published. Copies were sent to ASPNET RAC members and NARS and institutions of the regional network.

Three issues of the RISBAP Bulletin were published and distributed in June, August, and October 1998. This bulletin aims to keep network members informed about ongoing activities, upcoming conferences, seminars and workshops, new publications, and other technical information of regional interest.

For the RISBAP database, the ASPNET base received a total of 197 contributions: from Taiwan (83), Malaysia (64), and the Philippines (50). Information received is being converted and merged to the RISBAP database for submission to INIBAP headquarters for integration into *MUSA*LIT.

Funds for RISBAP's activities are provided by Taiwan.

Decapitation method for sucker production in the Kagera region, Tanzania. (Photo: KDCP)

Eastern and Southern Africa

The regional Banana Research Network for Eastern and Southern Africa (BARNESA), for which INIBAP provides coordination and secretariat, consists of 10 NARS: Burundi, Democratic Republic of Congo, Ethiopia, Kenya, Madagascar, Malawi, Rwanda, Republic of South Africa, Tanzania and Uganda. In addition the international and regional centres, INIBAP/IPGRI, IITA, the International Center for Insect Physiology and Ecology (ICIPE, Kenya) and the *Institut de recherches agronomique et zootechnique* (IRAZ, Burundi) are *ex-officio* members of the network.

Baseline information

During visits to NARS in the region early in 1998, it was observed that for most countries, there was a complete lack of baseline information about bananas and banana-based farming systems. This lack of information means that policy makers are largely unaware of the important role that bananas play in national economies in the region and explains the relative lack of support for research activities related to bananas in many countries. Baseline information is also essential before embarking on research and development activities in order to provide a base against which impact and achievements can be measured.

As a first step in developing a regional research strategy, BARNESA therefore organised a regional baseline information workshop supported by the Rockefeller Foundation. At this workshop, banana production constraints were identified and prioritised and critical information gaps highlighted. A key output of this meeting was a

IPM meeting resolutions

The meeting recognised that:

- *In relation to its importance as a staple food and rural cash crop, research on bananas is under-funded. The meeting participants therefore called for greater investment in banana research,*
- *Technologies are ready and available for testing on-farm, therefore steps should be taken to implement this – a proposed project title is: "Farmer participatory testing of banana IPM options for sustainable banana production",*
- *The target group for such testing is small-scale, resource-limited farmers, taking into account the gender of these farmers,*
- *Baseline information is a pre-requisite for impact assessment studies, both of which should be included in all project activities,*
- *The participation of all stakeholders—farmers, extension workers, NGOs, community based organisations, and researchers—in the planning and execution of activities is essential and all work must be carried out in a multi-disciplinary manner. Similarly, the implementation of projects should be through partnerships with farmers, NGOs and CBO's, making use of available methodologies for technology sharing and training, such as Farmers' Field Schools,*
- *Critical banana IPM research gaps have been identified as well as research partners that can contribute to address these. However, funding is essential for this research. Further research needs will be identified with the participation and input of the primary stakeholders.*

This meeting was organised with funding provided by Swiss Development Cooperation, Rockefeller Foundation, Natural Resources Institute and the Belgian Agency for Development Cooperation.

collaborative research proposal between BARNESA members (NARS and Centres) and other organisations that have a comparative advantage for handling baseline information and databases in the region. It is believed that the collection and analysis of baseline information will provide much need quantitative data on the importance of bananas to national economies in the region and thus provide the stimulus and justification for greater investment in research on this crop. As a first step in collecting baseline information, existing data will be collected and collated and information gaps will be identified.

Regional research strategy

Under the leadership of the Regional Coordinator, BARNESA has developed a five-year strategy and work programme, which provides details of a regional banana research agenda in which all BARNESA members will participate. In developing the plan the network members have demonstrated a strong willingness to support BARNESA and a spirit of collaboration and commitment to banana research is evident.

Taste testing of different banana varieties, Kagera region, Tanzania.
(Photo: KDCP)

Palatability testing of six banana varieties in Kagera region.

Banana cultivar	Fried/ cooked	Dessert	Brewing	Roasted	Preferred uses
Aacv Rose	nt	**	*	*	Dessert
Cardaba	*	nt	nt	*	Cooked/Fried
FHIA-01	**	**	*	*	Cooked/Dessert
FHIA-02	*	**	**	*	Dessert/Brewing
FHIA-03	**	**	*	*	Cooked/Dessert
Km 5	**	*	**	*	Cooked/Brewing

** : acceptable — ** : very much acceptable — nt : not tested*

Uganda germplasm collection

Support was provided to the National Agricultural Research Organisation (NARO), Uganda for the characterisation and relocation of the banana germplasm collection. This collection contains a large number of accessions from the region as a whole and is an important resource for regional banana research. The relocation of the collection will ensure the continued healthy growth of plants in the collection.

Integrated pest management (IPM) meeting

An important event organised by BARNESA during 1998, in collaboration with IITA, was an IPM workshop, which was held in South Africa in November. This workshop was attended by more than 50 scientists from Africa and beyond. As the workshop was organised in the framework of BARNESA, the focus was primarily on IPM options for small-scale *Musa* farmers in East and Southern Africa. However the presence of IPM researchers from other parts of Africa served to broaden the scope of the meeting and give it an Africa-wide perspective. The workshop provided a forum for the exchange of information and research results related to banana IPM activities and the proceedings of the meeting will provide an important publication detailing the 'state-of-the-art' of banana IPM. Research gaps requiring further attention were identified, together with IPM options already available and ready for testing in IPM 'packages' on-farm, in the framework of BARNESA and the *Musa* Research Network for West and Central Africa (*MUSA*CO). These options include the use of clean planting material, host plant resistance and cultural management practices.

BARNESA Steering Committee meeting

A second BARNESA Steering Committee meeting was held in November 1998. This was attended by representatives of all the network member countries and *ex-officio* international institutes. During the meeting, progress over the last year was reviewed and plans for 1999 discussed. During the meeting the network members gave a vote of thanks and appreciation to BADC for the support provided to INIBAP, which has allowed BARNESA to make significant progress over the last year.

Germplasm characterisation in Tanzania

As reported in the INIBAP Annual Report 1997, in the framework of the Kagera Community Development Project (KCDP), a number of improved and introduced varieties are being multiplied and tested in the Kagera region of Tanzania.

During 1998, the KCDP, working in close collaboration with KUL and the Agricultural Research Institute (ARI-Maruku, Tanzania) continued expanding the multiplication and demonstration fields of 15 superior banana varieties: AAcv Rose, Cardaba, FHIA-01, FHIA-02, FHIA-03, FHIA-17, FHIA-23, IC 2, Kamaramasenge, Km 5, Pelipita, Pisang Berlin, Pisang Ceylan, Saba, SH3436-9. The project covers the five districts of the Kagera Region and now includes 30 fields and more than 26,000 mother plants. By the end of 1998, 25,000 suckers were available for diffusing to farmers and for expansion of multiplication and demonstration fields.

Varieties are continuously evaluated under farmers' conditions. The acceptance by farmers is evaluated through palatability tests. These tests have given some positive results and it seems that more varieties can be used as cooking bananas than expected. Palatability tests organised along the Victoria Lakeshore show that FHIA-01 tends to surpass FHIA-03 as a cooking bananas but during other tests Cardaba was more popular than all the FHIA hybrids because of its taste.

Based on morphology, farmers were not impressed by AAcv Rose and some even refused to plant this variety in the demonstration fields. During palatability tests however, AAcv Rose ranks high and sometimes even surpasses local varieties as a dessert banana.

Bananas harvested from test fields have already found their way to the local markets, showing the acceptance of the new varieties by the farmers and their customers.

West and Central Africa

Following the establishment of the regional office in 1997 and the appointment of a Regional Coordinator, 1998 saw the consolidation and strengthening of relations with partners in West and Central Africa.

Collaboration with CRBP

Recognising the global role of INIBAP in *Musa* research and development and the close relationship between Cameroonian research institutions and INIBAP, the Minister of Scientific and Technical Research of Cameroon invited INIBAP to be a member of the Executive Committee of CRBP, the institution hosting the regional office. INIBAP seconded a VVOB associate expert in entomology and a biotechnology intern to CRBP.

***MUSA*CO**

The regional *Musa* research network (*MUSA*CO), established under the auspices of the *Conférence des Responsables de la Recherche Agronomique Africains* (CORAF) as the banana and plantain network for West and Central Africa, grew from 10 countries to 12 during 1998. Benin and Sierra Leone are the new members.

At the second annual *MUSA*CO Steering Committee meeting held in Douala, Cameroon and attended by all 12 member countries, IITA, CRBP and INIBAP/IPGRI, a draft network strategy was discussed and a draft version agreed upon. Participants also discussed and accepted that surveys to collect baseline data from benchmark sites in each country be a priority activity for 1999. It was agreed that the on-farm methodology used to describe and diagnose constraints and to monitor changes in production systems on a continuous basis, which is currently being used in Cameroon by CRBP, should be introduced into other countries. *MUSA*CO members gave a vote of thanks and appreciation to BADC for the support provided to INIBAP, which has allowed *MUSA*CO to make significant progress over the last year.

The Regional Coordinator visited Côte d'Ivoire, Gabon, Central Africa Republic, Guinea, and Democratic Republic of Congo to discuss possible collaboration with INIBAP and to present the goals and objectives of the newly formed *Musa* network, *MUSA*CO. On these trips, which were a continuation of those initiated in 1997, the Regional Coordinator obtained first-hand knowledge of the situation of *Musa* research and development in the countries and institutes and had the opportunity to meet with researchers, managers and policy makers. Some of these trips were joint missions with management of CRBP.

Transport of bananas at Gueckedou market, Guinea.
(Photo: E. Akyeampong, INIBAP)

Roadside plantain production in Cameroon.
(Photo: S. Sharrock, INIBAP)

Support to regional research

Plantain and banana yields in West and Central Africa are low, ranging from 5 to 15 t/ha, mainly due to losses caused by black Sigatoka, nematodes and weevils. INIBAP provided support to the International Centre for Development Oriented Research in Agriculture

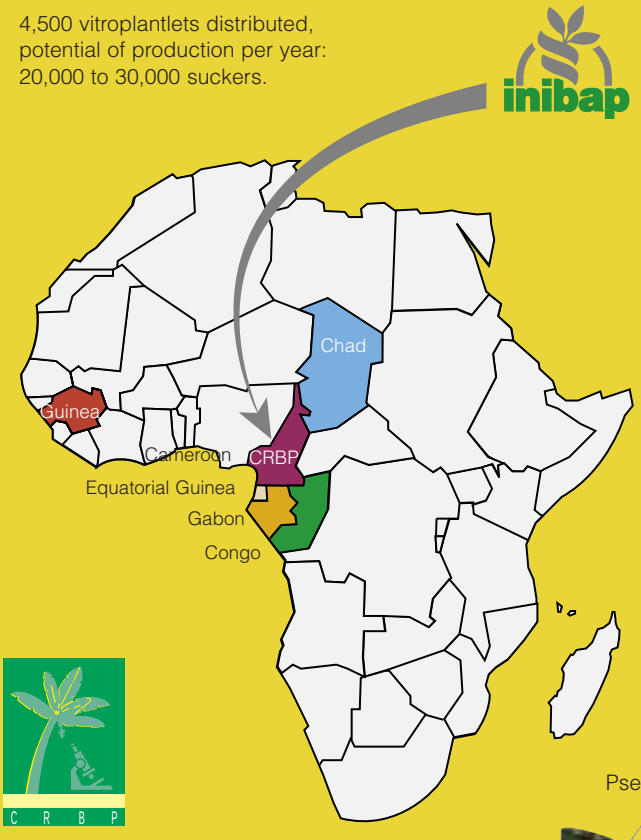
Regional multiplication centre

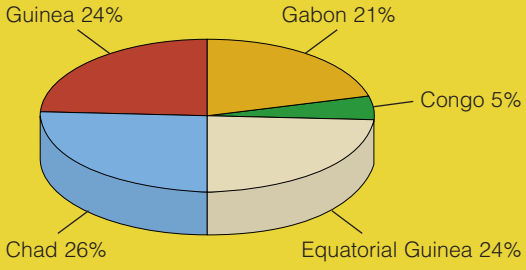
Following an agreement signed in 1996, CRBP acts as a regional multiplication centre for INIBAP.
The centre holds a collection of 50 virus-tested accessions, supplied by INIBAP. These accessions are multiplied in vitro *and used to supply the region with planting material according to demand.*

Map of distribution

Distribution in central and West Africa

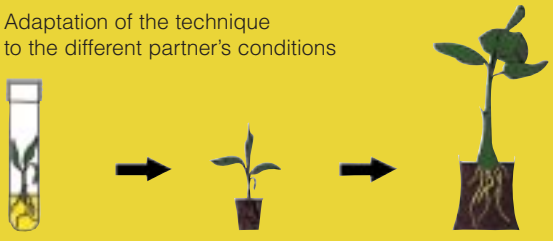
4,500 vitroplantlets distributed,
potential of production per year:
20,000 to 30,000 suckers.





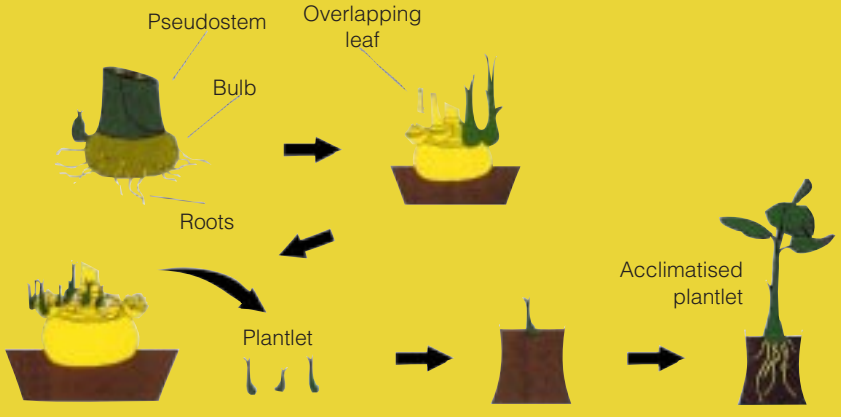
Acclimatisation of the vitroplantlets

Adaptation of the technique
to the different partner's conditions



Nursery multiplication under shade house

Multiplication on de-leafed bulb
(E. Auboiron 1997)



Acclimatised plants are planted in field/greenhouse nursery plots for further production of suckers to supply to farmers.

(ICRA) in Central African Republic, *Institut national pour l'étude et la recherche agronomiques* (INERA) in the Democratic Republic of Congo and *Institut sénégalais de recherche agronomique* (ISRA) in Senegal to introduce and evaluate new high yielding, disease and pest resistant varieties.

Lack of clean and healthy planting material in sufficient quantities also limits the expansion of areas under *Musa* production in West and Central Africa. Productivity suffers as farmers plant suckers contaminated with diseases and pests that produce low yields. INIBAP has therefore provided the Agricultural Research Station of the University of Ghana funds to study improvements in the split corm technique as a means to rapidly produce good quality suckers.

Capacity building

The network has been able to play a role in capacity building in the region. Funds were provided to support the participation of *Musa* scientists in the international symposium 'Bananas and food security' held in Cameroon in

November 1998. In addition, INIBAP supported surveys in Benin and Senegal that described the *Musa* production systems in these countries. These reports were presented at the symposium. Several scientists from the region were also sponsored to attend the Banana IPM meeting held in South Africa in November 1998 and a student from Côte d'Ivoire is spending three months training at CRBP.

International symposium "Bananas and food security"

The first international symposium on the socioeconomics of non-export banana production was held in Douala, Cameroon in November 1998. The symposium focused on all types of bananas and plantains grown for local consumption and was attended by more than 150 participants from all *Musa* producing regions of the world. The symposium was jointly organised by CRBP and INIBAP in collaboration with CTA and CIRAD.

The presentations made during the symposium confirmed the important role that bananas and plantains play in food and income security in the tropical and sub-tropical regions of the world. It was also recognised that this crucial role is still largely ignored by decision makers and that therefore a special public awareness effort is required to sensitise policy makers in both producing countries and donor countries.

The symposium also highlighted the great diversity related to banana and plantain production. This diversity covers varieties grown, systems of production and methods of consumption and utilisation. It was emphasised that research towards improving production must be based on consumers needs, and must be multi-sectorial and multi-discipline. Research should also be participative, and take into account the needs of all the actors in the marketing channel, from producer to consumer.

In view of the wide range of experiences and information presented during the symposium, it became clear that there is an essential need to exchange experiences in the area of socioeconomics. This was indeed the most important recommendation emerging from the symposium. In addition, it was recommended that information on consumer needs should be assembled and analysed and brought together with data on available sources of supply. Studies are also required towards improving traditional utilisation processes.

IPM for banana weevil borer

Research into the development of an integrated pest management strategy against the banana weevil borer, *Cosmopolites sordidus*, has been re-initiated by an INIBAP/VVOB Associate Expert located at CRBP, Cameroon. Initial efforts are focused on:

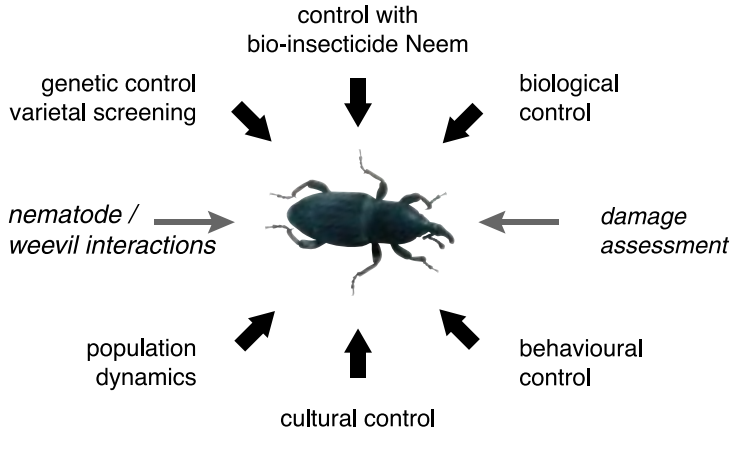
- varietal screening for resistance and tolerance, including the development of an early screening method and screening in the field under high parasite pressure,
- the use of Neem seeds (*Azadirachta indica)* as a bio-pesticide,
- biological control with the fungus *Beauveria bassiana* and with entomopathogenic nematodes,
- development of methods for population dynamics studies,
- behavioural control based on enhanced trapping techniques using pheromones,
- cultural control, including the use of clean planting material together with hot water treatment or paring of suckers, and the use of crop rotations.

Previous research has shown that weevils can cause severe damage even in the first production cycle. In a field trial in the South West of Cameroon, more than 75% of plants of the plantain variety French Sombre were destroyed by foraging larvae during the first cycle. Giant Cavendish was more tolerant to the weevil attack. Although a similar proportion of the mats were attacked (85%), plant mortality was only 20%.

The mode of action of Neem and the *in vivo* efficiency of various application methods, both in the greenhouse and field, are being assessed. Results show that Neem has a repellent rather than a toxic effect on the adults of *C. sordidus*. Although the application method needs further improvement, it has been shown that Neem applied to the suckers at planting can reduce the damage caused by the weevil larvae.

The research strategy in relation to integrated pest management of *C. sordidus* is summarised in the Figure below.

IPM of Cosmopolites sordidus *at CRBP*



Focus paper 2

Musa production around the world – trends, varieties and regional importance

Suzanne Sharrock and Emile Frison

Introduction

Bananas and plantains are cultivated in over 100 countries throughout the tropical and sub-tropical regions of the world. They are grown over a harvested area of approximately 10 million hectares, with an annual production of around 88 million metric tonnes, of which approximately one third is produced in each of the African, Asia-Pacific and Latin America and Caribbean regions. The vast majority of producers are small-scale farmers growing the crop either for home consumption or for local markets.

Bananas and plantains are popular for many reasons. They are one of the cheapest foods to produce. The cost of production of one kilogram of plantain for example being less than for most other staples, including sweet potato, rice, maize and yam (Chandler 1995). They will also grow in a range of environments and will produce fruit year-round, thus providing a source of energy when other crops are not available. They are particularly suited to intercropping systems and to mixed farming with livestock and are also popular as a backyard crop in urban settings. In mixed farming systems, bananas are often used as a ground shade and nurse-crop for a range of shade-loving plants including cocoa, coffee, black pepper and nutmeg. In many countries, bananas are more than just a food crop. Among other uses they also provide an important source of fibre and are fermented to produce alcohol. (See INIBAP Annual Report 1996, Focus Paper 3).

Banana and plantain production at the global level is characterised by diversity. This diversity manifests itself in the varieties that are produced, the way they are prepared, eaten and marketed, and in the systems in which they are produced. However, within each region, certain similarities

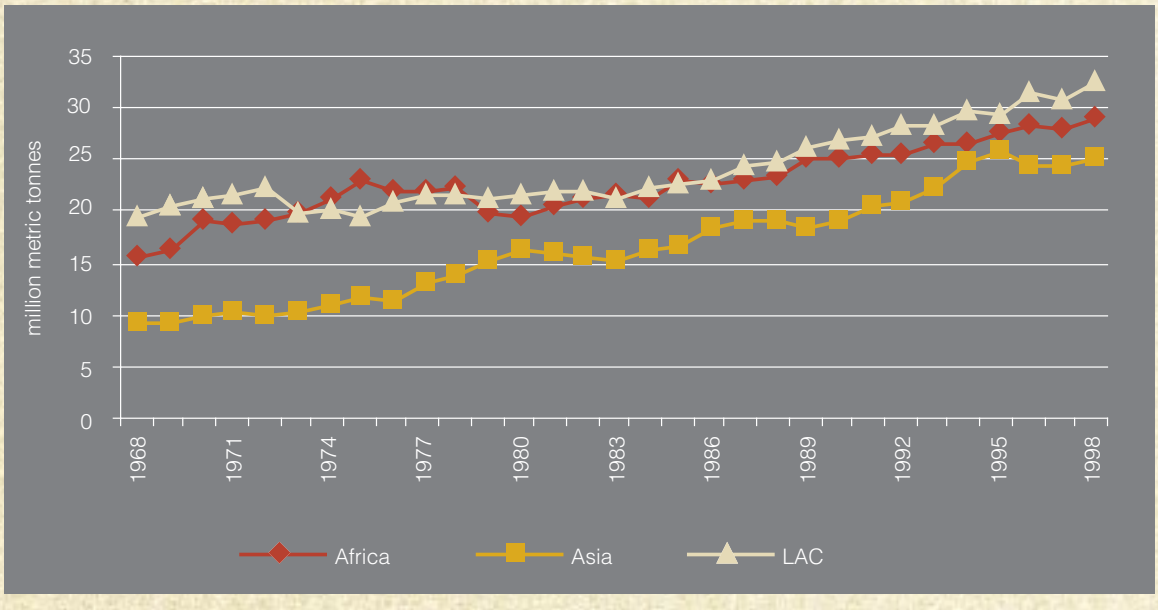


Figure 1. Increase in Musa *production by region, 1968 to 1998*

All production data used in this paper are obtained from the FAO Agricultural Production Statistics Database (FAOSTAT) or from INIBAP, in collaboration with CIRAD-FLHOR.

can be found. This Focus Paper gives an overview of production trends at the global level, followed by a synthesis of banana and plantain production in each of the three major producing regions. Information is provided on the diversity and origins of bananas and plantains in each region and the importance of the crop for local populations.

Trends in production

Over the last thirty years, global *Musa* production has grown by 90%, from 46 million tonnes in 1968 to 88 million tonnes in 1998. This increase in production has occurred in all regions (Figure 1). At the global level, average yields of bananas and plantains have risen by around 18%, from 8.45 t/ha in 1968 to 9.96 t/ha in 1998. However this yield increase occurred primarily in Asia between 1970 and 1980 (Figure 2). Yields in Africa and Latin America and the Caribbean have not changed significantly in the last 30 years and increases in production are due almost exclusively to an expansion in the area under *Musa* production (Figure 3).

Main producing countries

Although more than 100 countries produce bananas and plantains world-wide and 22 produce more than one million tonnes per year, the top five producing countries (Table 1) account for 44% of world production.

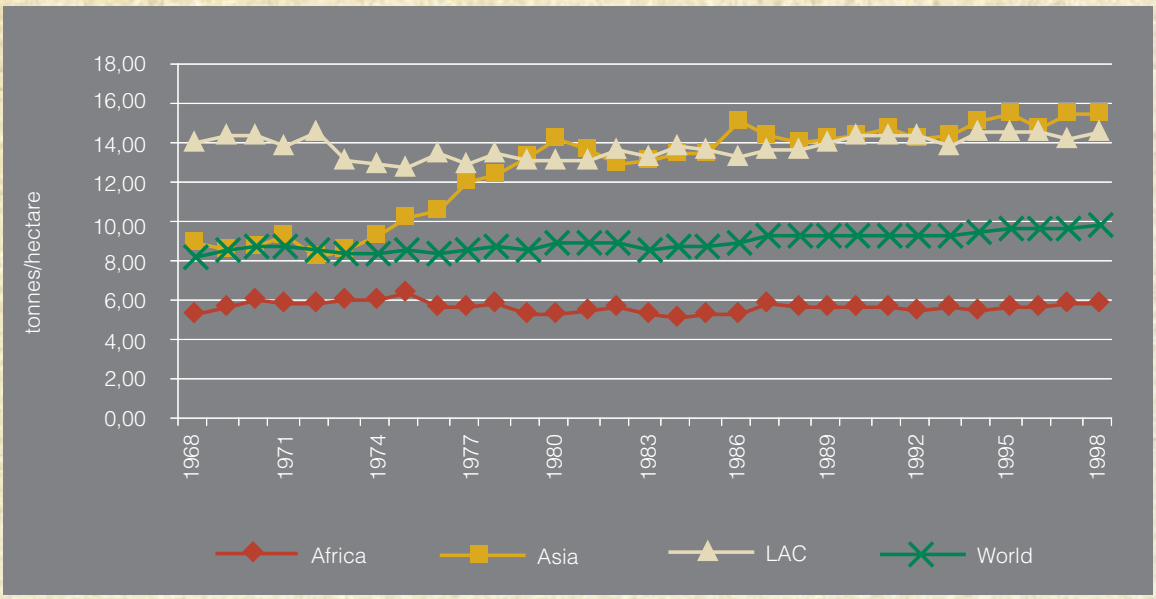


Figure 2. Increase in Musa *yield by region, 1968 to 1998*

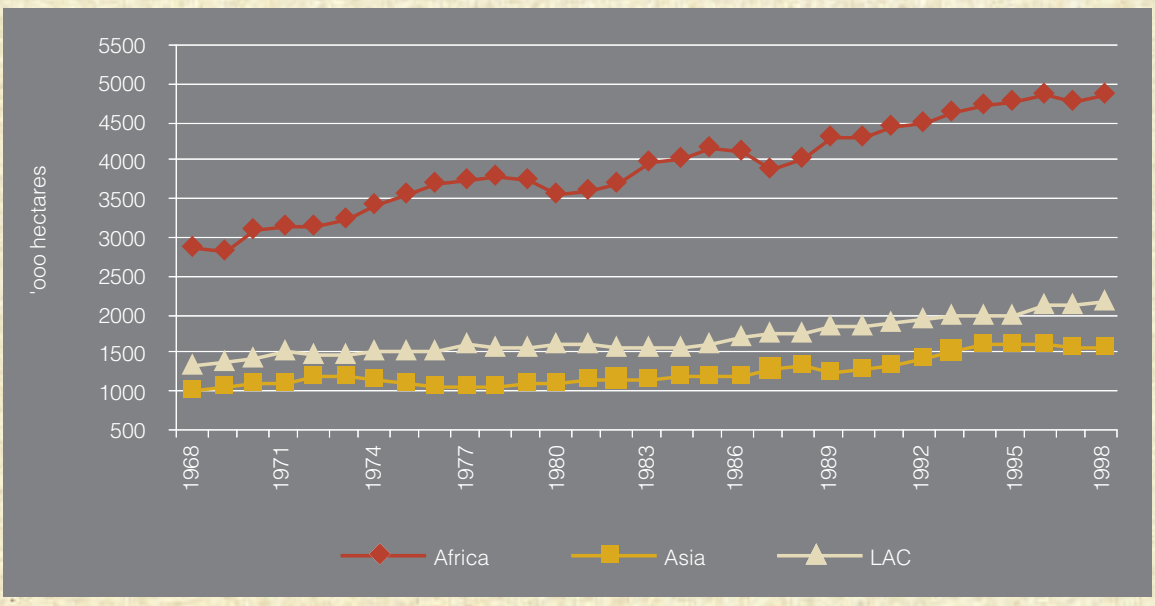


Figure 3. Increase in area of Musa *by region, 1968 to 1998*

Table 1. The 10 largest banana and plantain producers in 1998 (metric tonnes) (FAO 1998)

Country	Production (mT)
India	9 934 600
Uganda	9 835 000
Ecuador	8 388 210
Brazil	5 970 680
Colombia	4 797 300
Philippines	3 500 000
China	3 240 997
Indonesia	2 800 010
Democratic Republic of Congo	2 640 000
Costa Rica	2 300 000

Table 2. Banana exports 1996 (FAO 1998)

Country	Total production (mT)	Total Export (mT)	Percentage of production exported	Percentage of world exports
Ecuador	6 596 416	4 088 845	61,99%	32,97%
Costa Rica	2 505 000	2 126 493	84,89%	17,15%
Colombia	5 362 397	1 476 523	27,53%	11,91%
Philippines	3 391 150	1 252 196	36,93%	10,10%
Panama	980 562	682 827	69,64%	5,51%
Guatemala	766 000	669 686	87,43%	5,40%
Honduras	1 132 466	575 255	50,80%	4,64%
Côte d'Ivoire	1 668 825	200 551	12,02%	1,62%
Mexico	2 209 550	162 914	7,37%	1,31%
Cameroon	1 985 990	160 192	8,07%	1,29%

Main varieties

Despite the fact that bananas are the world's most traded fruit, the export crop, which is almost exclusively one variety – 'Cavendish' – accounts for little more than 13% of global banana and plantain production. The remaining 87% or so of production is made up of a very wide range of varieties, each adapted to a specific eco-region and selected for specific eating or cooking qualities. These include the true plantains (AAB) of West Africa and Central and South America, which are cooked by frying, boiling or roasting when they are green or ripe; the highland bananas (AAA) of East Africa, which are generally steamed to make 'Matooke', but are also used for beer-making; the cooking bananas (ABB) and sweet-acid dessert bananas (AAB) of Southeast Asia and the Americas; and the Pacific Maia Maoli/Popoulu (AAB) type of cooking-banana. The relative importance of the main groups of bananas is illustrated in Figure 5.

Increasing exports

Over the last 30 years world exports of bananas have increased from just over 5 million tonnes per year in 1968 to over 12 million tonnes in 1996 (Figure 4). This represents around 13% of total *Musa* production. Growing world exports are almost entirely due to increasing exports from Latin America and the Caribbean. Banana exports from Africa and Asia together make up less than 15% of world exports, with a few countries, most notably the Philippines, dominating non-Latin American exports (Table 2).

Bananas and plantains in Asia and the Pacific

Origins

The centre of origin of the genus *Musa* is South East Asia, stretching from India to Papua New Guinea and including Malaysia and Indonesia. In this region there still exists today a large number of wild, seeded relatives of the banana. Domestication is thought to have arisen in this region as a result of mutations in these wild species resulting in the production of plants with seedless, edible fruits. Diploid (AA) and triploid

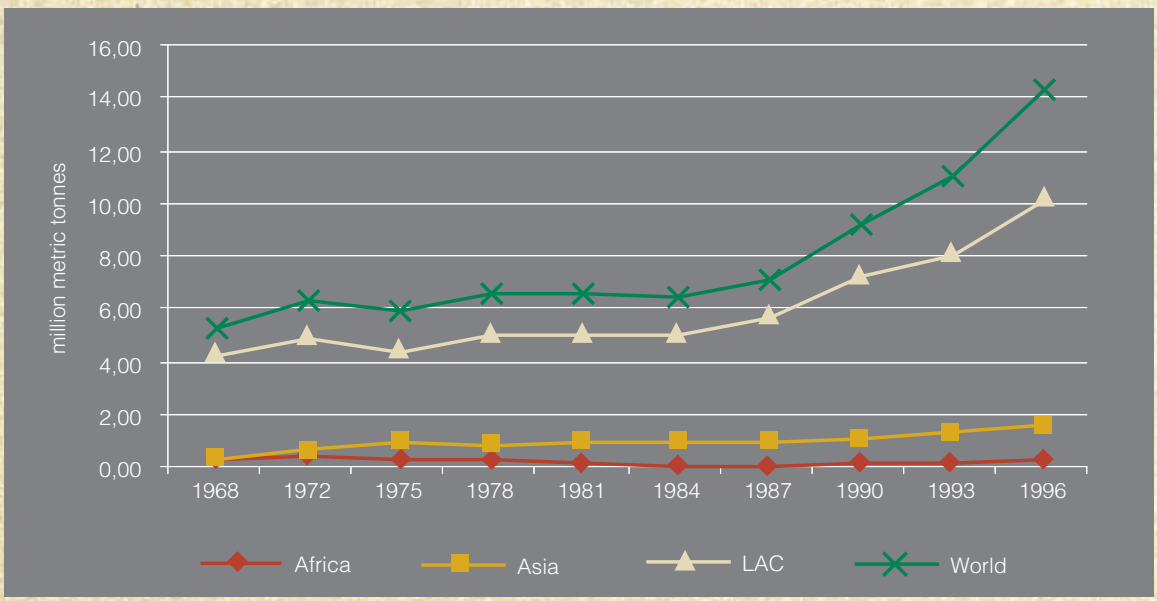
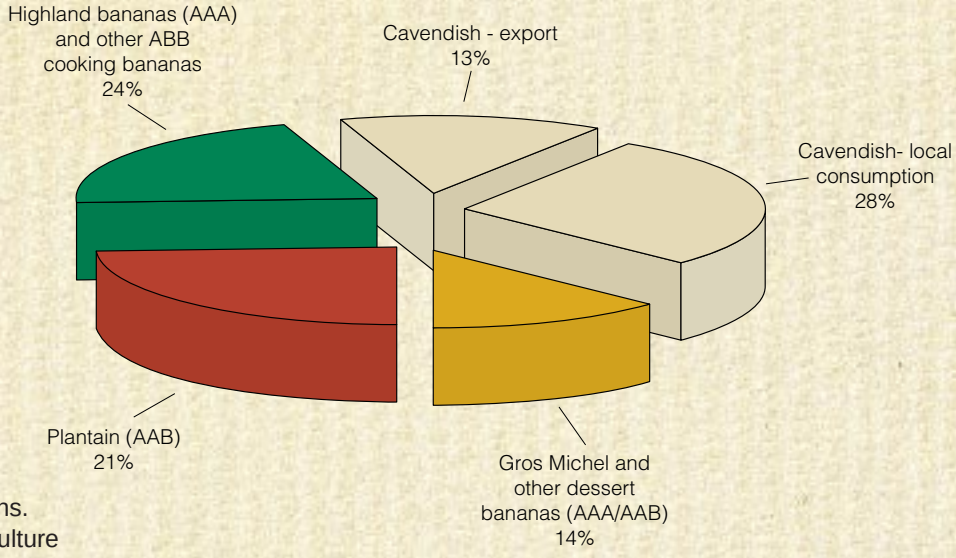


Figure 4. Banana export trends, 1968 to 1996



(AAA) *Musa acuminata* cultivars were taken by man to areas where *M. balbisiana* is native and natural hybridizations resulted in the formation of progeny with the genomes AB, AAB and ABB. (Simmonds 1962). It is thought that the subsequent dispersal of edible bananas outside South East Asia was brought about solely by man. The history of banana varieties is therefore closely linked to the early movement of human populations.

In the Pacific region, the earliest agriculture has been dated at around 8,000 BC, and it is in this region that the Fe'i bananas are of some importance (See INIBAP Annual Report 1997, Focus Paper 3). Their early cultivation has been described as 'proto-agriculture', that is, they were gathered from the wild rather than planted (Price 1995). The domestication of *M. acuminata/balbisiana* derived bananas is thought to have occurred at around the same time in South East Asia (Simmonds 1962) and it has been suggested that the earliest uses of these plants may have been non-food, or at least not involving the fruit. The plants would have produced a fibre, which could be used in fishing nets, and leaves could be used for constructing shelters. In addition, various parts of the plant apart from the fruit are edible, and the male bud is still widely used in parts of Asia as a vegetable.

Importance of the crop

In Asia, bananas are the most widely produced fruit in the Philippines, Thailand, Indonesia and India, while they rank second in Malaysia. 95% of the region's production, some 27 million tons annually, is consumed or marketed locally. Three Asian countries have had a major influence on global production levels. Between 1970 and 1980, yields in the Philippines and China, two of the biggest Asian producers, increased dramatically. Yields in the Philippines rose from 4.5 to 12.9 t/ha while in China the increase was from 12 to 19 t/ha. Yield increases in the Philippines coincided with a major growth in the export industry (Figure 6), with the majority of exports destined for the Japanese market. Since the mid-1980's banana production in Asia has continued to increase, largely due to increasing acreage in India, the world's largest producer (Table 1) and China.

Production and consumption in Asia is characterised by diversity. A wide range of cultivars are produced (Figure 7) and many parts of the plant are utilised. For example, the banana "heart" may be removed from the centre of the pseudostem after harvest and cooked. Similarly, new shoots and male buds, after the removal of the outer bracts, are also cooked as vegetables. Banana fibre is also widely used throughout the region for the production of a diversity of handicrafts.

Figure 5. Major types of bananas grown worldwide

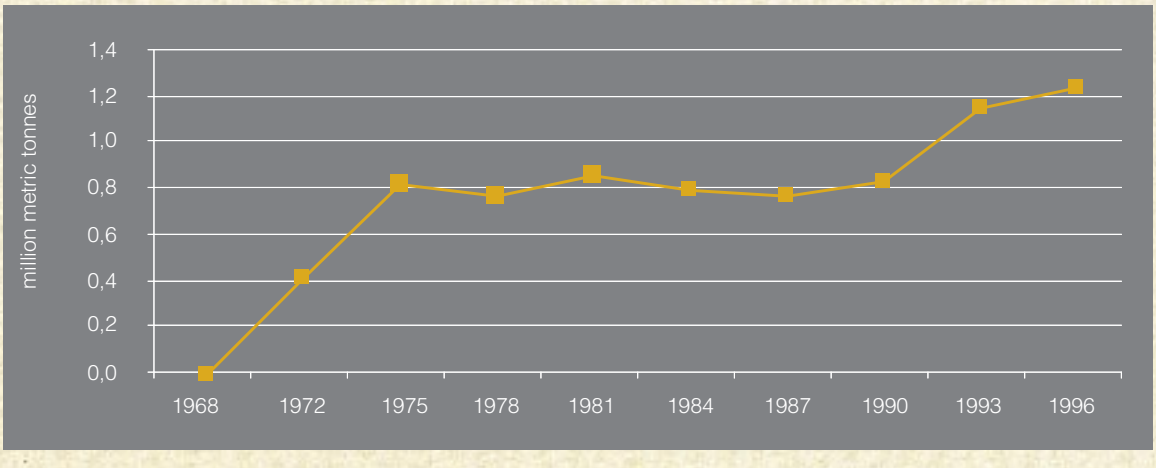


Figure 6. Increase in banana exports from the Philippines, 1968 to 1996

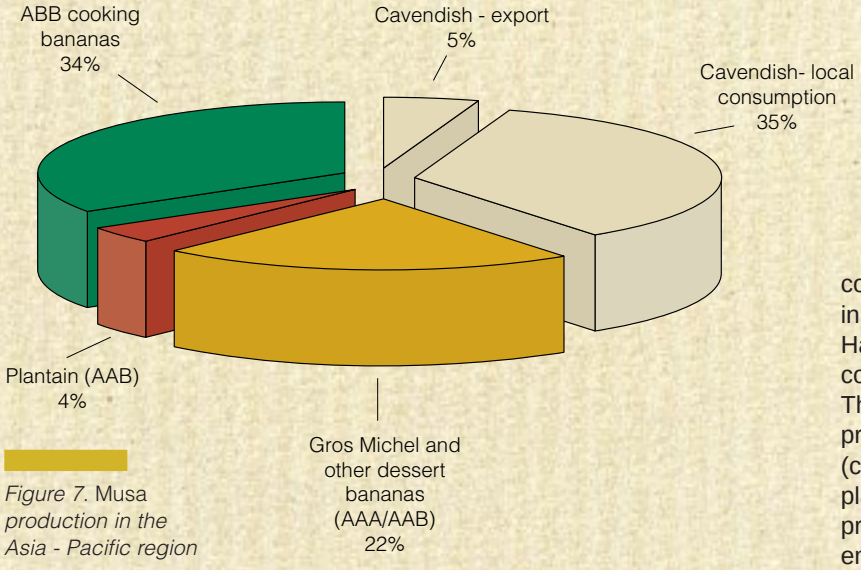


Figure 7. Musa *production in the Asia - Pacific region*

Bananas and plantains in Latin America and the Caribbean

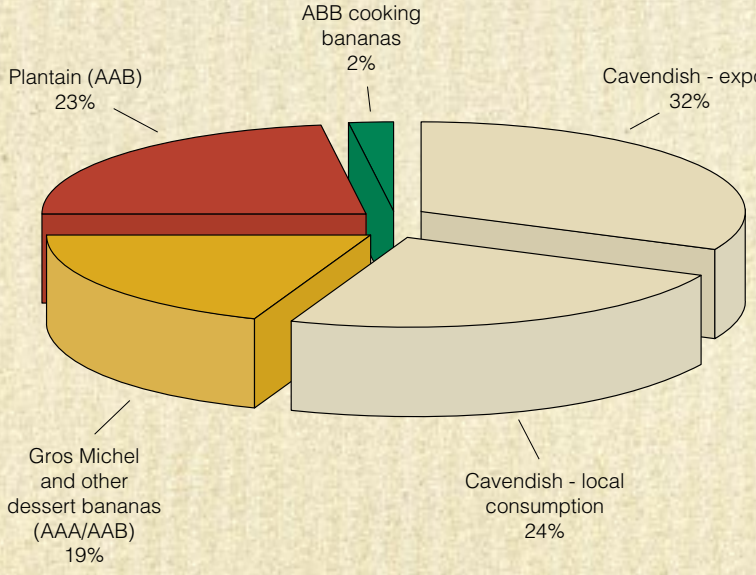
Origins

Although it is widely believed that the Portuguese were the first to introduce bananas to the Americas, the origin of the crop in the New World is still a subject of some discussion. It is thought that bananas were taken from Africa to the Canary Islands in the early 1400's, and from there, Friar Tomas de Berlanga introduced an unidentified clone to Santo Domingo in 1516 (Simmonds 1966). This is considered to be first of many such introductions over the years. However, it is also argued by some that bananas existed in South America in pre-Columbian times, and this is taken as evidence for early Polynesian contact with America. (Langdon 1993).

Importance as a food crop

Nearly 70% of the bananas and plantains produced in Latin America and the Caribbean are locally consumed (Figure 8), and plantains (AAB) play a particularly important role as a local food crop. Plantain consumption in the region reaches a peak in parts of Colombia with annual *per capita* consumption averaging 160 kg. In other countries in the region, most notably Dominican Republic, Haiti, Panama and Venezuela, plantains also constitute an important part of the national diet. Throughout the region, small businesses which produce a range of processed plantain products (chips, packed patacóns, microwaveable ripe plantain, etc.) have developed in recent years providing an increasingly important source of employment and income generation for local populations.

Figure 8. Musa *production in Latin America and the Caribbean*



Export bananas

This region is most well known for the production of bananas for export, and includes seven of the top ten exporting nations (Table 2). The export banana industry, as well as providing a major source of foreign exchange for a number of Latin American countries, is also the backbone of the economies of many Caribbean countries. In some of the Windward Islands, this one crop accounts for up to 90 per cent of primary exports, 70 per cent of foreign exchange earnings and 60 per cent of agricultural employment. Production is often on steep and difficult terrain and on small family farms. In this region, bananas are the only year-round crop which can be viably cultivated to produce a regular weekly income for small scale farmers.

Bananas and plantains in Africa

Origins

Two main centres of banana cultivation are found in Africa: the wet tropical zones of West and Central Africa and the East African Highlands.

In the west and central humid tropical areas, a very distinct type of cooking banana (plantain, AAB) is widely cultivated. Plantains are relatively rare in most of Asia as well as in other parts of Africa, and their origin in West Africa is shrouded in mystery. It is thought that they have been cultivated in this region for more than 3,000 years, but the identity of the people responsible for such cultivation is unknown (De Langhe *et al.* 1996). It is possible that the same proto-Polynesians that carried the banana east to the Pacific islands, also carried it west to Africa. Such a hypothesis fits with the finding that plantains must have reached Africa more than 3,000 years ago, but archaeological evidence for such voyages is unlikely to be found. Plantains constitute over 70% of the bananas and plantains grown in this area (Figure 9).

Another distinct group of bananas are found in the East African Highlands. These are thought to have been introduced between the 5th and 10th

centuries and a wide range of unique varieties now exists here. This area of secondary diversity is clearly the work of East Bantu-speaking people, but the origins of these bananas remain unknown (De Langhe 1996). These East African Highland bananas make up around 70% of the bananas produced in this region (Figure 10).

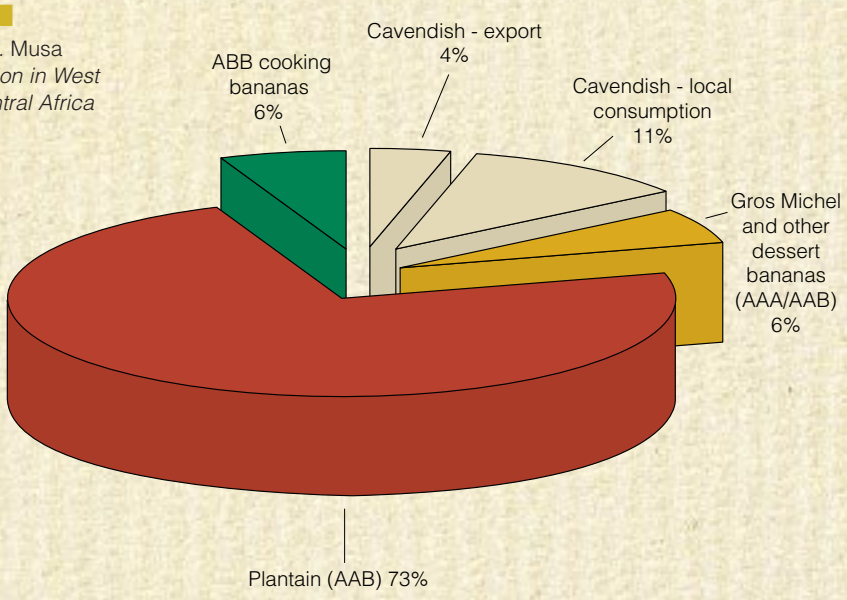


Figure 9. Musa *production in West and Central Africa*

Importance as a food crop

Bananas and plantains provide an important food source for over 100 million people in sub-Saharan Africa. Indeed the four countries with the highest *per capita* consumption of bananas and plantains in the world are found in this region (Table 3). The importance of the crop as a staple food reaches a peak in Uganda where average consumption is 243 kg/cap./year., but the crop is also extremely important in parts of Rwanda, Burundi and Tanzania. In Uganda, the staple food 'matooke', which is made from bananas, is eaten daily and the crop has great cultural and social significance. The importance of the crop is illustrated by the fact that the word 'matooke' is synonymous with the word for food in Uganda. In this region, the juice from the ripe fruit of varieties known as "beer bananas" is also drunk fresh or fermented to make a beer with a low alcohol content. Beer brewing has long been an important activity among various communities in the Great Lakes region and it is reported that consumption in Rwanda may reach 1.2 litres *per capita* per day (Stover and Simmonds 1987). The beer is important nutritionally and is rich in vitamin B due to the yeast content. In Uganda and Sudan, banana beer is also distilled to produce banana alcohol, or "waragi".

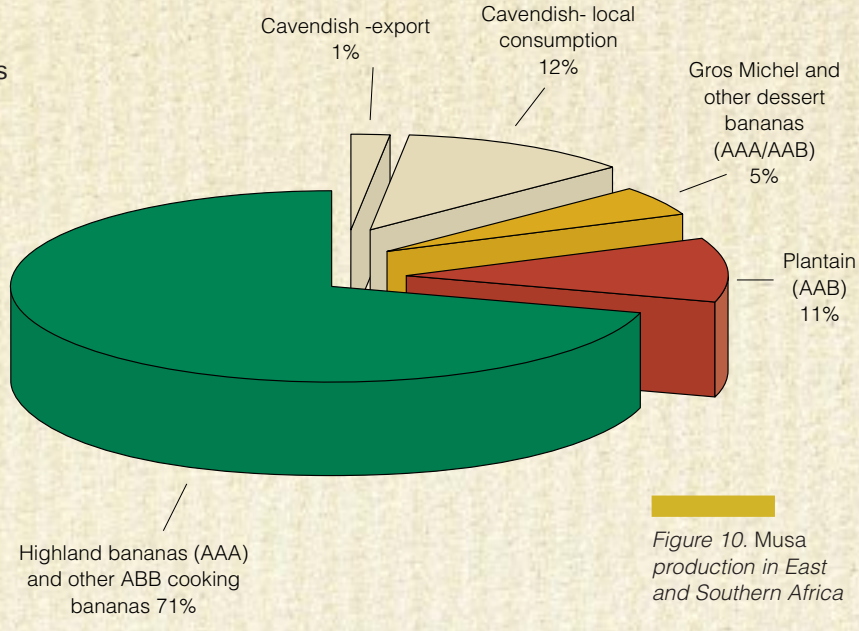


Figure 10. Musa *production in East and Southern Africa*

Table 3. Consumption of bananas, 1996 (kg/cap./year). (FAO 1998)

Country	Consumption (kg/cap/yr)
Uganda	243
Rwanda	197
Gabon	161
Cameroon	128
Papua New Guinea	121
Sao Tomé & Principe	93
Ghana	92
Burundi	89
Ecuador	88

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[1] All production data used in this paper are obtained from the FAO Agricultural Production Statistics Database (FAOSTAT) or from INIBAP, in collaboration with CIRAD-FLHOR.

Getting the word out

Objective: to make available and accessible a continuous flow of relevant and high quality *Musa* information for a wide range of clients.

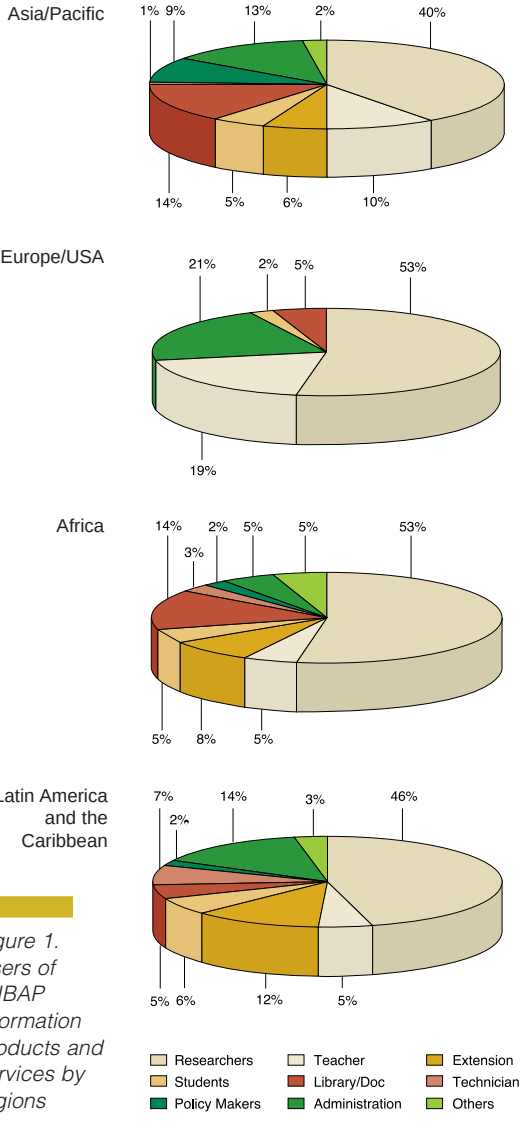

Figure 1. Users of INIBAP information products and services by regions

Information strategy

Information plays a critical role in the effective operation of the INIBAP programme and the rapid uptake of new communication technologies, such as CD-ROM and the Internet, holds great potential for improving the information services INIBAP provides. In 1998, a strategic planning meeting focused on the role of INIBAP in the provision of *Musa* information globally and regionally and identified those areas where INIBAP has a comparative advantage. These were identified as follows:

- ability to access, and make widely available, “grey” literature through the regional information networks,
- availability of information in three languages,
- information available free of charge,
- guaranteed access to primary documents.

The following set of principles which underpin INIBAP’s information activities were identified:

- flexibility of approach according to users’ needs,
- multilingualism,
- use of the most appropriate media for disseminating information, including the latest communication tools,
- working through partnerships and networks,
- increasing regionalisation of information activities.

An analysis was made of the users of INIBAP information products by region, and these are presented in Figure 1. It can be seen that vast majority of INIBAP’s information clients in all regions are researchers. However, there are also a diversity of other users, including teachers, documentalists, librarians, students, policy makers and administrators, and their needs must also be taken into account.

Third LACNET regional information meeting

In August 1998, INIBAP organised a refresher workshop on information activities in LACNET in order to evaluate the reactivation of the regional information network. The workshop took place at FHIA, Honduras and was attended by representatives from Colombia (*Asociación de Bananeros de Urabá*, AUGURA), Costa Rica (CORBANA and IICA-CATIE), Honduras (FHIA), Panama (*Unión de Países Exportadores de Banano*, IICA-UPEB), and Venezuela (*Fondo Nacional de Investigaciones Agropecuarias-Centro Nacional de Investigaciones Agropecuarias,* FONAIAP-CENIAP). A new member, INIFAP (Mexico) joined the network on this occasion.

A participative exercise organised during the workshop highlighted the lack of institutional commitment to the information network with the consequences being no real interaction between members, no institutional funds devoted to the network activities, and poor visibility of the network.

Taking the above into account, the participants developed a logical framework which will be used as a basis for the development of a common project. The global objective of the project was defined as to contribute to the sustainable development of the Latin America and Caribbean banana sector through the compilation and dissemination of information on *Musa* and through the optimisation of the use of the available information resources in the region.

The main activities required to meet this objective include:

- strengthening the coordination centre;
- obtaining the commitment of the participating institutes by the signature of new letters of agreement;
- improving visibility of the network through the development of promotional tools (Web page, logo, leaflets, etc.);
- improving the efficiency of the network.

Some specific action points were identified during the meeting:

Training: Participating centres were invited to take advantage of information training courses organised by CATIE.

CD-ROM: The database SIBBANA (IICA-UPEB) will be included in the 3rd edition of the CD-ROM of agricultural databases of Latin America and the Caribbean co-produced by IICA and the University of Colima, Colombia.

Visibility: The group identified the need for a specific Web page for the information network and IICA-UPEB offered to design and host the page on its server.

Technical assistance: CATIE offered its technical assistance to the network members regarding making their bibliographic databases available online.

Coordinating center: It was recommended that IICA-UPEB again take on the coordinating function of the regional information network.

AGRI 2000

INIBAP participates in the project Agri 2000 which is managed by IICA, Costa Rica, which aims to assemble and make available on-line various bibliographic agricultural databases. INIBAP provided to IICA a bilingual version (English/Spanish) of *MUSA*LIT, which is searchable at the following address: http://www.iica.ac.cr/espanol/. The SIBBANA database managed by IICA-UPEB is also available through this address.

Publications

In 1998, INIBAP published two new issues in its series "INIBAP Technical Guidelines". Guidelines No. 3, published in English, French and Spanish, deals with the "Evaluation of *Musa* germplasm for resistance to Sigatoka diseases and Fusarium wilt". Guidelines No. 4, published only in English, covers the "Post-harvest characteristics of black Sigatoka resistant banana, cooking banana and plantain hybrids".

The Information/Communications Unit produced a range of other publications during the year, including the INIBAP 1997 Annual Report and the proceedings of the meeting of the PRO*MUSA* Virology working group on Banana streak virus. A booklet containing the abstracts of presentations and posters presented at the "Bananas and food security" symposium held in November in Cameroon, was also prepared and distributed during the meeting. Several regional publications, two issues of INFO*MUSA,* which now includes a special section on PRO*MUSA* activities, and two issues of the bibliographic abstract journal *Musarama* with its annual indexes were also published.

The revision and updating of the Spanish version of the "Tesauro del Banano" (banana thesaurus), originally published by UPEB in 1983, has been completed. This new version of the thesaurus includes 21 thematic areas covering all aspects of *Musa*. This edition of the thesaurus is computerized and can be consulted on screen in Spanish. Translation into French and English is in progress. The software is very user-friendly, and allows the thesaurus to be linked to any relevant database, thus facilitating the indexation of documents and the retrieval of information.

In 1998, the Information/Communications Unit disseminated more than 16,000 INIBAP publications and serials to users of information on banana.

Mrs Rivera de Castillo and Dr Rafael Perez Duvergé from CEDAF (ex FDA), Dominican Republic, visited the INIBAP/CIRAD stand at the Paris Agricultural Fair in March. (Photo: INIBAP)

Public awareness

Salon international de l'agriculture de Paris

INIBAP participated in the 1998 Paris Agricultural Fair as a partner with CIRAD. The stand developed by CIRAD and INIBAP focused on informing visitors about the global importance and wide diversity of bananas and plantains. As the fair attracts over half a million visitors each year, this was an important public awareness event for INIBAP. In collaboration with CIRAD, INIBAP participated in the production of a range of materials, and was particularly involved in the development of an interactive multimedia display presenting, in an informal and attractive manner, all aspects of the crop. A beautifully illustrated brochure about bananas was also produced and proved very popular with visitors to the stand. INIBAP's activities were described on several posters and more than 2,000 banana diversity posters were distributed.

Participation in international banana conference

INIBAP was invited to participate in the international banana conference "Towards a sustainable banana economy" which was held in Belgium from 6-8 May, 1998. This three day conference brought together more than 300 people from 45 countries representing the key players in the banana trade, including banana workers, small-scale producers, companies, international institutions, scientists and policy makers. The presentation by the Director of INIBAP focused on the important role that research on genetic improvement of bananas can play in the development of sustainable production systems and highlighted the need for further resources to be directed towards such research.

INIBAP publications

Global publications

Dadzie B.K. Post-harvest characteristics of black Sigatoka resistant banana, cooking banana and plants hybrids. INIBAP Technical Guidelines 4.

Frison E.A. and S.L. Sharrock (eds). Banana streak virus: a unique virus-*Musa* interaction? Proceedings of a workshop of the PRO*MUSA* virology working group held in Montpellier, France, 19-21 January 1998.

Orjeda G. in collaboration with the PRO*MUSA* working groups on Sigatoka and Fusarium. Evaluation of *Musa* germplasm for resistance to Sigatoka diseases and Fusarium wilt. INIBAP Technical Guidelines 3.

Orjeda G. en collaboration avec les groupes de travail de PRO*MUSA* sur les cercosporioses et la fusariose. Evaluation de la résistance des bananiers aux cercosporioses et à la fusariose. Guides techniques INIBAP 3.

Orjeda G. en colaboración con los grupos de trabajo de PRO*MUSA* sobre Sigatoka y Fusarium. Evaluación de la resistencia de los bananos a las enfermedades de Sigatoka y marchitamiento por Fusarium. Guías Técnicas INIBAP 3.

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CIRAD/INIBAP. Les bananes.

Regional publications

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Picq C. (ed.). Segundo seminario/taller de la Red regional de información sobre banano y plátano de América Latina y el Caribe. San José, Costa Rica, 10-11 July 1997.

Valmayor R.V. and V. Roa (eds). Minutes: Seventh meeting of INIBAP/ASPNET Regional Advisory Committee (RAC) hosted by the Vietnam Agricultural Science Institute (VASI) in Hanoi, Vietnam, 21-23 October 1997.

Serials

Musarama Vol 11, No. 1 & 2 (English, French and Spanish).

Musarama Annual Indexes (English, French and Spanish).

INFO*MUSA* Vol 7, No. 1 & 2 (English, French and Spanish).

RISBAP Bulletin Vol. 2, No. 1 & 2.

Posters

A series of five technical posters were produced in French at the occasion of the Paris Agricultural Fair and translated into English and Spanish:

PRO*MUSA*: A Global Programme for *Musa* Improvement.

The International *Musa* Testing Programme (IMTP)

The *Musa* Germplasm Information System (MGIS)

The largest *in vitro* collection of bananas in the world

Strategic research at INIBAP

INIBAP

INIBAP staff presentations in 1998

Arnaud E. and *J.P. Horry*. The *Musa* Germplasm Information System (MGIS). Paper presented at the 1st MGIS regional training workshop held at QDPI, South Johnstone, Australia, 6-11 July 1998.

Arnaud E. and J.P. Horry. The *Musa* Germplasm Information System (MGIS). Paper presented at the MGIS regional training workshop for Latin America and Caribbean held at INIFAT, La Havana, Cuba, 21-26 September 1998.

Frison E.A. and *S.L. Sharrock*. 1998. Biodiversity and sustainable banana production. Paper presented at the Banana Conference "Sustainable consumption and Trade", Brussels, Belgium, 6-8 May 1998.

Frison E.A. 1998. PRO*MUSA* – A global programme for *Musa* improvement. Paper presented at the INIBAP Support Group meeting, Brasilia, Brazil, 24 May 1998.

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Frison E.A. 1998. The role of INIBAP in the improvement of *Musa*. Paper presented at the International symposium on black Sigatoka. Manzanillo, Mexico, 8-10 July 1998.

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Molina A.B. 1998. Banana and plantain industry in Asia and Pacific region: The role of INIBAP-ASPNET. Paper presented at the 1st National Banana Congress, Tacloban City, Leyte, Philippines, 8-9 December 1998.

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INIBAP 1998

Financial Highlights

Revenue	Research Agenda			
US $	**Unrestricted**	**Restricted**	**Non-agenda**	**Total**
Australia	131	8		139
Belgium	315	1 306		1621
Canada	187			187
European Union	250			250
France	184	132		316
India	25			25
Netherlands	77			77
Peru		9		9
South Africa	20			20
Spain	40	15		55
United Kingdom		67		67
CIRAD		72		72
CTA		30		30
IBRD	400			400
IDB		99		99
IDRC		89		89
NRI		14		14
Rockefeller Foundation		25		25
TBRI		2		2
UNDP		270		270
USAID	100	13		113
Other Income	78			78
Total Revenues	**1 807**	**2 151**	**0**	**3 958**

As at December 31, 1998 (US$000)

Expenditures	Research Agenda			
	Unrestricted	**Restricted**	**Non-Agenda**	**Total**
Research Programme				
Germplasm and Breeding	1 018	1 976		2 994
Conferences and Training	92	49		141
Information Services	271	90		361
General Administration	445			445
Total Expenditures	**1 826**	**2 115**	**0**	**3 941**
Recovery of Indirect Costs	(36)	36		0
	1 790	2 151	0	3 941

As at December 31, 1998 (US$000)

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Staff list 1998

Name	Position	Nationality	Joined	Stationed
E. Frison	Director	Belgium	01-10-95	Montpellier
E. Akyeampong	Regional Coordinator WCA	Ghana	01-06-97	Cameroon
E. Arnaud	Documentalist	France	01-10-89	Montpellier
R. Bogaerts	Technician	Belgium	12-02-88	ITC, Belgium
P. Deschamps**	Documentalist	France	01-09-92	Montpellier
H. Doco*	Documentalist	France	15-09-98	Montpellier
S. Faure	Senior Programme Assistant	UK	01-06-88	Montpellier
E. Gonnord*	Accounting Assistant	France	17-08-98	Montpellier
J.P. Horry	Germplasm Coordinator	France	15-08-94	Montpellier
E. Karamura	Regional Coordinator ESA	Uganda	01-04-97	Uganda
E. Kempenaers	Research Technician	Belgium	15-10-90	ITC, Belgium
S.B. Lwasa	Programme Assistant ESA	Uganda	01-08-97	Uganda
F. Malafosse	Programme Assistant	France	01-02-91	Montpellier
M.M. Mbakop Ngamy	Programme Assistant WCA	Cameroon	01-12-97	Cameroon
S. Messiaen*	Associate Expert, Entomology	Belgium	01-07-98	Cameroon
T. Moens*	Associate Expert, Nematology	Belgium	01-06-98	Costa Rica
A.B. Molina*	Regional Coordinator ASP	Philippines	20-02-98	Philippines
G. Orjeda	Genetic Improvement Scientist	Peru	15-05-96	Montpellier
C. Picq	Head, Information/ Communications	France	01-04-87	Montpellier
V. Roa	Programme Assistant ASP	Philippines	01-01-91	Philippines
F. Rosales	Regional Coordinator LAC	Honduras	01-04-97	Costa Rica
R. Roux**	Programme Assistant	France	02-06-87	Montpellier
J. Schurges*	Intern. Biotechnology	Belgium	01-11-98	Cameroon
B. Sellers	Programme Assistant	UK	17-07-97	Montpellier
S. Sharrock	Scientific Assistant	UK	07-07-96	Montpellier
R. Swennen	Honorary Research Fellow	Belgium	01-12-95	KUL, Belgium
T. Thornton	Financial Manager	U.K.	01-08-90	Montpellier
S. Tripon	Associate Scientist, Germplasm Evaluation	France	15-11-96	Costa Rica
R. Valmayor	Honorary Research Fellow	Philippines	01-01-98	Philippines
I van den Bergh	Associate Expert, Nematology	Belgium	01-10-97	Vietnam
I. van den Houwe	Officer in Charge ITC	Belgium	01-02-92	ITC, Belgium
L. Vega	Programme Assistant LAC	Costa Rica	01-02-92	Costa Rica
S. Voets	Technician	Belgium	01-01-93	ITC, Belgium
J. Wilmaers	Research Technician	Belgium	01-11-97	ITC, Belgium
A. Yesiime	Driver/Messenger ESA	Uganda	01-11-97	Uganda

** joined during the year — ** left during the year*

List indicates members of the INIBAP programme of IPGRI. In addition, staff within other programmes and departments of IPGRI contributed to the INIBAP programme during 1998.

Acronyms and abbreviations

ACIAR	Australian Centre for International Agricultural Research
AGCD	Administration générale de la coopération pour le développement, Belgium
APAARI	Asia Pacific Association of Agricultural Research Institutions
ARI	Agricultural Research Institute, Tanzania
ARIs	Advanced Research Institutes
ASPNET	Asia and Pacific Regional Network, INIBAP, Philippines
BAC	bacterial artificial chromosomes
BADC	Belgian Agency for Development Cooperation
BARNESA	Banana Research Network for Eastern and Southern Africa, Uganda
BBrMV	banana bract mosaic virus
BBTV	banana bunchy top virus
BPI	Bureau of Plant Industry, Philippines
BSV	banana streak virus
CARDI	Caribbean Agricultural Research and Development Institute
CATIE	Centro Agronómico Tropical de Investigación y Enseñanza, Costa Rica
CENARGEM	Centro Nacional de Pesquisa de Recursos Geneticos y Biotecnologia, EMBRAPA, Brazil
CINVESTAV	Centro de Investigaciones y de Estudios Avanzados de Irapuato, Mexico
CIRAD	Centre de coopération internationale en recherche agronomique pour le développement, France
CMV	cucumber mosaic virus
CORAF	Conférence des Responsables de la Recherche Agronomique Africains
CORBANA	Corporación Bananera Nacional, Costa Rica
CORPOICA	Corporación Colombiana de Investigación Agropecuaria, Colombia
CRBP	Centre de recherches régionales sur bananiers et plantains, Cameroon
CTA	Technical Center for Agricultural and Rural Cooperation, The Netherlands
DFID	Department for International Development, UK
DNA	deoxyribonucleic acid
EARTH	Escuela de Agricultura de la Región Tropical Húmeda Costa Rica
ECS	embryogenic cell suspension
ELISA	enzyme-linked immunosorbent assay
EMBRAPA	Empresa Brasiliera de Pesquisa Agropecuaria, Brazil
FAO	Food and Agriculture Organization of the United Nations, Italy
FC	Flemish Community
FFTC	Food and Fertilizer Technology Center, Taiwan
FHIA	Fundación Hondureña de Investigación Agrícola, Honduras
FLHOR	Département des productions fruitières et horticoles, CIRAD, France
Foc	*Fusarium oxysporum* f. sp. *cubense*
FONAIAP	Fondo Nacional de Investigaciones Agropecuarias, Venezuela
FUSAGx	Faculté universitaire des sciences agronomiques de Gembloux, Belgium
GISH	genomic *in situ* hybridisation
IAEA	International Atomic Energy Agency, Austria
IARC	International Agricultural Research Center
IBP	Instituto de Biotecnología de Plantas, Cuba
IBRD	International Bank for Reconstruction and Development, USA
ICAR	Indian Council for Agricultural Research
ICIA	Instituto Canario de Investigaciones Agrarias, Spain
ICIPE	International Center for Insect Physiology and Ecology, Kenya
ICRA	International Centre for Development Oriented Research in Agriculture, France
IC-PCR	immune-capture polymerase chain reaction
IDB	Inter-American Development Bank
IDRC	International Development Research Centre, Canada
IICA	Instituto Interamericano de Cooperación para la Agricultura, Costa Rica
IITA	International Institute of Tropical Agriculture, Nigeria
IMTP	International *Musa* Testing Programme, INIBAP
INERA	Institut national pour l'étude et la recherche agronomiques, Democratic Republic of Congo
INIFAP	Instituto Nacional de Investigaciones Forestales y Agropecuarias, Mexico
INIVIT	Instituto de Investigaciones en Viandes Tropicales, Cuba
IPGRI	International Plant Genetic Resources Institute, Italy
IPM	integrated pest management
IRAZ	Institut de recherches agronomique et zootechnique, Burundi
ITC	INIBAP Transit Centre, Belgium
ITSC	Institute of Tropical and Subtropical Crops, South Africa
JIC	John Innes Centre, UK
JIRCAS	Japanese International Research Centre for Agricultural Sciences
KCDP	Kagera Community Development Programme, Tanzania
KUL	Katholieke Universiteit Leuven, Belgium
LACNET	INIBAP Regional Network for Latin America and the Caribbean, Costa Rica
MARDI	Malaysian Agricultural Research and Development Institute
MAS	marker-assisted selection
MGIS	*Musa* Germplasm Information System, INIBAP
*MUSA*CO	*Musa* Research Network for West and Central Africa/Réseau *Musa* pour l'Afrique Centrale et Occidentale, Cameroon
NARIs	National Agricultural Research Institutes
NARO	National Agricultural Research Organisation, Uganda
NARS	National Agricultural Research Systems
NBPGR	National Board for Plant Genetic Resources, India
NGO	Non-Governemental Organization
NRCB	National Research Centre on Banana, India
NRI	Natural Resources International, UK
PCARRD	Philippines Council for Agriculture, Forestry and Resources Research and Development
PCR	polymerase chain reaction
PPRI	Plant Protection Research Institute, South Africa
QDPI	Queensland Department of Primary Industries, Australia
RAC	Regional Advisory Committee
RAPD-PCR	random amplified polymorphic DNA-PCR
RC	Regional Coordinator
RISBAP	Regional Information System for Banana and Plantain – Asia and the Pacific, INIBAP
RFLP	restriction fragment length polymorphism
SCAU	South China Agricultural University
SIDBAP	Servicio de Información y Documentación sobre Banano y Plátano, Panama
SSRs	simple sequence repeats
STMS	sequence-tagged microsatellite
TBRI	Taiwan Banana Research Institute
UNDP	United Nations Development Programme
UPEB	Unión de Países Exportadores de Banano, Panama
USAID	United States Agency for International Development
VASI	Vietnam Agricultural Science Institute
VIC	virus indexing centre
VVOB	Vlaamse Vereniging voor Ontwikkelingsamenwerking en Technische Bijstand, Belgium
WIBDECO	Windward Islands Banana Development and Exporting Company

L'INIBAP en 1998

En 1998, l'INIBAP a renforcé son rôle d'animateur de réseaux : les deux réseaux sous-régionaux qu'il appuie en Afrique sont devenus opérationnels au cours de l'année, et un important atelier panafricain sur la lutte intégrée contre les ravageurs et les maladies des bananiers a été organisé dans le cadre des activités du Réseau sur la recherche bananière pour l'Afrique orientale et australe (BARNESA). Les bienfaits de la lutte phytosanitaire intégrée menée en Amérique latine et dans les Caraïbes ont fait l'objet d'une importante discussion à l'occasion d'une réunion sur la production de bananes écologiques, co-organisée par l'INIBAP au Costa Rica. Les partenariats internationaux se sont renforcés lors de la deuxième réunion mondiale de PRO*MUSA*; les participants ont manifesté leur soutien au programme, et de nouvelles collaborations ont été établies. L'INIBAP a également co-organisé le premier Symposium international sur les aspects socio-économiques de la production bananière destinée à la consommation domestique. Cette rencontre, qui s'est tenue au Cameroun, a réuni de nombreux participants du monde entier et a permis de mettre en évidence le besoin d'intensifier les échanges inter-régionaux d'informations sur cette culture que l'on cultive partout mais sur laquelle la recherche en est encore à ses balbutiements.

L'INIBAP poursuit ses activités de soutien à la recherche sur un certain nombre d'aspects de l'amélioration bananière. La transformation des bananes au moyen d'*Agrobacterium* a donné d'excellents résultats à l'Université catholique de Leuven (KUL), ouvrant la voie à l'élaboration de futurs protocoles de transformation plus performants. Dans le cadre des initiatives liées à PRO*MUSA*, une réunion a été organisée sur la mosaïque en tirets du bananier, et la recherche se poursuit sur ce virus exceptionnel et très répandu. La seconde phase du Programme international d'évaluation des *Musa* (IMTP) s'est achevée en 1998 et les évaluations de 14 pays ont été envoyées à l'INIBAP pour y être analysées. Un certain nombre d'hybrides possédant une bonne résistance aux principaux ravageurs et maladies des *Musa* et montrant une bonne stabilité dans divers environnements ont été identifiés. On peut à présent en recommander une plus grande utilisation pour des essais au champ.

Activités thématiques

Gestion du matériel génétique de *Musa*

Banque de gènes

La collection de matériel génétique de *Musa,* située au Centre de transit de l'INIBAP (ITC), comptait 1119 accessions à la fin de 1998. Au cours de l'année, l'ITC a expédié 55 colis contenant au total 267 accessions à 27 pays dans le monde entier pour des travaux de recherche et développement. En outre, 140 accessions ont été soumises à l'indexation pour les virus et 56 autres accessions ont été dupliquées au CATIE (Costa Rica). Ceci signifie que, répondant à des objectifs de sécurité, 51 % de la collection de l'ITC a été dupliquée et 66 % de cette collection a été indexée pour les virus. Un nouveau centre d'indexation a été créé en Afrique du Sud au PPRI dans le but d'accroître la capacité d'indexation pour les virus de l'INIBAP.

La présence de bactéries endogènes est systématiquement recherchée dans les accessions de la collection de l'ITC. Un milieu sélectif est actuellement utilisé pour identifier les mycobactéries à croissance lente qui étaient auparavant difficiles à identifier. Les accessions infectées sont débarrassées de l'infection par la culture de méristèmes apicaux. Le dépistage de la maladie de Moko a été introduit en 1998 et, bien que cette bactérie ne soit jamais passée inaperçue dans les cultures de tissus, cette opération est à présent systématique pour les échantillons destinés aux pays exigeant un certificat de dépistage de cette maladie.

La recherche sur la cryoconservation, technique de prédilection pour le stockage à long terme de matériel génétique de *Musa*, a obtenu de bons résultats cette année. Une collaboration entreprise en 1997 avec le JIRCAS (Japon) a permis de mettre au point trois protocoles de cryoconservation offrant la possibilité de conserver n'importe quelle accession de *Musa* préalablement testée. Cette année, l'accent a été placé sur la comparaison et l'optimisation de ces trois protocoles dans l'utilisation de tissus méristématiques.

Collecte de matériel génétique

En 1998, une campagne de collecte de matériel génétique de *Musa* a été organisée en Inde avec le soutien de l'INIBAP. Trente six accessions ont pu être collectées dans les états d'Assam et de Meghalaya. Une étude préliminaire réalisée dans la région a permis d'identifier une importante variabilité des clones ABB et aussi probablement de l'espèce sauvage *Musa balbisiana*. Comme la diversité de cette espèce n'avait pas été suffisamment explorée auparavant, les futures campagnes de collecte devraient donner des résultats intéressants.

Recherche sur le virus de la mosaïque en tirets du bananier (BSV)

Le BSV est maintenant reconnu comme l'un des virus les plus répandus chez les *Musa*; on le trouve partout où pousse cette culture. Ce virus appartient au groupe des badnavirus et il est donc très variable du point de vue sérologique. Le BSV est unique parmi les virus des plantes car ses séquences virales sont intégrées dans le génome hôte et on peut les trouver dans toutes les lignées de *Musa* testées. Chez certains cultivars, ces séquences peuvent être activées et être responsables d'une infection épisomale. Des travaux ont été menés au Centre John Innes (Royaume-Uni) sur les séquences intégrées présentes dans le cultivar Obino L'Ewai dans le but de fournir des informations pouvant servir dans l'établissement d'un diagnostic. Le procédé d'amplification en chaîne par polymérase (PCR) et l'hybridation *in situ* ont mis en évidence la présence de deux loci des séquences BSV dans les chromosomes d'Obino L'Ewai, et tous les deux ont une structure complexe. La séquence intégrée du BSV n'est pas, elle-même, un simple génome viral car elle comporte de nombreuses séquences inversées et réarrangées. On pense que seule une partie du complexe intégrant serait activée chez Obino L'Ewai car des séquences du BSV intégrées chez ce cultivar se trouvent également dans le génôme d'autres cultivars qui ne présentent aucun antécédent d'activation. On ne sait pas encore comment cette forme épisomale simple peut dériver de complexes intégrants mais on pense que la différence entre activation et non-activation proviendrait d'un détail de l'intégrant ou de la présence d'un activateur inconnu.

Caractérisation du matériel génétique

Les travaux de caractérisation du matériel génétique de *Musa* se poursuivent tant sur les aspects morphologiques que moléculaires. Dans le cadre des travaux sur la caractérisation morphologique, l'INIBAP a organisé en 1998 deux formations régionales sur l'utilisation du système d'information sur le matériel génétique de *Musa* (MGIS). Ces stages se sont déroulés en Australie et à Cuba, et ont permis de porter à 32 le nombre des gestionnaires de banques de gènes formés à ce système. La base de données renferme actuellement des informations sur 2453 accessions fournies par six instituts partenaires (CRBP, CIRAD-FLHOR, BPI, FHIA, ITC et SCAU). Outre des données de caractérisation pour 647 accessions, il existe des données d'évaluation agronomique concernant 956 accessions et des données d'évaluation au stress pour 183 accessions. Les photos de plus de 400 accessions sont également disponibles dans la base qui est distribuée gratuitement sur CD-ROM à tous les instituts qui collaborent à ce projet.

En 1998, plus de 320 accessions de la collection de l'ITC ont fait l'objet d'une caractérisation moléculaire. Ces travaux ont été menés par le CIRAD-FLHOR à l'aide de marqueurs de type STMS (*Sequence-tagged microsatellite*). Dix de ces marqueurs ont été choisis pour leur grande capacité de discrimination. Des allèles spécifiques des génomes *balbisiana* et Australimusa ont été identifiés, permettant ainsi la détection de clones interspécifiques. Les accessions testées avaient déjà été classées en fonction de leurs caractéristiques morphologiques; ces travaux ont donc permis de confirmer les classifications existantes et, dans certains cas, de nouvelles classifications au niveau du groupe et du sous-groupe ont été suggérées.

Amélioration du matériel génétique de *Musa*

*PRO*MUSA

Réunion sur le BSV

En janvier 1998, les plus éminents virologues travaillant sur le BSV se sont réunis pendant trois jours à Montpellier (France) pour discuter et échanger leurs vues dans le cadre des activités du groupe de travail sur la virologie de PRO*MUSA*. Cette rencontre a permis de faire le point sur les progrès réalisés au niveau de la maîtrise du virus et sur l'importance des séquences intégrées du virus dans le génome de *Musa*. Les besoins de la recherche ont été analysés et classés suivant des ordres de priorité, et les protocoles d'indexation du BSV actuellement utilisés ont été réévalués à la lumière des résultats les plus récents. Les participants ont reconnu que les méthodes actuelles étaient encore ce qu'il y avait de plus fiable pour détecter un large éventail d'isolats du BSV, et la révision des directives techniques FAO/IPGRI en matière d'échange de matériel génétique de *Musa* n'a pas été jugée nécessaire. Les actes de cette réunion, édités par l'INIBAP, offrent des informations très importantes sur l'état de la recherche sur ce virus exceptionnel.

Seconde réunion mondiale

La seconde réunion mondiale de PRO*MUSA*, qui a rassemblé quelques 70 chercheurs, s'est déroulée à Douala (Cameroun) en novembre 1998. Cette réunion, en partie plénière, a également permis aux divers groupes de travail sur l'amélioration génétique, les cercosporioses, la nématologie et la virologie de se rencontrer. Chaque groupe a réexaminé les priorités fixées en Guadeloupe et a identifié des possibilités de collaboration pour les années à venir. La réunion a été l'occasion d'échanges entre les différents groupes de travail, ce qui a été jugé particulièrement utile.

De nouvelles initiatives ont résultés des discussions des différents groupes, et notamment :

- L'attribution et la répartition de tâches entre les membres du groupe sur la virologie dans le but d'accroître l'efficacité des travaux dans ce domaine et d'en accélérer la progression;
- La formation de deux sous-groupes, génétique moléculaire et cytogénétique, au sein du groupe sur l'amélioration génétique, qui travailleront ensemble pour mettre en place des projets de collaboration;
- L'idée du groupe sur la nématologie de rassembler toutes les informations disponibles sur certains aspects de la nématologie des *Musa* et de les diffuser le plus largement possible dans les publications de PRO*MUSA*.

Au cours de cette seconde réunion, les participants de PRO*MUSA* ont réitéré leur soutien au programme et leur engagement vis à vis de celui-ci, reconnaissant les apports positifs d'une collaboration accrue et d'un échange d'informations plus soutenu tel que le propose PRO*MUSA*. Cette rencontre a contribué au renforcement de l'esprit de collaboration qui s'était déjà manifesté à l'occasion de la première réunion de 1997 en Guadeloupe.

IMTP

La phase II du Programme international d'évaluation des *Musa* (IMTP), financé par le PNUD, s'est achevée en 1998. Les données d'évaluation de 14 pays ont été envoyées pour analyse et le rapport définitif sera disponible en 1999. Les données initiales mettent en évidence que FHIA-23, un hybride de banane dessert produit par la FHIA, possède une bon niveau de résistance à la cercosporiose noire, même sous de fortes pressions de la maladie, et produit de bons rendements dans un grande diversité d'environnements. FHIA-23 paraît également être tolérant aux races 1 et 4 de la fusariose. Un certain nombre de clones, dont des clones provenant de Taiwan (TBRI) et du Brésil (EMBRAPA), donnent également des résultats prometteurs au niveau de la résistance aux maladies.

Une nouvelle phase de l'IMTP a démarré avec la publication des guides techniques pour l'évaluation de la résistance et de la tolérance aux cercosporioses et à la fusariose. Plusieurs pays ont exprimé l'intérêt de participer à cette nouvelle phase et ont déjà fait la demande de matériel pour évaluation.

La base de données de l'IMTP contient des informations sur les hybrides et cultivars de référence du programme. On y trouve des données sur les caractères morphologiques et la résistance aux maladies ainsi que des données de performance générale et des photos des différents clones. Cette base de données est déjà accessible aux participants de la phase II de l'IMTP ainsi qu'à 20 autres pays concernés.

Transformation génétique

Analyse des suspensions cellulaires par cytométrie en flux

Les suspensions cellulaires par cytométrie en flux offrent de très bonnes perspectives pour la multiplication rapide et sont systématiquement utilisées dans les travaux de transformation génétique des bananiers et bananiers plantain. La cytométrie en flux, technique puissante pour déterminer le degré de ploïdie, est un outil d'avenir pour un contrôle plus précis des suspensions cellulaires de bananiers. Cette technique facilite la vérification de l'euploïdie ou l'aneuploïdie des cellules, conditions qui entraînent une variation somaclonale chez les plantes produites à partir de suspensions. Dans le cadre de ces travaux, l'analyse d'une culture embryogénique par suspension cellulaire de quatre ans a été effectuée, mettant en évidence un pic de triploïdie normal. Les plantes issues de cette suspension à haut pouvoir régénérant ont été plantées au champ afin d'y évaluer leur niveau de variation somaclonale, et les observations préliminaires sur 50 plantes cultivées en serre n'ont montré aucune variation au cours du développement végétatif. Dans un autre test en revanche, le pic d'une suspension cellulaire du cultivar Bluggoe a mis en évidence une déviation vers la gauche, indiquant une perte de chromosomes. Cette suspension a produit de nombreux hors types dans les premières années de culture mais son potentiel de régénération est à présent totalement perdu. Même si cette technique doit être évaluée sur une plus grande variété de génotypes, il semblerait, à ce stade, que l'analyse par cytométrie en flux soit un très bon moyen d'identifier rapidement les suspensions de mauvaise qualité. Ces travaux ont été menés dans le cadre du programme de recherche coordonné par la FAO, l'IAEA et l'AGCD au sein duquel collaborent l'IAEA, l'INIBAP et la KUL.

Transformation génétique au moyen d'Agrobacterium

Des progrès ont été réalisés à la KUL dans les travaux sur la transformation génétique au moyen d'*Agrobacterium*. Cette technique, développée comme alternative au bombardement de particules, permet de manipuler des fragments d'ADN plus importants, contenant donc plus de gènes. Etant donné que les caractères relatifs à la résistance aux ravageurs et aux maladies sont généralement contrôlés par plusieurs gènes, on pense que cette technique donnera de très bons résultats. Les premiers tests ont été réalisés sur des cellules en suspension du cultivar Three Hand Planty (plantain) et la régénération de plantules apparaît chez certaines colonies supposées transgéniques. La nature transgénique des plantes a été confirmée par coloration histochimique de l'enzyme (-glucuronidase exprimée par le gène étranger *gusA*. Dans une autre expérience, parmi 188 plantes régénérées, 174 (92,5 %) exprimaient le gène *gusA* dans leur tissu foliaire. Toutes les plantes transgéniques sont actuellement multipliées par micropropagation, conservées *in vitro* et soumises à une analyse

moléculaire comme la PCR ou l'hybridation Southern. Ces travaux ont permis de mettre en évidence que *Agrobacterium tumefaciens* n'est pas seulement compatible avec divers tissus du bananier dans les premiers stades de leur interaction mais qu'il est aussi capable de transférer et d'intégrer l'ADN-T dans les cultures cellulaires de bananier.

Recherche sur les nématodes parasites du bananier

Des tests d'évaluation sont actuellement réalisés par des experts associés INIBAP/VVOB au Viêt-nam (VASI) et au Costa Rica (CORBANA) dans le but d'identifier les sources de résistance aux principales espèces de nématodes qui parasitent les *Musa.* Par ailleurs, la KUL effectue un criblage précoce et mène des travaux qui ont permis d'identifier deux variétés du bananier Fe'i et trois variétés diploïdes du bananier AA de Papouasie Nouvelle Guinée présentant un niveau de résistance plus élevé à *Radopholus similis.* Aucune autre source de résistance à d'autres nématodes n'a été identifiée à ce jour. Des travaux similaires sont actuellement menés au CIRAD-FLHOR (France) sur la diversité de *R. similis.* Il semble qu'une relation directe existe entre l'aptitude des populations de nématodes à se reproduire et les dégâts observés sur les racines. La virulence (l'aptitude intrinsèque à causer des dégâts) de *R. similis* semble être relativement uniforme parmi les populations de cette espèce de nématodes mais l'agressivité (l'aptitude à se multiplier dans les tissus de la plante) varie considérablement en fonction des populations. L'étendue des dégâts sur les plantes est vraisemblablement liée à ce dernier caractère. En outre, il n'existe pas de lien simple entre les conditions écologiques d'un site donné et l'agressivité des populations de nématodes.

Activités régionales

Amérique latine et Caraïbes

Ouragans dévastateurs

Les producteurs de bananes et de bananes plantain d'Amérique centrale ont essuyé des pertes considérables en 1998 lors du passage dévastateur des ouragans « Georges » et « Mitch ». Porto Rico, la République dominicaine, Haïti et Cuba ont été durement frappés par l'ouragan « Georges » qui a littéralement balayé la plupart des plantations dans les trois premiers pays et causé de graves dégâts dans 70 % des régions productrices de Cuba. L'ouragan « Mitch » a lui dévasté pratiquement toutes les régions productrices de bananes et de bananes plantain au Honduras, et le Nicaragua ainsi que le Guatemala ont été aussi durement frappés. Sur une note plus positive, les hybrides FHIA, dont la culture s'étend actuellement sur plus de 8000 hectares à Cuba, ont pu mieux résister à l'ouragan que d'autres cultivars. C'était particulièrement le cas de FHIA-18, l'un des hybrides préférés des producteurs cubains.

Dissémination de la cercosporiose noire au Brésil

Suite à la confirmation de la présence de cette maladie dévastatrice au Brésil au début de 1998, l'INIBAP-LACNET a aidé l'EMBRAPA à mettre en place une stratégie pour minimiser les dégâts causés par cette maladie. Une équipe d'experts, composée du Coordinateur régional de l'INIBAP-ASPNET et d'un consultant recruté par l'INIBAP, s'est rendue dans les zones affectées (sur les rives de l'Amazone près de la frontière colombienne) dans le but de faire un bilan de la situation et de mettre en place des mesures pour empêcher que la maladie ne se propage davantage. Des techniques de gestion de la lutte contre cette maladie qui menace presque un demi-million d'hectares de *Musa* au Brésil ont également été mises au point.

Projet BID

Le projet « Musa *research and technology transfer network* », mis en œuvre au profit des pays d'Amérique latine et des Caraïbes, et financé par la Banque interaméricaine de développement (BID), s'est achevé en août. D'une durée de deux ans, ses activités ont associé six instituts de recherche (FHIA, Honduras; CORBANA, Costa Rica; EMBRAPA, Brésil; CORPOICA, Colombie; WIBDECO, Ste. Lucie; et CATIE, Costa Rica). Les trois programmes de sélection de la région ont reçu un soutien considérable pour leurs activités d'amélioration des bananiers et des bananiers plantain, et pour augmenter leurs collections de matériel génétique. Des tests d'évaluation de la résistance de certaines variétés de *Musa* aux cercosporioses noire et jaune et à la fusariose ont été menés dans cinq pays dans le cadre de ce projet qui incluait également des activités de formation et de documentation.

Atelier sur la production de bananes biologiques

L'INIBAP-LACNET et l'École d'agriculture pour la région des tropiques humides (EARTH) au Costa Rica ont organisé, avec l'appui financier de la BID, un atelier international sur la production organique/écologique de bananes. L'objectif de cet atelier était de faire un bilan des connaissances sur la production organique de cette culture et d'identifier les besoins auxquels il faudra répondre pour garantir la durabilité et la rentabilité de ce type de production. Vingt cinq spécialistes des bananes, des bananes plantain et de la culture biologique venus de dix pays ont partagé leur expérience sur ce thème. Les participants ont souligné le rôle potentiel important des variétés résistantes aux ravageurs et aux maladies dans la production biologique et ont recommandé qu'un centre d'information sur la production biologique de *Musa* soit établi, de même qu'un réseau de production organique, dans le but d'évaluer l'impact des types de production alternatifs qui auront été retenus.

Asie et Pacifique

Partenariat avec l'APAARI

Dans le but de renforcer la collaboration entre l'INIBAP-ASPNET et divers partenaires de la région, un important accord a été signé en 1998 par le Directeur général de l'IPGRI et le Secrétaire exécutif de l'association des institutions de recherche agricole pour l'Asie et le Pacifique (APAARI). Cet accord jette les bases de la collaboration et du partenariat entre l'APAARI et l'IPGRI-INIBAP et place le réseau régional ASPNET sous les auspices de l'APAARI.

Ateliers/formation

L'INIBAP-ASPNET a participé à l'organisation et au co-parrainage d'un certain nombre d'ateliers et de formations en 1998. Un atelier régional sur le thème « *Disease Management of Banana and Citrus : the use of and management of disease free planting materials* » (Gestion des maladies du bananier et des agrumes : utilisation et gestion de matériel végétal sain), organisé en collaboration avec le FFTC-ASPAC, a réuni 17 intervenants de la région et de l'extérieur, dont des virologues renommés des États-Unis, d'Australie et de Taiwan. Les travaux de l'atelier ont abouti à des recommandations sur les priorités de la recherche, les activités de développement et les politiques à promouvoir pour améliorer la lutte contre les maladies virales affectant la production de bananes et d'agrumes dans la région.

Profitant de la présence de virologues de renommée internationale, l'atelier a été suivi par une formation sur l'indexation des virus qui s'est tenue à l'université des Philippines à Los Baños, à laquelle ont participé 17 chercheurs et techniciens. Ces derniers travaillent dans les universités d'État ou des laboratoires privés, et mènent des travaux sur la production de matériel végétal de bananiers et de bananiers plantain issu de cultures de tissus. Les participants ont été formés à l'identification d'infections virales chez les bananiers à l'aide des techniques ELISA et PCR. Cette formation s'est avérée très utile dans la mesure où les virus du bunchy top bananier (BBTV) et de la mosaïque des bractées du bananier (BBrMv) sont des maladies très répandues aux Philippines. L'organisation de formations à l'identification des maladies virales du bananier contribuera à la production de matériel végétal indemne de maladies. L'utilisation, par les petits producteurs, de matériel végétal sain jouera un rôle important non seulement en réduisant les effets des maladies et leur dissémination, mais aussi en diminuant les pertes causées par les nématodes et les charançons.

Afrique orientale et australe

Dans le cadre des activités du réseau régional BARNESA, deux ateliers ont été organisés au cours de 1998. En outre, le plan stratégique quinquennal de BARNESA a été finalisé en accord avec les directives fournies par l'ASARECA, en collaboration avec les membres du réseau.

Atelier sur les informations de référence sur les bananiers

Cette réunion, organisée en février 1998 à Kampala, et financée par la Fondation Rockefeller, avait pour objectif de faire le bilan des informations disponibles sur la production bananière dans les pays membres de BARNESA, d'identifier les domaines où l'information reste insuffisante, de déterminer dans quelle mesure ces insuffisances pouvaient affecter la mise en œuvre et le bon déroulement du plan stratégique, et de proposer des actions pour résoudre ces problèmes. Une des réalisations principales de cette réunion a été d'élaborer un projet de collaboration entre les membres

de BARNESA (SNRA et centres de recherche) et d'autres organisations de la région qui bénéficient d'un avantage comparatif dans le traitement d'informations de référence et dans la gestion de bases de données. On pense que la collecte et l'analyse de ces informations fournira les données quantitatives dont on a besoin sur l'importance des bananes dans les économies nationales de la région pour stimuler et justifier des investissements plus importants dans la recherche sur cette culture.

Atelier sur la lutte phytosanitaire intégrée

Cette réunion a été coorganisée par l'INIBAP, l'IITA et l'ITSC (Afrique du Sud) dans le cadre des activités de BARNESA. L'intérêt d'une réunion sur ce thème est né du constat suivant : si de nombreuses technologies de lutte phytosanitaire sont disponibles et peuvent d'ores et déjà être testées en milieu réel, elles ne s'appliquent qu'à un seul problème à la fois. Or, le cultivateur souhaiterait que tous ses problèmes phytosanitaires soient résolus en même temps. La rencontre d'un groupe de travail interdisciplinaire a permis de déterminer les trois principaux domaines dans lesquels les tests de lutte phytosanitaire intégrée sur le terrain devaient être menés :

- Utilisation de matériel végétal sain;
- Résistance de la plante hôte;
- Gestion des cultures.

Il a été rappelé que le partenaire principal dans ces tests était le cultivateur. Il doit participer à toutes les étapes du processus, de l'identification des contraintes au suivi et à l'évaluation de ces techniques sur le terrain en passant par la sélection des différentes options de lutte.

Les participants de l'atelier se sont engagés à faire une diffusion plus large des tests de lutte phytosanitaire intégrée en milieu réel et ont convenu que les recommandations de la réunion devaient être prises en compte dans la mise en œuvre de nouveaux projets.

Afrique occidentale et centrale

*MUSA*CO

En 1998, le réseau *Musa* pour l'Afrique de l'ouest et centrale (*MUSA*CO), créé avec le soutien de la CORAF et placé sous son patronage, est passé de 10 pays membres à 12, le Bénin et la Sierra Leone en étant les nouveaux membres. Lors de la deuxième réunion annuelle du comité de pilotage de *MUSA*CO à Douala (Cameroun), les participants (incluant les 12 pays membres ainsi que l'IITA, le CRBP et l'INIBAP-IPGRI) ont examiné un projet de stratégie pour le réseau. Ils ont convenu que les enquêtes réalisées pour recueillir des données de bases à partir de sites de référence dans chaque pays devaient être considérées comme une activité prioritaire en 1999. Les participants ont également convenu que la méthodologie, actuellement utilisée sur le terrain au Cameroun par le CRBP, pour décrire et diagnostiquer les contraintes et pour suivre continuellement les changements apportés dans les systèmes de production, devait être introduite dans d'autres pays.

Soutien à la recherche régionale

En Afrique occidentale et centrale, les rendements des bananiers et bananiers plantain sont faibles, de 5 à 15 t/ha, essentiellement en raison des effets de la cercosporiose noire, des nématodes et des charançons. L'INIBAP apporte son soutien à l'ICRA en République centrafricaine, à l'INERA en République démocratique du Congo et à l'ISRA au Sénégal pour faciliter l'introduction et l'évaluation de nouvelles variétés à hauts rendements qui sont résistantes aux ravageurs et aux maladies.

La quantité insuffisante de matériel végétal sain est également un facteur de limitation de l'expansion des zones de production de *Musa* en Afrique occidentale et centrale. La productivité est affectée dans la mesure où les producteurs plantent des rejets contaminés par les maladies et les ravageurs, produisant ainsi de faibles rendements. L'INIBAP a par conséquent fourni à la station de recherche agricole de l'université du Ghana les financements nécessaires à l'évaluation de la technique de la multiplication sur fragments de bulbe en tant que moyen de production rapide de rejets de bonne qualité.

Symposium international « Les productions bananières : un enjeu économique majeur pour la sécurité alimentaire »

Le premier symposium international sur les aspects socio-économiques de la production bananière non destinée à l'exportation s'est déroulé à Douala (Cameroun) en novembre 1998. Cette réunion s'est concentrée sur tous les types de bananiers et bananiers plantain cultivés pour la consommation locale, et a rassemblé plus de 150 participants de toutes les régions productrices de *Musa* du monde entier. Le symposium était coorganisé par le CRBP et l'INIBAP, en collaboration avec le CIRAD et le CTA.

Les exposés présentés lors du symposium ont confirmé l'importance du rôle que la banane et la banane plantain jouent dans la sécurité alimentaire et financière des régions tropicales et subtropicales dans le monde entier. Le symposium a reconnu que ce rôle fondamental est largement ignoré par les décideurs et qu'il est par conséquent nécessaire d'accentuer les efforts pour les sensibiliser, tant dans les pays producteurs que dans les pays donateurs.

Le symposium a également souligné la grande diversité de la production bananière. Cette diversité inclut non seulement toutes les variétés cultivées mais aussi les systèmes de production et les aspects consommation et utilisation. Il a été rappelé que la recherche visant l'amélioration de la production devait s'appuyer sur les besoins des consommateurs et devait être multisectorielle et pluridisciplinaire. La recherche doit également être participative et tenir compte des besoins de tous les acteurs de la filière commerciale, du producteur au consommateur.

Le large éventail d'expériences et l'information présentés au cours de ce symposium ont également permis de mettre en évidence le besoin d'intensifier les échanges sur les aspects socio-économiques de cette culture. C'était en fait la recommandation principale de la réunion. Par ailleurs, il a été recommandé que les informations sur les besoins des consommateurs soient rassemblées, analysées et consolidées avec les données sur les diverses sources d'approvisionnement. Des études sur l'amélioration des méthodes traditionnelles d'utilisation des produits issus de la production bananière sont également nécessaires.

Information et communication

Stratégie d'information de l'INIBAP

L'information joue un rôle essentiel dans la mise en œuvre effective du programme de l'INIBAP, et la rapidité d'assimilation des nouvelles technologies de communication, comme le CD-ROM et l'Internet, est un facteur d'amélioration des services d'information du réseau. En 1998, une réunion de planification stratégique s'est intéressée plus particulièrement au rôle de l'INIBAP dans la diffusion d'informations sur les *Musa* au niveau mondial et régional, et a identifié les domaines où l'INIBAP bénéficiait d'un avantage comparatif. Les principes qui sous-tendent la stratégie d'information de l'INIBAP ont été décrits comme suit :

- Flexibilité d'approche en fonction des besoins des utilisateurs;
- Plurilinguisme;
- Recours aux moyens de diffusion les plus adaptés, y compris les outils de communication les plus récents;
- Recours au partenariat et au fonctionnement en réseau;
- Régionalisation croissante des activités d'information.

Sensibilisation

Salon international de l'agriculture de Paris

En collaboration avec le CIRAD, l'INIBAP a participé en 1998 au Salon international de l'agriculture de Paris. La mission du CIRAD et de l'INIBAP était d'informer les visiteurs sur l'importance et la diversité des bananiers et des bananiers plantain. Etant donné que ce Salon attire plus d'un demi-million de visiteurs chaque année, c'était pour l'INIBAP une excellente occasion de mener une importante campagne de sensibilisation. Toujours en partenariat avec le CIRAD, l'INIBAP a collaboré à la production d'un large éventail de produits d'information et s'est montré particulièrement actif dans la mise au point d'une borne interactive multimédia, présentant d'une façon informelle et attrayante, tous les aspects de cette culture. Une très jolie brochure illustrée sur les bananes a également été produite et a été très appréciée par les visiteurs du stand. Les activités de l'INIBAP étaient exposées sur plusieurs posters et plus de 2000 affiches sur la diversité des bananiers ont été distribuées.

INIBAP en 1998

El papel de INIBAP como una organización de red fue destacado durante 1998. Las dos redes de banano subregionales, que INIBAP apoya en Africa, se hicieron totalmente operacionales durante este año, organizándose un taller sobre el manejo integrado de plagas de banano (MIP), importante para toda Africa, en el marco de la Red de Investigación Bananera para Africa Oriental y del Sur (BARNESA). Los beneficios del MIP también fueron destacados en América Latina y el Caribe durante una reunión sobre la producción bananera orgánica y amistosa con el ambiente, coorganizada por INIBAP en Costa Rica. Las asociaciones globales fueron fortalecidas durante la segunda reunión mundial de PRO*MUSA*, donde los participantes demostraron un fuerte apoyo al programa y donde se desarrolló una gran cantidad de iniciativas de colaboración. INIBAP también participó en la organización del primer simposio internacional sobre los aspectos socioeconómicos de la producción de bananos para el consumo interno. Esta reunión, celebrada en Camerún, atrajo una amplia audiencia internacional y sirvió para destacar la necesidad de mejorar el intercambio de información entre las regiones sobre este cultivo tan ampliamente cultivado, pero tan poco investigado.

INIBAP continúa apoyando las investigaciones sobre varios aspectos del mejoramiento de bananos. La transformación de bananos mediante *Agrobacterium* fue exitosamente demostrada en la Universidad Católica de Lovaina (KUL), abriendo un camino para protocolos más eficaces en el futuro. Se organizó una reunión en el marco de PRO*MUSA* sobre el virus del rayado del banano, y la investigación continúa en torno este virus único tan ampliamente propagado. La segunda fase del Programa Internacional de Evaluación de *Musa* (IMTP) fue completada en 1998 y los resultados de 14 países fueron enviados a INIBAP para realizar un análisis global. Se identificó una cantidad de híbridos promisorios con buenos niveles de resistencia a las principales plagas y enfermedades, que afectan las musaceas, y que son estables en una gran variedad de ambientes. Actualmente, estos híbridos pueden ser recomendados para pruebas más amplias en los campos de agricultores.

Actividades temáticas

Manejo de germoplasma de *Musa*

Actividades del banco de genes

A finales de 1998, la colección de germoplasma de *Musa* que se encuentra en el Centro de Tránsito de INIBAP (ITC) contaba con 1119 accesiones. El centro de tránsito desplegó una gran actividad en la distribución del material durante el año, enviando 55 embarques con 267 accesiones diferentes a 27 países alrededor del mundo para actividades de investigación y desarrollo. Adicionalmente, 140 accesiones fueron enviadas para su indización respecto a la presencia de los virus y otras 56 accesiones fueron duplicadas en CATIE, Costa Rica. Esto significa que actualmente el 51 % de la colección del ITC tiene duplicados de seguridad y el 66 % de la colección fue indizada para la presencia de los virus. Con el fin de incrementar la capacidad de INIBAP con respecto a la indización para la presencia de virus, se abrió un nuevo centro de indización en el PPRI en Africa del Sur.

Se realiza el tamizado regular de las accesiones que se encuentran en la colección del ITC para detectar la presencia de bacterias endógenas. Se utiliza un medio selectivo para la identificación de las micobacterias de crecimiento lento, las cuales era muy difícil detectar en el pasado. Las accesiones infectadas son limpiadas mediante el uso de los cultivos de ápices de meristemas. En 1998 también se introdujo el tamizado para detectar la presencia de la enfermedad de Moko (marchitamiento bacteriano) y aunque no se conoce que esta bacteria pase sin ser notada a través del cultivo de tejidos, el tamizado se realiza regularmente en las muestras destinadas a los países que requieren la certificación de ausencia de esta enfermedad en el material vegetal.

La investigación sobre la crioconservación, como el método preferido para el almacenamiento del germoplasma de *Musa* a largo plazo, hizo buen progreso durante este año. Como resultado de la colaboración establecida en 1997 con el JIRCAS (Japón), se desarrollaron tres métodos alternativos. Mediante una combinación de estos métodos, cualquier accesión de *Musa* examinada puede ser conservada en frío. El énfasis durante este año fue enfocado en la comparación y optimización de los tres protocolos para los tejidos meristemáticos.

Recolección de germoplasma

Una recolección de germoplasma de *Musa*, apoyada por INIBAP, tuvo lugar en India en 1998. Se recolectaron 36 accesiones en los estados de Assam y Meghalaya. Una encuesta preliminar realizada en la región identificó una gran variabilidad en los clones ABB y posiblemente en las especies silvestres, *Musa balbisiana*. Ya que anteriormente poca diversidad se ha descubierto en estas especies, se espera que las futuras misiones de recolección revelen resultados interesantes.

Investigación del virus del rayado del banano (BSV)

Actualmente, el BSV se conoce como el virus de *Musa* más propagado, y se encuentra en todos los lugares donde se cultivan musaceas a nivel mundial. El virus pertenece al grupo de los badnavirus y como otros badnavirus, es muy variable serológicamente. El BSV es único entre los virus de las plantas ya que las secuencias virales están integradas en el genoma del huésped y pareciera que las secuencias del BSV pueden ser encontradas en todas las líneas de *Musa* examinadas. En algunos cultivares de *Musa*, las secuencias pueden ser activadas para dar una infección episomal. En el Centro John Innes, Reino Unido, se realizó una investigación sobre las secuencias integradas descubiertas en el cultivar Obino L'Ewai, con el fin de suministrar información que pudiera ser utilizada en el desarrollo de un diagnóstico. Las técnicas utilizadas incluyen la reacción en cadena de la polimerasa (PCR) e hibridación *in situ*. Se descubrió que existen dos loci de secuencias del BSV en los cromosomas del Obino L'Ewai y ambos tienen una estructura compleja. La secuencia integrada del BSV por si misma no es un simple genoma viral, sino que tiene muchas secuencias invertidas y rearregladas. Se considera que probablemente sólo un subjuego del complejo integrante es activado en el Obino L'Ewai, ya que las secuencias integradas del BSV también se encuentran en los cultivares que no tienen historial de activación. Hasta ahora no disponemos de información sobre cómo la

forma episomal simple es derivada a partir de los integrantes complejos, sin embargo se piensa que probablemente la diferencia entre las situaciones activables y no activables se encuentra en el detalle del integrante o en la presencia de un activador desconocido.

Caracterización de germoplasma

La caracterización del germoplasma de *Musa* continúa tanto a nivel morfológico, como molecular. Con respecto a la caracterización morfológica, INIBAP organizó durante 1998 dos cursos de capacitación regionales sobre el uso del Sistema de Información sobre el Germoplasma de *Musa* (MGIS). Estos cursos fueron realizados en Australia y Cuba, aumentando a 32 el número de curadores de los bancos de germoplasma entrenados en el uso del sistema. Actualmente, la base de datos global contiene registros de 2,453 accesiones proporcionados por seis instituciones asociadas : CRBP, CIRAD-FLHOR, BPI, FHIA, ITC y SCAU. Está disponible la información sobre la caracterización de 647 accesiones, los datos sobre los resultados de las evaluaciones agronómicas de 956 accesiones y de evaluaciones para el estrés de 183 accesiones. La base de datos, que también incluye fotografías de más de 400 accesiones, está disponible en CD-ROM y se distribuye gratuitamente a todas las instituciones colaboradoras.

La caracterización molecular de más de 320 accesiones seleccionada de la colección del ITC fue completada en 1998. Este trabajo fue realizado por CIRAD-FLHOR, utilizando marcadores de tipo STMS (*Sequence-tagged microsatellite*). Diez marcadores STMS fueron seleccionados debido a su alto potencial de discriminación. Se identificaron los alelos específicos de los genomas *balbisiana* y Australimusa, permitiendo de este modo la identificación de clones interespecíficos. Las accesiones examinadas fueron clasificadas previamente de acuerdo a sus características morfológicas. Este trabajo permitió confirmar las clasificaciones existentes y en algunos casos se sugirieron reclasificaciones a niveles de grupo o subgrupo.

Mejoramiento del germoplasma de *Musa*

*PRO*MUSA

Reunión sobre el BSV

En el marco del grupo de trabajo en virología de PRO*MUSA*, se celebró una reunión sobre el BSV en Montpellier, Francia, en enero de 1998. La reunión congregó a los más prominentes virólogos que trabajan en BSV para tres días de discusiones y intercambio de información e ideas. La reunión se enfocó en los avances recientes en el entendimiento del virus y en el significado de las secuencias virales integradas en el genoma de *Musa*. Se analizaron y priorizaron las necesidades de investigación y se reevaluaron los procedimientos corrientes de indización para el BSV a la luz de los resultados de las investigaciones. Se acordó que los métodos de indización existentes siguen siendo los más confiables para detectar un gran rango de los aislados del BSV y se consideró innecesaria la revisión de las Guías técnicas para el movimiento seguro de germoplasma de *Musa* de FAO/IPGRI. Las memorias de la reunión fueron publicadas por INIBAP proporcionando información importante sobre el estado de las investigaciones sobre este virus único.

Segunda reunión global

La segunda reunión global de PRO*MUSA* fue celebrada en Douala, Camerún en noviembre de 1998. A la convocatoria asistieron unos 70 investigadores e incluyó reuniones de los grupos de trabajo sobre el mejoramiento genético, Sigatoka, nematología y virología. Cada grupo se enfocó en la revisión de las prioridades establecidas en Guadalupe y en la identificación de los planes de trabajo y oportunidades para la colaboración en los años venideros. En adición a las discusiones de los grupos individuales, se dedicó un tiempo para las interacciones entre estos, lo que fue considerado particularmente útil.

Entre las iniciativas positivas, resultado de las discusiones de los grupos de trabajo, se encuentran las siguientes :

- La designación y distribución de las tareas entre los diferentes miembros del grupo de trabajo en virología, dirigidas hacia el aumento de la eficiencia y progreso rápido en esta disciplina,
- La formación de dos subgrupos dentro del grupo de trabajo en mejoramiento genético (genética molecular y citogenética). Estos dos subgrupos trabajarán conjuntamente para desarrollar proyectos de colaboración
- La idea del grupo de trabajo en nematología de reunir toda la información en ciertas áreas de la nematología de *Musa* y hacerla ampliamente disponible a través de las publicaciones de PRO*MUSA*.

Durante esta segunda reunión, los participantes en PRO*MUSA* demostraron un creciente compromiso con el programa y una apreciación de los beneficios que se obtendrán a través de una colaboración mejorada e intercambio de información promovidas por PRO*MUSA*. Se expreso claramente el apoyo al programa. Esta segunda reunión ayudó a mejorar el espíritu de colaboración que ya ha sido bien desarrollado durante la primera reunión en Guadalupe en 1997.

IMTP

La fase II del Programa Internacional de Evaluación de *Musa* (IMTP), financiado por el PNUD, fue completada en 1998. Los resultados procedentes de 14 países, fueron recibidos para un análisis global y el informe final estará disponible a principios de 1999. Los resultados iniciales muestran que el FHIA-23, un híbrido de banano de postre producido por la Fundación Hondureña de Investigación Agrícola, tiene un nivel muy bueno de resistencia a la Sigatoka negra, aún bajo altos niveles de presión de la enfermedad, y produce buenos rendimientos a través de una serie de ambientes. El FHIA-23 también parece ser tolerante a las razas 1 y 4 del marchitamiento por Fusarium. Una cantidad de otros clones, incluyendo materiales de Taiwan (TBRI) y Brasil (EMBRAPA), también mostró resultados promisorios en términos de resistencia a la enfermedad.

Una nueva fase del IMTP ha comenzado con la publicación de las Guías técnicas para la evaluación de la resistencia y tolerancia a las enfermedades de Sigatoka y el marchitamiento por Fusarium. Varios países han expresado deseo de participar en la siguiente fase del IMTP y ya han solicitado material para la evaluación.

Se ha desarrollado una base de datos del IMTP que contiene información sobre los híbridos IMTP y cultivares de referencia. También se incluyen datos sobre las características agronómicas y de resistencia, junto con la información sobre el desempeño general y fotografías de diferentes clones. Esta base de datos ya está disponible para los participantes en la fase II del IMTP, así como para otros 20 países interesados.

Transformación genética

Análisis mediante citometría de flujo de las suspensiones celulares

Las suspensiones celulares son promisorias para la multiplicación rápida y generalmente se utilizan para la ingeniería genética de bananos y plátanos. La citometría de flujo, que es una técnica poderosa para la evaluación de ploidia, ofrece perspectivas para el monitoreo de la calidad de las suspensiones celulares del banano. Esta técnica facilita la verificación de la euploidia/aneupoidia de las células, condiciones que dan como resultado la variación somaclonal en las plantas derivadas de suspensiones celulares. Como parte de este trabajo, un cultivo de suspensión embriogénica de cuatro años de edad del cultivar Three Hand Planty fue analizado y los resultados muestran un pico triploide normal. Las plantas derivadas de esta suspensión altamente regenerable fueron sembradas en el campo para la evaluación de la variación somaclonal, y las observaciones preliminares de 50 plantas de invernadero no mostraron variación durante el desarrollo vegetativo. En contraste con otra prueba, el pico de un cultivo de suspensión de células para el cultivar Bluggoe exhibió un desplazamiento hacia la izquierda, indicando una pérdida de cromosomas. Esta suspensión produjo numerosos tipos anormales en los años tempranos de cultivo, pero su regeneración potencial actualmente está perdida por completo. Mientras que esta técnica requiere de realizar más evaluaciones sobre una mayor variedad de genotipos, parecería en esta etapa que el análisis mediante citometría de flujo mantiene el potencial como un medio para la identificación rápida de los cultivos de suspensiones de baja calidad. Este trabajo fue realizado en el marco del Programa de Investigación Coordinado de FAO/IAEA/BADC en el cual colaboran IAEA, INIBAP y la KUL.

Transformación mediante *Agrobacterium*

En la Universidad Católica de Lovaina, se alcanzó un progreso en la transformación de bananos y plátanos mediante *Agrobacterium*. Esta técnica está siendo desarrollada como una alternativa al bombardeo con partículas ya que permite la manipulación de pedazos mayores de ADN que comprenden varios genes. Ya que características como la resistencia a plagas y enfermedades generalmente son controladas por varios genes, se considera que la técnica tiene un gran potencial. Los ensayos iniciales se realizaron en los cultivos de células en

suspención del cultivar de plátano Three Hand Planty. Actualmente ocurrió la regeneración de brotes en las colonias transgénicas putativas seleccionadas. La naturaleza transgénica de las plantas fue confirmada mediante una coloración histoquímica de la enzima de (-glucuronidasa expresada por el gen foráneo *gusA*. En un experimento, 174 de las 188 plantas regeneradas (92.5 %) mostraron la expresión del gen *gusA* en su tejido foliar. Todas las plantas transgénicas están siendo micropropagadas, mantenidas *in vitro* y sujetas a un análisis molecular como el PCR e hibridación Southern. Este trabajo fue capaz de demostrar que el *Agrobacterium tumefaciens* no es sólo compatible con varios tejidos de banano en las etapas tempranas de su interacción, sino que es capaz de entregar e integrar el T-ADN en las células cultivadas de banano.

Investigación de los nematodos de banano

Ensayos de evaluación con el fin de identificar fuentes de resistencia a las principales especies de nematodos que afectan las musaceas están siendo realizados por los Expertos Asociados de INIBAP/VVOB en Vietnam (VASI) y Costa Rica (CORBANA). Adicionalmente, el tamizado precoz se está realizando en KUL. El trabajo en KUL ha identificado dos variedades de banano Fe'i y tres diploides AA procedentes de Papua Nueva Guinea con niveles aumentados de resistencia a *Radopholus similis*. Hasta la fecha, no se identificaron fuentes de resistencia a otros nematodos. En un trabajo relacionado, que se realiza en CIRAD-FLHOR en Francia, se estudia la diversidad dentro del *R. similis*. Ahí parece haber una relación directa entre la capacidad reproductora de las poblaciones de nematodos y el daño resultante a las raíces. La virulencia (la habilidad intrínseca para causar daños) en *R. similis* parece ser relativamente uniforme a través de las poblaciones de esta especie de nematodos, pero la agresividad (la habilidad de multiplicarse en los tejidos vegetales), varía ampliamente de una población a otra. Lo más probable es que la extensión de los daños a las plantas está ligada a la última característica. Más, no existe una relación simple entre las condiciones ecológicas en un área dada y la agresividad de las poblaciones de nematodos.

Actividades regionales

América Latina y el Caribe

Daños por huracanes

Los productores de bananos y plátanos en América Central sufrieron considerables pérdidas durante 1998 como resultado de los huracanes 'Georges' y 'Mitch'. Puerto Rico, República Dominicana, Haití y Cuba fueron severamente afectados por el 'Georges' que barrió prácticamente todas las plantaciones en los primeros tres países y causó daños en un 70 % en las áreas productoras de Cuba. El huracán 'Mitch' devastó casi toda la zona productora de bananos y plátanos en Honduras, y Nicaragua y Guatemala también fueron severamente afectadas.

Desde un punto de vista positivo, en Cuba se hizo claro que los híbridos de la FHIA, que actualmente cubren más de 8,000 hectáreas, fueron capaces de resistir mejor a los vientos del huracán que otros cultivares. Este fue específicamente el caso del FHIA-18, uno de los híbridos preferidos de los agricultores de Cuba.

Propagación de la Sigatoka negra a Brasil

Después de confirmar la presencia de esta devastadora enfermedad en Brasil en la primera mitad de 1998, INIBAP-LACNET apoyó las actividades de EMBRAPA en sus esfuerzos por desarrollar una estrategia para minimizar el daño causado por esta enfermedad. Un equipo de expertos incluyendo al Coordinador regional de INIBAP-ASPNET y un consultor contratado por INIBAP visitaron el área afectada (a lo largo de las orillas del río Amazona cerca de la frontera con Colombia), con el fin de evaluar la situación y desarrollar medidas para prevenir la propagación de la enfermedad. También se desarrollaron prácticas de manejo para controlar la enfermedad, que amenaza a casi medio millón de hectáreas de *Musa* en Brasil.

Proyecto BID

El proyecto "Musa *Research and Technology Transfer Network*" para América Latina y el Caribe, financiado por el Banco Interamericano de Desarrollo (BID), llegó a su final en agosto de este año. Este proyecto duró dos años e incluyó la participación de seis instituciones de investigación (FHIA, Honduras; CORBANA, Costa Rica; EMBRAPA, Brasil; CORPOICA, Colombia; WIBDECO, Santa Lucia; y CATIE, Costa Rica). Los tres programas de mejoramiento de la región recibieron un apoyo considerable para las actividades de mejoramiento de bananos y plátanos, así como para el fortalecimiento de sus colecciones de germoplasma. La evaluación de las variedades de *Musa* respecto a la presencia de las Sigatokas negra y amarilla y del marchitamiento por Fusarium fue implementada en cinco países con apoyo del proyecto, y las actividades de capacitación y documentación también formaron una parte importante del proyecto.

Taller sobre la producción de bananos orgánicos

INIBAP-LACNET, conjuntamente con la Escuela de Agricultura para la Región del Trópico Húmedo (EARTH), Costa Rica, organizó un taller internacional sobre la producción de bananos orgánicos y amistosos con el ambiente, financiado por el BID. El objetivo de este taller consistió en analizar el actual conocimiento con respecto a la producción de bananos y plátanos orgánicos e identificar los requerimientos para la producción orgánica sostenible y económicamente rentable de este cultivo. Veinticinco expertos en producción orgánica, en banano y en plátano asistieron a esta reunión y compartieron sus experiencias sobre este tópico. Se destacó el papel importante que las variedades resistentes a plagas y enfermedades pueden desempeñar en la producción orgánica. Se recomendó establecer un centro de información sobre la producción orgánica de *Musa*, junto con una red de producción orgánica para evaluar el impacto de las alternativas de producción seleccionadas para la validación.

Asia y el Pacífico

Asociación con APAARI

Para mejorar la colaboración entre INIBAP-ASPNET y sus principales socios en la región, se firmó un importante Memorándum de Entendimiento durante este año por el Director General de IPGRI y el Secretario Ejecutivo de la asociación de instituciones de investigación agrícola para Asia y el Pacífico (APAARI). Este Memorándum de Entendimiento proporciona un marco de colaboración y asociación entre IPGRI-INIBAP y APAARI y pone ASPNET bajo los auspicios de APAARI.

Talleres y capacitación

INIBAP-ASPNET participó en la organización y patrocinio de varios talleres y cursos de capacitación en 1998. Un taller regional sobre "*Disease Management of Banana and Citrus : the use of and management of disease free planting materials*" (Manejo de enfermedades de bananos y cítricos : uso y manejo de materiales de plantación libres de enfermedades), organizado conjuntamente con el FFTC-ASPAC, reunió a 17 expositores de la región y de afuera. Varios destacados virólogos de Estados Unidos, Australia y Taiwan estaban entre los expositores invitados. Entre los resultados del taller están las recomendaciones con respecto a las prioridades de investigación, actividades de desarrollo y recomendaciones de las políticas para mejora el control de las enfermedades virales en la producción de bananos y cítricos en la región.

Tomando ventaja de la presencia de virólogos experimentados, el taller fue seguido por un curso de capacitación en la indización respecto a la presencia de virus, celebrado en la Universidad de Filipinas en Los Baños. Diecisiete investigadores y técnicos procedentes de los colegios estatales y laboratorios privados, que trabajan directamente en la producción de los materiales de plantación a partir de cultivos de tejidos, asistieron a la capacitación. Ellos fueron capacitados en cómo detectar la infección de bananos por un virus utilizando técnicas basadas en ELISA y PCR. Este curso fue muy importante ya que el virus bunchy top de banano (BBTV) y el virus del mosaico de las brácteas del banano (BBrMV) son enfermedades muy serias en Filipinas. La capacitación sobre cómo detectar adecuadamente una infección de banano con virus ayudará a asegurar la producción de materiales de plantación libres de enfermedades. El uso de materiales de plantación sanos por los pequeños agricultores desempeñará un papel importante no sólo en la reducción de los efectos y propagación de las enfermedades virales, sino también en la reducción de pérdidas causadas por nematodos y picudos.

Africa oriental y del sur

En el marco de la red regional, BARNESA, durante 1998 se organizaron dos talleres. En adición, un plan estratégico de cinco años para BARNESA fue concluido de acuerdo con los lineamientos proporcionados por ASARECA, en colaboración con los miembros de la red.

Taller sobre información básica bananera

Esta reunión se celebró en febrero de 1998 en Kampala, apoyada por la Fundación Rockefeller, con el fín de determinar cual información básica en relación con la producción bananera en los países miembros de BARNESA estaba disponible; determinar lagunas en información; determinar cuales lagunas en información prioritaria serían críticas para el desarrollo y ejecución del plan estratégico de investigaciones y que acciones serían necesarias para llenar estas lagunas. Uno de los resultados clave de esta reunión fue la propuesta para un proyecto de colaboración entre los miembros de BARNESA (SNIA y centros) y otras organizaciones que tienen ventajas comparativas para manejar la información básica y bases de datos en la región. Se cree que la recolección y análisis de esta información proporcionará muchos datos cuantitativos necesarios sobre la importancia de los bananos en las economías nacionales de la región y proporcionar de este modo el estímulo y la justificación para una mayor inversión en la investigación de este cultivo.

Taller sobre el manejo integrado de plagas (MIP)

Esta reunión fue organizada por INIBAP, IITA e ITSC (Africa del Sur) en el marco de BARNESA. La organización de una reunión con enfoque en el MIP surgió del hecho de que ya existen muchas tecnologías para el control de plagas y enfermedades para ser evaluadas en el campo, pero que estas tecnologías se desarrollan y se aplican para cada limitación por separado. Claro está que el agricultor necesita que todas las limitaciones sean abarcadas al mismo tiempo. Como resultado de las discusiones interdisciplinarias entre los grupos de trabajo, se acordó que las opciones del MIP que podrían ser recomendadas para su evaluación en el campo de manera integrada, se dividen claramente en tres áreas principales :

- Uso de material de plantación sano,
- Resistencia de la planta huésped,
- Manejo cultural.

Se enfatizó que el socio clave en las evaluaciones del MIP en el campo es el agricultor que debería estar involucrado en todo el proceso, desde la identificación de la limitación, a través de la selección de las opciones del MIP para la evaluación y el monitoreo y la evaluación de estas tecnologías en la finca.

Los participantes en el taller se comprometieron a trabajar hacia una evaluación más amplia de las opciones del MIP en el campo y acordaron que las recomendaciones de la reunión deberían ser tomadas en cuenta en el desarrollo de nuevos proyectos.

Africa occidental y central

*MUSA*CO

La red regional de investigación de *Musa* para Africa occidental y central (*MUSA*CO), establecida bajo los auspicios de la CORAF, creció de 10 a 12 países miembros durante el año 1998. Benin y Sierra Leona son los nuevos miembros. En la segunda reunión anual del Comité directivo de *MUSA*CO celebrado en Douala, Camerún y a la cual asistieron todos los 12 países miembros, IITA, CRBP e INIBAP/IPGRI, se discutió un borrador de la estrategia de la red. Los participantes también discutieron y aceptaron que las encuestas para recolectar la información básica de los sitios seleccionados en cada país deben ser la prioridad en 1999. Se acordó que la metodología utilizada en el campo en Camerún por CRBP para describir y diagnosticar las limitaciones y monitorear cambios en los sistemas de producción sobre una base continua, debería ser introducida en otros países.

Apoyo a la investigación regional

Los rendimientos de los bananos y plátanos en Africa occidental y central actualmente fluctúan entre 5 y 15 t/ha, principalmente debido a los efectos de la Sigatoka negra, nematodos y picudos. INIBAP proporcionó apoyo a ICRA en la República Central Africana, INERA en la República Democrática de Congo e ISRA en Senegal, para permitir la introducción y evaluación de nuevas variedades, resistentes a plagas y enfermedades y de alto rendimiento.

La carencia de material de plantación limpio y sano en cantidades suficientes también limita la expansión de las áreas con producción de *Musa* en Africa occidental y central. La productividad sufre a medida que los agricultores utilizan retoños ya contaminados con plagas y enfermedades lo que causa bajos rendimientos. Por lo tanto, INIBAP proporcionó a la estación de investigación agrícola de la Universidad de Ghana fondos para evaluar la técnica de multiplicación sobre fragmentos de cormos como medio para producir con rapidez retoños de buena calidad.

Simposio internacional 'Bananos y seguridad alimentaria'

El primer simposio internacional sobre la socioeconomía de los bananos no destinados a la exportación se realizó en Douala, Camerún, en noviembre de 1998. El simposio se centró en todos los tipos de bananos y plátanos cultivados para el consumo local y al mismo asistieron más de 150 participantes de todas las regiones productoras de *Musa* del mundo. El simposio fue organizado conjuntamente por CRBP e INIBAP en colaboración con CIRAD y CTA.

Las ponencias presentadas durante el simposio, confirmaron el papel importante que desempeñan los bananos y plátanos en la seguridad alimentaria y obtención de ingresos en las regiones tropicales y subtropicales del mundo. También se reconoció que este papel crucial es todavía ignorado en gran medida por las personas que toman decisiones y que, debido a esto, se requiere de un esfuerzo de concienciación para sensibilizarlas tanto en los países productores, como donantes.

El simposio también destacó la gran diversidad relacionada con la producción de bananos y plátanos. Esta diversidad abarca a las variedades cultivadas, sistemas de producción y métodos de consumo y usos. Se enfatizó que la investigación hacia el mejoramiento de la producción debe estar basada en las necesidades de los consumidores, y debe ser multisectorial y multidisciplinaria. La investigación también debería ser participativa y tomar en cuenta las necesidades de todos los actores en el canal de comercialización, desde el productor, hasta el consumidor.

En vista de una gran variedad de experiencias e información presentadas durante el simposio, se hizo claro que existe una necesidad esencial de intercambiar experiencias en el área de la socioeconomía. Realmente, esta fue la recomendación más importante surgida en el simposio. En adición, se recomendó que se debería recolectar y analizar la información sobre las necesidades de los consumidores y unirla con los datos sobre las fuentes disponibles de suministro. También se requieren estudios sobre el mejoramiento de los procesos de utilización tradicionales.

Información y comunicación

Estrategia de información de INIBAP

La información desempeña un papel crítico en la operación eficaz del programa de INIBAP y la rápida asimilación de nuevas tecnologías de comunicación, como CD-ROM e Internet, tiene un gran potencial para mejorar los servicios de información que brinda INIBAP. En 1998, se celebró una reunión de planeación estratégica que examinó el papel de INIBAP en el suministro de información sobre *Musa* a nivel global y regional e identificó aquellas áreas donde INIBAP tiene ventajas comparativas. Se identificaron los siguientes principios que destacan la estrategia de información de INIBAP :

- Flexibilidad de enfoque de acuerdo a las necesidades de los usuarios;
- Manejo de varios idiomas;
- Uso de los medios más apropiados para la diseminación de la información, incluyendo las últimas herramientas de comunicación;
- Uso de asociaciones y redes;
- Aumento de la regionalización de las actividades de información.

Concienciación pública

Salón internacional de la agricultura en París

INIBAP participó en la Feria Agrícola Internacional 1998 en París conjuntamente con CIRAD. La exhibición realizada por CIRAD e INIBAP se enfocó en informar a los visitantes sobre la importancia mundial y gran variedad de bananos y plátanos. Ya que la feria atrae más de medio millón de visitantes cada año, este fue un evento importante de concienciación pública para INIBAP. En colaboración con CIRAD, INIBAP participó en la producción de una serie de materiales y particularmente, fue involucrada en el desarrollo de una presentación interactiva multimedia que, de manera informal y atractiva, trata de todos los aspectos del cultivo. También se diseñó un bonito folleto ilustrado sobre los bananos, que resultó ser muy popular entre los visitantes de la exhibición. Varios carteles describían las actividades de INIBAP y se distribuyeron más de 2,000 carteles describiendo la diversidad de bananos en el mundo.

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