inibap

Networking Banana and Plantain

Annual Report 2000

Networking Banana and Plantain

Annual Report 2000

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.

INIBAP is a programme of the International Plant Genetic Resources Institute (IPGRI), a Future Harvest Centre.

The **International Plant Genetic Resources Institute** 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 genetic diversity for the well-being of present and future generations. IPGRI's headquarters is based in Rome, Italy, with offices in another 19 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 2000, 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, Norway, Pakistan, Panama, Peru, Poland, Portugal, Romania, Russia, Senegal, Slovakia, Sudan, Switzerland, Syria, Tunisia, Turkey, Uganda and Ukraine.
Financial support for the Research Agenda of IPGRI is provided by the Governments of Australia, Austria, Belgium, Brazil, Bulgaria, Canada, China, Croatia, Cyprus, Czech Republic, Denmark, Estonia, F.R. Yugoslavia (Serbia and Montenegro), Finland, France, Germany, Greece, Hungary, Iceland, India, Ireland, Israel, Italy, Japan, Republic of Korea, Latvia, Lithuania, Luxembourg, Macedonia (F.Y.R.), Malta, Mexico, the Netherlands, Norway, Peru, the Philippines, Poland, Portugal, Romania, Slovakia, Slovenia, South Africa, Spain, Sweden, Switzerland, Turkey, the UK, the USA and by the Asian Development Bank, Common Fund for Commodities, Technical Centre for Agricultural and Rural Cooperation (CTA), European Environment Agency (EEA), European Union, Food and Agriculture Organization of the United Nations (FAO), International Development Research Centre (IDRC), International Fund for Agricultural Development (IFAD), Interamerican Development Bank, Natural Resources Institute (NRI), Centre de coopération internationale en recherche agronomique pour le développement (CIRAD), Nordic Genebank, Rockefeller Foundation, United Nations Development Programme (UNDP), United Nations Environment Programme (UNEP), Taiwan Banana Research Institute (TBRI) and the World Bank.

The geographical designations employed and the presentation of material in this publication do not imply the expression of any opinion whatsoever on the part of IPGRI or the CGIAR concerning the legal status of any country, territory, city or area or its authorities, or concerning the delimitation of its frontiers or boundaries. Similarly, the views expressed are those of the authors and do not necessarily reflect the views of these participating organizations.

Citation: INIBAP. 2001. Networking Banana and Plantain: INIBAP Annual Report 2000. International Network for the Improvement of Banana and Plantain, Montpellier, France.

Illustrations: Rebecca Holtom

INIBAP ISSN: 1029-2209
© International Plant Genetic Resources Institute, 2001

IPGRI Headquarters
Via dei Tre Denari 472/a
00057 Maccarese (Fiumicino), Rome, Italy

INIBAP Headquarters
Parc Scientifique Agropolis 2
34 397 Montpellier Cedex 5, France

Contents

Foreword 5

***Musa* germplasm management** 6

Focus paper I 14

Diversity in the genus *Musa* – Focus on Australimusa

***Musa* germplasm improvement** 20

Focus paper II 28

Building partnerships, 15 years of networking to improve food security

INIBAP around the world 32

- Latin America and the Caribbean 34
- Asia and the Pacific 35
- Eastern and Southern Africa 39
- West and Central Africa 41

***Musa* information and communications** 44

INIBAP publications 49

INIBAP 2000

- Board of Trustees 54
- Financial highlights 54
- Staff list 55

Acronyms and abbreviations 56

L'INIBAP en 2000 (résumé en français) 57

INIBAP en 2000 (resumen en español) 63

In memoriam

To our colleagues Dirk Vuylsteke, John Hartman
and Paul Speijer of IITA-ESARC and Abdou Salam Ouédraogo
of IPGRI-SSA, whose lives were cut short in January 2000
in the crash of the Kenya Airways aeroplane.

Foreword

The year 2000 stands out not only for the events that took place during it but for the occasion it supplied to reflect on the past. INIBAP took time to review its 15 years of networking. Years that have brought together several hundred collaborators and delivered significant achievements in *Musa* research, conservation and more recently production at the farmer level. Although it is premature to say that networking has made a substantial impact on banana productivity, the success of INIBAP's *modus operandi* has been recognised by the Centre-commissioned external review, which took place this year, and, most recently, it was cited as a model for others by the chair of the Technical Advisory Committee of the CGIAR. This positive feedback has prompted us to use one of the focus papers, published in this report, to relate some of our experiences as a networking organization.

It is good practise to highlight one's achievements, especially in the present age where awareness-raising is essential. However it is equally important to acknowledge the contribution made by others. This is no small task for INIBAP, whose every project involves numerous collaborators, donors, researchers and end-users. One group of contributors, who provide such wide-ranging support to INIBAP that it is impossible to mention them in every project where they have an influence, are the donor agencies who provide unrestricted funds. Without their support there is little doubt that the INIBAP programme would become unsustainable. At a time when the scope for improving smallholder production is so promising, such support is vital.

It is timely, then, that in 2000 the first signs of improving yields are reported from projects, where improved varieties are being adopted by smallholder farmers. For INIBAP and many others, this represents an enormously welcome return for years of investment in banana breeding and hopefully just a taste of what is to come.

A further indication of things to come is embodied in the launch of the Banana genomics consortium, the group of researchers who intend to move the study of the *Musa* genome onto a faster track. The advances being made in the field of genomics are impressive and for *Musa* researchers and breeders to benefit from new technologies a great deal of groundwork must first be covered. While setting up a group of like-minded and well-positioned researchers is an achievement in itself, it is only the first step - the real challenge is still to come.

Emile Frison
Director, INIBAP

Geoffrey Hawtin
Director General, IPGRI

Musa germplasm management

INIBAP genebank — bananas in transit

The genebank at *Katholieke Universiteit Leuven* (KUL), where INIBAP manages the world's largest collection of banana germplasm, is known widely as the INIBAP Transit Centre (ITC). A name which doesn't say much about bananas, genes or conservation but defines very well one of the chief aims of INIBAP to create a major highway for *Musa* germplasm.

Up to now, more than 9000 assignments of germplasm (in reality many more considering five samples per accession are made available at one time) have been sent out from the genebank. Around a quarter of these were sent in the last two years alone. The recipients of the germplasm are diverse (see p. 8). Although until now the dominant use has been for research, contributing to major breeding efforts, varietal evaluation and diagnostic tests for pests and diseases, a steady focus remains on the delivery of improved varieties to the people who need them most.

Achieving this aim of supplying smallholder farmers with improved varieties, depends on sustaining the programme of germplasm management. The procedure of sending banana germplasm worldwide may seem routine, but year-round and often high-tech research goes on in the background. Attempts are made to broaden the representative base of genetic diversity in the collection. This year collecting took place in India (see p. 9) and next year it will resume in Indonesia and begin in East Africa. The collection is checked for infections of bacteria and viruses. Detecting and eradicating invisible pathogens demands that methods are devised specifically for each one (see p. 11, 12). The challenges of conserving seedless banana varieties, for the short and long term, are overcome by refining techniques of tissue culture and cryopreservation specifically for the banana (see p. 10,11).

The banana highway is, therefore, in place, but the speed limit needs to increase. Reading this annual report you will discover projects where farmers in Nicaragua, Benin, Ghana and Tanzania are receiving germplasm from the INIBAP genebank (see p. 35, 40, 41). However dwindling banana yields and production are confronted in other parts of the world. The genebank's limited capacity prevents it from distributing planting material to individual farmers on such a large scale. Agreements are in place with regional multiplication centres in India, Costa Rica, Fiji and Cameroon, which help to take the pressure off the INIBAP genebank. This year also, members of the Asia and Pacific Regional Network on banana and plantain (ASPNET) launched their ideas to set up repository, multiplication and dissemination centres at a national level, paying special attention to countries where there is little existing capacity (p. 35). Laying these foundations hopefully means that soon a large part of the annual distribution of germplasm will find its way more directly into the farmers' hands.

NEW ACCESSIONS 8
CONSERVATION – MEDIUM-TERM STORAGE 8
BANANA GERMPLASM AROUND THE WORLD 8
REJUVENATION OF THE COLLECTION 9
COLLECTING - EXPLORING INDIA'S BANANA HOTSPOT 9
CONSERVATION - CRYOPRESERVATION 10
RESEARCH ON VIRUSES 11
CHARACTERIZATION – CHROMOSOMAL AND MORPHOLOGICAL STUDIES 12

New accessions

Germplasm available from the INIBAP genebank at KUL is now displayed on the Web at www.inibap.org/research/itctable_eng.htm. The collection holds a total of 1143 accessions. During 2000, the Taiwan Banana Research Institute (TBRI) donated two new somaclonal variants resistant to Fusarium wilt, which will be used for evaluation trials in the International *Musa* Testing Programme (IMTP). The Directorate General for International Cooperation (DGIC) in Belgium funds a large part of the work at the INIBAP genebank.

Conservation, medium-term storage

For medium-term storage, 20 samples of germplasm per clone are kept on MS-based medium under slow-growth conditions. Cultures are reinstated on fresh medium (i.e. subcultured) when only 12 of the 20 samples remain. Frequent access to the stocks for distribution and early physiological ageing, which causes necrosis in certain tissues, increases the need for subculturing. Certain genotypes appear to be more susceptible than others.

Research is being carried out to examine the causes of premature ageing. One of the contributing factors may be the effect on plant tissue of the movement from normal conditions used for multiplication to those of cold storage, involving a drop in temperature of 12°C. The benefits of allowing the cultures to acclimatize slowly are now under investigation.

Banana germplasm around the world

In the collection almost all accessions (over 90%) have completed tests for viral or bacterial contamination. Bacterial contaminated tissue cultures are being successfully cleaned according to the routine procedure established in 1999 (see Annual Report 1999). Results from the three virus-indexing centres at the Plant Protection Institute (PPRI) in South Africa, *Centre de coopération internationale en recherche agronomique pour le développement* (CIRAD) in France, and Queensland Department of Primary Industries (QDPI) in Australia, also the University of Gembloux in Belgium indicate that 64.3% of the collection tested negative for viruses. These accessions are, therefore, available for distribution worldwide.

The increased levels of distribution witnessed in 1999 were matched in 2000. A total of 5791 samples of 705 different accessions left the genebank in the course of the year, a large part of them for characterization work. The most popularly-requested varieties are listed in Table 1. The recent release of improved varieties for the IMTP trials and their advertisement on the INIBAP Web site are likely to have contributed to the notable rise in requests for germplasm for general studies, especially evaluations (Figure 1). Shipments of 2643 *in vitro* cultures were sent to 33 different countries for this purpose.

Other destinations for germplasm were the regional multiplication centres at the *Centre régional de recherches sur bananiers et plantains* (CRBP) in Cameroon, *Centro Agronómico Tropical de Investigación y Enseñanza* (CATIE) in Costa Rica and the Secretariat of the Pacific Community (SPC). The Institute of Experimental Botany (IEB) in the Czech Republic and CIRAD-*Département des productions fruitières et horticoles* (CIRAD-FLHOR) in Guadeloupe also received accessions for characterization.

The increasing demand for germplasm necessitates new measures to ensure rapid supply. Every time a request is made the cultures must be removed from cold storage, checked for bacteria and repropagated at least once. As mentioned earlier, increased use of stocks is not without risk. Close monitoring of the health of cultures in storage is absolutely essential. Extra stocks of popular clones are kept as proliferating cultures in normal growth conditions for easy access, and additional staff have been hired to prevent delays in processing. The management and processing of data have likewise become increasingly arduous. To improve efficiency, but also to streamline the movement of data between the genebank and the *Musa* Germplasm Information System (MGIS), a database that will incorporate all aspects of maintenance, conservation and distribution of germplasm is under development.

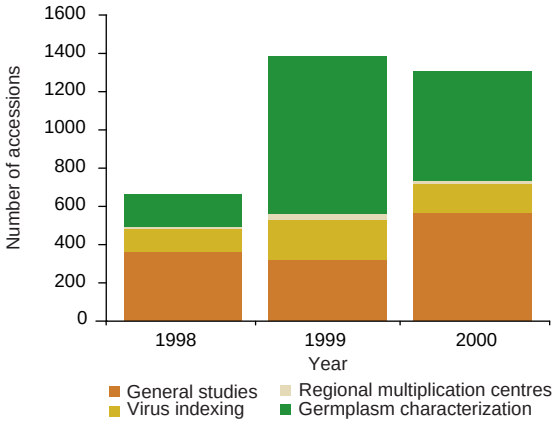


Figure 1. Distribution of germplasm from the INIBAP genebank. A notable rise in requests for germplasm for general studies (inc. IMTP) was noted in 2000 (some accessions are distributed more than once).

Rejuvenation of the collection

Around 85% of the accessions have now been in culture for over 10 years. In an effort to control the risks of somaclonal variation, accessions which have received more than 10 subculture cycles will be tested for trueness-to-type. In order to do this, cultures must be rejuvenated, plants grown and selected for observation in the field.

Collecting – exploring India's banana hotspot

The region of Assam in north-eastern India lies at a point where *Musa balbisiana*, from the Indian subcontinent, meets *M. acuminata* from South East Asia. The two species, as well as other wild relatives, have mingled naturally to form a distinctive concentration of genetic diversity. The hilly terrain is clothed in a number of forest types; much of the wild banana germplasm occurs in semi-evergreen and subtropical forest. Further sources of germplasm occur in the valleys and plains, where bananas are grown as backyard crops and in places at a commercial level. Unfortunately, a growing number of sites, where wild bananas once occurred, are now denuded.

Teams from the National Research Centre on Banana (NRCB) explored hill ranges in Tripura, Southern Assam and Mizoram on the India-Bangladesh-Burma border in May 2000. The region is politically unstable and recent ethnic clashes played a determining role in the planning of exploration routes. The details of the accessions collected may be found in Table 2. The multiple uses of banana varieties are striking. The male flower bud and succulent leaf sheath are commonly consumed as a vegetable, and fibre harvested from wild species has formed the backbone of a cottage industry which was established to help develop self-sufficiency in vulnerable parts of the community. Notable

Table 1. Most frequently requested accessions from the INIBAP genebank in 2000.

ITC code	Accession	Number of requests
ITC1265	FHIA-23	17
ITC1123	Yangambi Km5	16
ITC1264	FHIA-17	14
ITC1418	FHIA-25	14
ITC1319	FHIA-18	12
ITC1344	CRBP 39	11
ITC0504	FHIA-01	10
ITC0506	FHIA-03	9
ITC0180	Grande Naine	8
ITC0505	FHIA-02	8
ITC1307	SH-3640	8
ITC0627	*Musa laterita*	7
ITC1282	GCTCV-119	7

FHIA-23 - distributed as tissue culture plants from the INIBAP genebank and the full-grown plant. (KUL)

Table 2. *Musa* accessions collected during explorations in 2000 and their major uses.

Genus	Section	Species	No. accessions	Location	Use
Ensete		*Ensete glaucum*	1	Mizoram	Fibre, vegetable, ornamental
Musa	Eumusa	*M. acuminata*	9	Assam, Tripura, Mizoram	Fruit, vegetable
		M. balbisiana	1	Tripura	
		Cavendish (AAA)	2	Tripura	
		Red (AAA)	1	Tripura	
		Silk (AAB)	3	Tripura, Mizoram	
		Mysore (AAB)	1	Mizoram	
		Pisang Awak (AAB)	3	Mizoram	
		Unidentified	1	Tripura	
	Rhodochlamys	*M. ornata*	1	Mizoram	Ornamental
		Unidentified	5	Assam, Tripura, Mizoram	

amongst the wild accessions is Sai Su (*Ensete glaucum*), which reproduces only by seed, has orange sap and a flower with persistent bracts giving it a lotus-like appearance.

Map of the exploration route in Northeast India.

Wild banana habitat is shared with tribal groups who practise a form of shifting cultivation (right). Ensete glaucum *has lotus-like flowers and reproduces by seed (bottom left). (S. Uma, NRCB)*

Backyard cultivation of cooking bananas in Northeast India (bottom right). (S. Uma, NRCB)

Transfer of the accessions from the subtropical climate of Assam to Trichy in southern India, where the NRCB field genebank is located, has proved troublesome. However characterization data have been collected for 20 varieties. The MGIS database is being updated with this information as well as with data received from the National Bureau for Plant Genetic Resources (NBPGR) as part of the ongoing Memorandum of Understanding between IPRGI and the Indian Council of Agricultural Research (ICAR). Further areas for exploration have been identified as Nagaland, Manipur, Sikkim and Arunachal Pradesh.

Exploration for new banana germplasm continues in Northeast Indian communities. (S. Uma, NRCB)

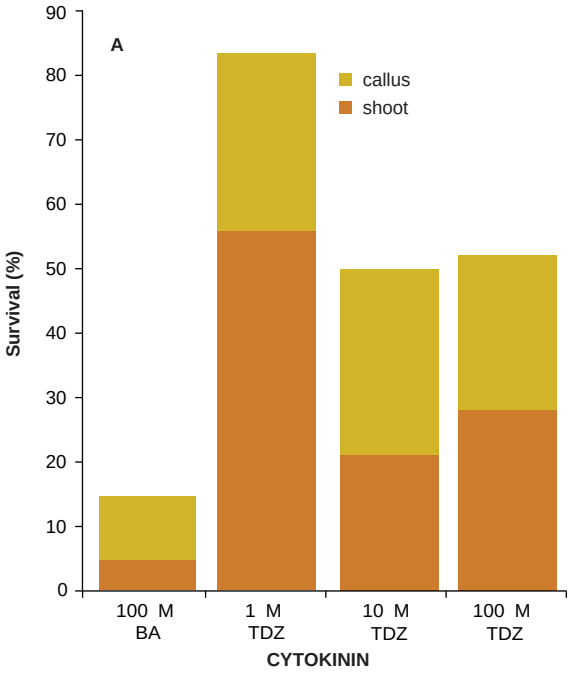
Conservation – cryopreservation

The protocol by which banana germplasm is cryopreserved for long-term storage continues to be refined. General steps involving either simple freezing or vitrification are described in the 1998 Annual Report (p. 9-10). Experiments in 2000 concentrated on the cryopreservation of two materials: proliferating meristem clumps and apical meristems from rooted *in vitro* plantlets. In the case of the former the influence of the following variables was examined:

a) subculture period before sucrose-preculture
b) duration of dehydration treatment with PVS2
c) composition of loading solution prior to dehydration
d) use of an alternative growth regulator, thidiazuron (TDZ), at different concentrations in preparing scalps for cryopreservation
e) concentration of TDZ in the regeneration medium.

Results of these investigations suggest that particular modifications in the protocol would bring about improvement in the regeneration of cultures after thawing. In particular by extending PVS2 treatment from 1 hour to 2.5 hours the average post-thaw regeneration increased by 16%. In addition, the use of 1 µM of TDZ instead of 100 µM benzyladenine (BA) brought about a more rapid production of ideal scalp material for cryopreservation and higher

survival rates of plant material after cryopreservation (Figure 2). This encouraging finding has provided impetus to introduce other cultivar types to TDZ medium.



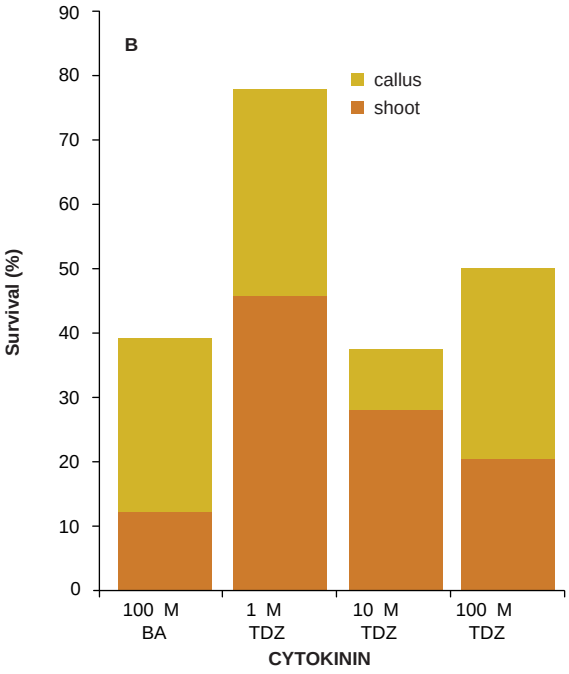


Figure 2. Callus and shoot regeneration of proliferating meristems of Williams variety after vitrification. Proliferating cultures were obtained on media containing 100 µM BA, 1 µM, 10 µM and 100 µM TDZ and transferred after 4 (A) or 7 (B) subcultures to 0.4 M sucrose preculture medium for two weeks prior to cryopreservation.

Vitrification of the proliferating meristems remains the most efficient method of cryopreservation. However, a non-routine procedure, involving the use of apical meristems from rooted plantlets was tested comprehensively in the course of 2000. This method has so far produced relatively poor results, but because it avoids the need for proliferating meristem cultures it deserves continued investigation. Indeed a particularly promising result has been obtained from the tests on numerous parameters during 2000. This involves a procedure, based on a technique devised for potatoes, where plant material is exposed to ultra high cooling and thawing rates. The banana meristem is surrounded in a droplet of PVS2 solution, placed on aluminium foil strips and plunged into liquid nitrogen. After storage the meristems are introduced directly into recovery solution for thawing. In comparison to the regular cryopreservation protocol where around 12% of the meristems regenerate, this procedure obtained 58% regeneration. So far only the cultivar Williams has been tested but clearly more trials are required.

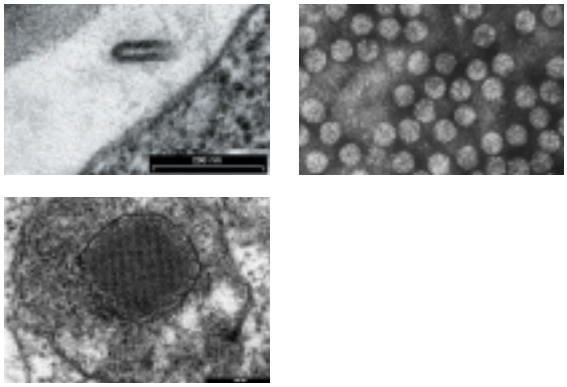
Since research into banana cryopreservation started at KUL, 42 accessions at the INIBAP genebank have been put into long-term storage. In 2000 alone, 299 cryotubes containing meristematic buds from 39 varieties were processed through the optimized protocol for vitrification of precultured meristem tissue. In addition 224 cryotubes of embryogenic cell suspensions from six cultivars were cryopreserved in liquid nitrogen.

The new Nalgene™ cryo 1°C Freezing Container and cryotubes - allowing slow cooling whilst avoiding exposure to toxic chemicals.

Research on viruses

Banana streak virus (BSV)

The integrated viral sequence, which produces banana streak disease symptoms when activated, occurs only in the *Musa balbisiana* genome and is absent from the *M. acuminata* genome, according to INIBAP-commissioned research at the University of Minnesota. The strain of BSV which arises from activated integrated sequences in tetraploid plantain hybrids has also been shown to occur widely in plantain landraces. BSV, therefore, is likely to have been present in plantain-growing countries prior to the introduction of improved plantain hybrids. Progress has been made in identifying the remaining section of the BSV integrant containing the activatable viral segment.



BSV-like particle in a BSV infected plant (top left). CMV particles observed by electron microscopy (top right). Virus-like crystal in a CMV-infected plant (bottom). (B. Elliot, FSAGx)

Related studies at CIRAD have identified a "releasing factor" which discharges the disease during hybridization. Studies to identify a molecular marker for the activatable sequence of BSV have been carried out on more than 300 individuals from interspecific crosses between varieties of *M. acuminata* (IDN 110 - 4x and Pisang pipit) and *M. balbisiana* (PKW- 2x and P. Batu). Eleven markers linked to the *balbisiana* parent have been identified. Of these, seven segregate with the "releasing factor" and are correlated with the expression of the episomal virus. These markers have been plotted on a genetic map of the BSV locus, with the marker for the disease being located very close to the "releasing factor". The sequence appears to be 86% homologous with the retrotransposon "Monkey" identified in *M. acuminata*.

Other strains of BSV are integrated in the *balbisiana* genome, and efforts have been made to determine their exact nature using three primers for the strains Wu, GF and IM. All samples contained Wu and some also contained the strain GF. Both these strains also appear to be activated by the same genetic mechanism. The integrated sequences for each of these strains must now be identified and the origin of the viral particles established.

Virus eradication

Banana bunchy top virus (BBTV) was eliminated from tissue culture with 100% success through meristem culture during research in 1999 by the University of Gembloux. Methods of removing cucumber mosaic virus (CMV) and BSV are still being improved. Meristem culture, thermotherapy, chemotherapy and cryotherapy are all being investigated.

Heat-treatment (thermotherapy) of the tissue culture prior to the excision of meristems resulted in 91% eradication of CMV. Cryopreservation of the "cauliflower-like" meristems following a one-hour period of vitrification cleaned CMV from 42% of the samples. Cryopreservation also gave good results for the elimination of BSV from the variety Williams, with 94% of regenerated plants testing clean. Further work is needed to verify these results. The results of different techniques for the elimination of BSV are shown in Figure 3. A virus eradication rate of 50% or more was achieved by developing a proliferating meristem culture. Rates were higher in plants derived from individual meristems (60%) compared to those from buds containing several meristematic domes (51%).

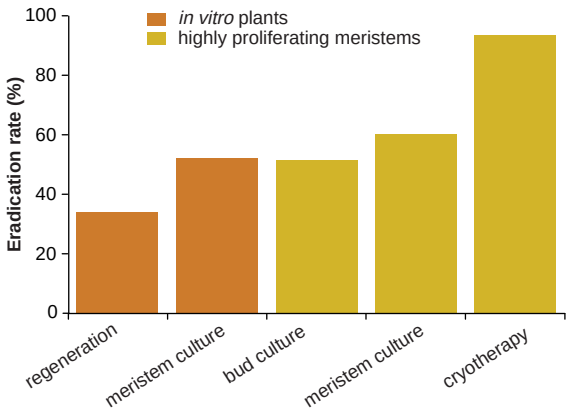


Figure 3. Results of different methods of BSV eradication on Williams.

Banana dieback virus (BDBV)

Research on BDBV has involved close collaboration between researchers at the International Institute of Tropical Agriculture (IITA), PPRI and QDPI. The virus has proved difficult to maintain and propagate in a banana host. *Nicotiana occidentalis* is being used more successfully as a host at IITA. Primers designed against nepoviruses have been used to detect the virus and surveys in Nigeria have confirmed its natural spread. However, the vector transmitting the disease is not yet known. DsRNA (double-stranded ribonucleic acid) bands have been obtained from BDBV-infected suckers at PPRI. Although these appear to be too small to represent a significant portion of the virus genome, they will be useful in generating sequence data, elucidating the relationship of BDBV and other viruses whose genomes are known, and developing a more specific detection test.

Characterization – chromosomal and morphological studies

Determination of ploidy levels

The characterization of 729 accessions from the INIBAP genebank has been confirmed by flow cytometry analyses at IEB. This technique measures the amount of nucleic deoxyribonucleic acid (DNA) in the cell nucleus and determines the ploidy level. In bananas, where diversification has occurred through polyploidy, this is obviously a

useful measure. A few hundred accessions remain to be assessed or reassessed and 68 accessions appear to exhibit a ploidy level according to flow cytometry that is not backed up by INIBAP records. These cases provide an interesting situation where the history surrounding the variety must now be examined carefully to determine if there has been a genuine misidentification.

Musa Germplasm Information System (MGIS)

The contents of the INIBAP-maintained database on worldwide banana accessions, MGIS, have been comprehensively expanded in 2000 in preparation for the publication of a second *Musa*logue. This edition of the catalogue will comprise accessions and taxonomic descriptions of representative varieties and species of the entire *Musa* genus. The effort focused on the addition of morphotaxonomic descriptions of selected accessions and corresponding photographic slides. QDPI provided agronomic evaluations and morphotaxonomic descriptions of the accessions collected in Papua New Guinea held in the South Johnstone collection. For the first time East African Highland bananas are covered with information coming from the collection at Kawanda in Uganda. BPI provided new data on their collection. IITA and CRBP have also provided extensive data and photographs of plantains. Current numbers of records are supplied in Table 3.

MGIS connects to several other data holdings. The link with the SINGER database (CGIAR System-wide Information Network for Genetic Resources) of the System-wide Genetic Resources Programme (SGRP) was significantly strengthened in 2000. Funds from SGRP allowed INIBAP to firm up information holdings on passport data, shipments, accession availability and FAO designation of accessions held at the genebank. These data, along with those of all Future Harvest centres with germplasm held in-trust, allows SINGER to offer free access to the complete range of information on genetic resources available within the CGIAR. SINGER is on the Web at singer.cgiar.org

An historical exploration of the parentage of some of the *Fundación Hondureña de Investigación Agrícola* (FHIA) hybrids has been conducted in a study commissioned by IPGRI. The aim is to relate the impact of improved varieties back to the origins of the germplasm, in this way exposing the true values of conservation of genetic resources *in situ* and *ex situ*. The FHIA hybrids were introduced in Cuba in 1992 to counteract the steep declines in banana production brought about by black Sigatoka. The impact they have had is unquestionable, as yields and income have risen dramatically whilst fungicides have become redundant. By consulting MGIS, the FHIA/INIBAP book on Paul Allen's work and the breeders at FHIA, the origins of the FHIA hybrids have been related back to the expeditions made by Paul Allen and J.J. Ochse in Asia and the Pacific in the 1960s. A family tree for each variety has been drawn. FHIA-03 has as many as 11 wild types and 2 triploid landraces which have contributed to its genetic make-up (Figure 4).

Table 3. Current data holdings of MGIS.

Data type	Number of records
Accessions (passport data)	4116
Shipments made by ITC	660
Collecting missions	22
Characterization descriptions	1186
Agronomic evaluations	1495
Stress evaluations	300
Photos	687

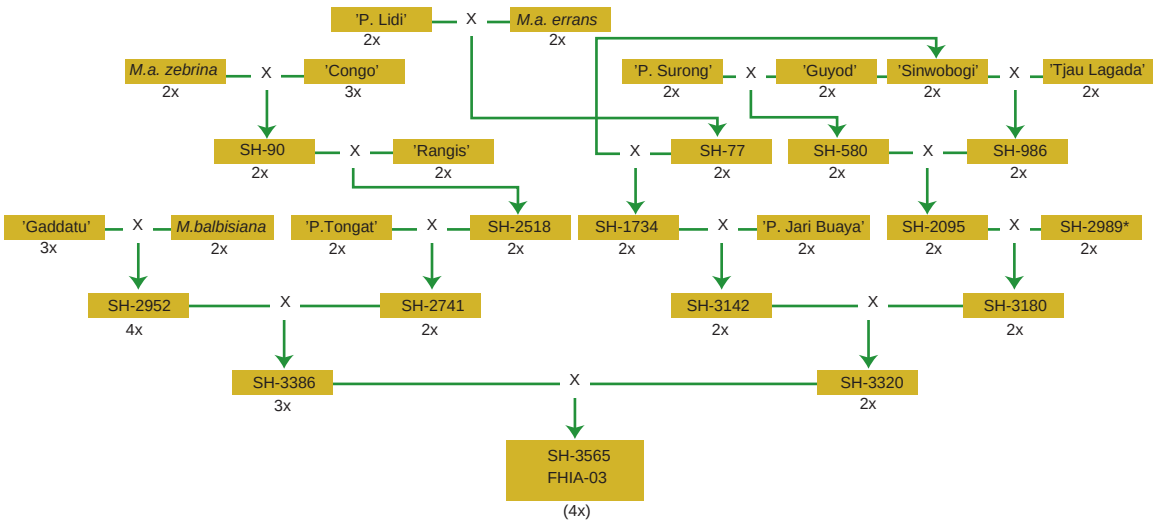
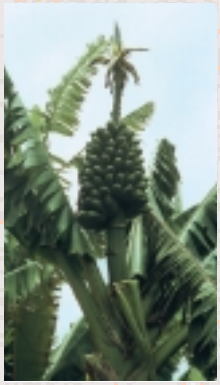


Figure 4. The genetic background of FHIA-03.

Diversity in the genus *Musa* Focus on Australimusa

Suzanne Sharrock, INIBAP, Montpellier, France.



The erect banana bunch of the cultivar Rimina. (J. Daniells, QDPI)

Introduction

The Australimusa section is one of the four sections into which the genus *Musa* is divided (the others being Eumusa, Rhodochlamys and Callimusa). Members of the Australimusa and Callimusa sections have a basic chromosome number of 2n = 20, as opposed to 2n = 22 of Eumusa and Rhodochlamys. There are seven species of Australimusa and a group of parthenocarpic edible types – known as Fe'i bananas – have also evolved within this section. These cultivars are distinguished by their erect bunches and red sap and are found almost exclusively in the Pacific region.

The wild species

Five Australimusa species are indigenous to Papua New Guinea (PNG) (*M. peekelii, M. angustigemma, M. boman, M. lolodensis, M. maclayi*). Two additional species are found outside – *M. textilis* (Philippines) and *M. jackeyi* (Australia). Several studies have been carried out on these species, including those of Cheesman (1950) and Argent (1976) who focused on their morphology. Hybridization studies have been carried out by Shepherd (1988), while Simmonds and Weatherup (1990) used numerical taxonomy to classify the species. More recently, molecular studies have been carried out by Jarret (1992) and Carreel (1994). These different studies have resulted in various theories about the status and relationships

a – ***M. peekelii***
Distribution – New Ireland (PNG). Fruits coloured red at maturity with bright yellow flesh. (J. Daniells, QDPI)

b – ***M. angustigemma***
Distribution – New Ireland (PNG). (J. Daniells, QDPI)

c – ***M. boman***
Distribution – PNG Distinctive cream male bud and similarity in appearance to M. ingens. *By numerical taxonomy and morphology, Simmonds and Weatherup (1990) classified this species with* M. ingens. *Hybridization is possible with* M. lolodensis *(Argent 1976). The inclusion of* M. boman *in Australimusa has been disputed, but the RFLP studies of Jarret* et al. *(1992) and Gawel* et al. *(1992) support its position in this section. While Carreel using molecular techniques found* M. boman *to be distinct from both the Australimusa and Callimusa sections, she noted that in its morphology and geographic distribution it is closer to the Australimusa. (S. Sharrock, INIBAP)*

d – ***M. lolodensis***
Distribution – PNG, Halmaheira, Moluccas Considered by Jarret (1992) as the origin of the Fe'i cultivars. (J. Daniells, QDPI)

between the different species. Shepherd concluded that Australimusa is a recent group and the individual species are isolated more by geographic distribution than genetics. He therefore proposed that all the members should be classified at the sub-species level, rather than having individual species status. Studies by Carreel (1994) of the mitochondrial and nuclear genomes of the species in the section also revealed that, with the exception of *M. boman*, the section contains little diversity. At the mitochondrial level, the species *M. angustigemma*, *M. maclayi*, *M. peekelii* and *M. jackeyi* were grouped together, while at the nuclear level, the species *M. angustigemma* could be distinguished from *M. maclayi* and *M. peekelii.*

e – ***M. jackeyi***
Distribution – north Queensland, Australia. Classified by Argent (1976) as a sub-species of M. maclayi. *This species has an erect bunch and red sap It is little known and considered under threat. (J. Daniells, QDPI)*

f – ***M. textilis***
Distribution – Philippines. Also known as Abaca or Manilla hemp. The fibre extracted from this species was an extremely important source of revenue in the Philippines in the past. It is also grown commercially in Ecuador. (T. Lescot, CIRAD)

g – ***M. maclayi***
Distribution – PNG. Two subspecies are known – M. maclayi *ssp.* maclayi *and* M. maclayi *ssp.* alululai. *These are differentiated by the persistence of the male bracts on the rachis. This species has erect bunches and red sap. The similarity between this species and the Fe'i cultivars led Simmonds (1956) to believe that* M. maclayi *had significantly contributed to the origins of the Fe'i cultivars. (J. Daniells, QDPI)*

Argent (1976) proposed *M. angustigemma* as a sub-species of *M. peekelii.* However, more recent studies indicate that *M. angustigemma* should be treated as a separate species (Jarret *et al.* 1992). Jarret also noted a close relationship between *M. angustigemma* and *M. boman*, a relationship not confirmed by Carreel (1994).

Fe'i cultivars

The domestication of Fe'i bananas, through the processes of parthenocarpy and sterility, occurred independently from the domestication of other types of bananas and plantains. This unique group of cultivars is widely distributed throughout the Pacific islands, from the Moluccas to Hawaii and Tahiti. They are distinguished by their erect bunches, the bright orange colour of the mature fruit and the colour of the sap, which ranges from dark violet to pink (as opposed to the milky or nearly clear sap of most other bananas). In addition, the bracts of the inflorescence of the Fe'i bananas are a bright shiny green, in comparison to the normal dull red or purple of other bananas. These cultivars are poorly understood and reports in the literature are few.

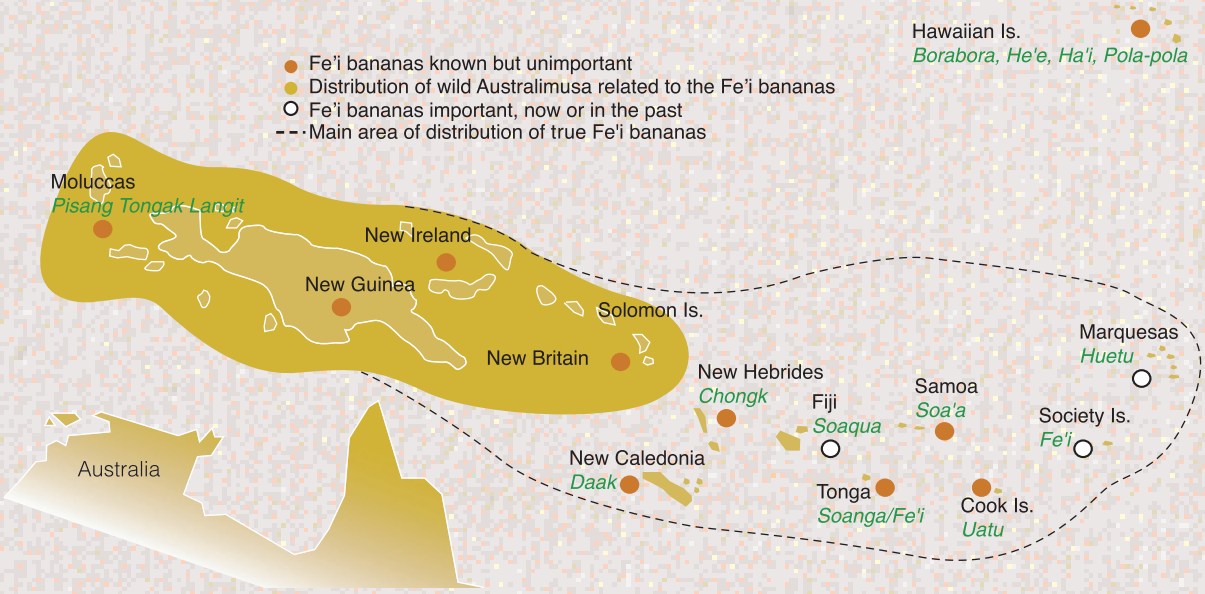
Origin and distribution

Little is known about the origins of Fe'i bananas, although various authors have speculated about possible wild ancestors. Simmonds (1956) suggests that *M. maclayi* is the most likely wild ancestor, while Cheesman (1950) notes their similarity to *M. lolodensis*. This latter view was backed up by evidence from an RFLP-based study by Jarret *et al.* (1992), which indicated that *M. lolodensis* was the closest wild relative of the Fe'i bananas. More recent studies however, have

e

f

g



Distribution of Fe'i bananas in the Pacific. Based on Mac Daniels (1947), supplemented by more recent information and the local names of the varieties. Source: Stover, R.H. & N.W. Simmonds (1987).

shown that, while the Fe'i cultivars seem to be closest to the species *M. maclayi, M. peekelii* and *M. lolodensis*, diversity amongst these cultivars is as great as that within the section as a whole, excluding *M. boman*. The possibility of an interspecific origin for the Fe'i bananas therefore cannot be excluded, but further studies are required before this can be confirmed (Careel 1994).

Fe'i bananas are thought to have originated in the New Guinea area and from there, were spread westward through the Pacific by human travellers (Smith *et al*. 1992, Stover and Simmonds 1987). It

Australimusa bananas gathered from the wild in New Ireland. (S. Sharrock, INIBAP)

is known that the cultivars found in the eastern-most range of the group are frequently seeded, while those from Fiji, Tahiti and the Marquesas are rarely, if ever, found with seeds. Thus, as the concentration of seeded forms is in the region of Bougainville and areas further west to north-eastern New Guinea, it is considered that this region is probably the origin of the cultivars (MacDaniels 1947).

Fe'i bananas are a significant food crop in the Marquesas and in the Society Islands, where they have the status of a prestige food and are thus an essential component of feasts and other special occasions. They are also cultivated in Melanesia, the Cook Islands, Samoa, Tonga, Fiji and Hawaii. Botanical and horticultural evidence indicates that the Fe'i bananas have been in the Society Islands for many centuries. Introduction into the Hawaiian Islands is however, known to be more recent (MacDaniels 1947).

There are no archaeological relics or fossils to shed light on the origin and distribution of the Fe'i bananas; however, one Samoan legend states that the mountain and lowland plantains had a fight, in which the 'soaqua', that is the mountain plantain, or Fe'i, won. Flushed with victory, they raised their heads, whereas the vanquished were so humiliated they never raised their heads again. Such legends give some indication of the antiquity of the plant in these islands.

Diversity in the Fe'i cultivars

A complete treatment of the diversity of existing cultivars is available only for Tahiti, where MacDaniels revealed the existence of thirteen distinct forms. Although reports of Fe'i bananas from elsewhere in the Pacific are fragmentary, it appears unlikely that such levels of diversity are to be found outside Tahiti. According to Seeman, in the late 19th century about 18 forms occurred in Fiji. However, MacDaniels did not find any evidence of this wide variety of forms during a visit there in 1927 (MacDaniels 1947). In Tahiti,

MacDaniels distinguished two groups of cultivars. Var. *typica* is characterized by a prolonged male axis and large, imbricate, obtuse bracts on the male bud. By contrast, var. *acutaebracteata* has a short, rapidly degenerating male axis and less markedly imbricate bracts with acute tips.

During banana collecting missions in Papua New Guinea, Sharrock (1989) reported the existence of cultivars with a bunch orientation apparently intermediate between the Fe'i and Eumusa cultivars. The occurrence of both Australimusa and *M. acuminata* genomes in these cultivars has been confirmed by molecular analysis (Careel 1994), although the identity of the particular Australimusa species involved has not been determined. The occurrence of cultivars of hybrid origin thus agrees with the report from Rarotonga of Wilder (1931) in which he describes a variety with a bunch which becomes pendulous as it ripens, though it is erect when it flowers. This characteristic is also found in the variety Tati'a from Tahiti, which has a prolonged rachis which bends down over the bunch when grown in the rich alluvial lowlands, whereas the upland forms have short bracts. MacDaniels suggested that that this lowland form of Tati'a could be interpreted as an intermediate form or phylogenetic transition between the mountain Fe'i and the lowland Eumusa types. A similar type of banana was described by Rumpius (1750) from Amboina, Moluccas. Cultivars have also now been identified from Papua New Guinea containing genomes from *M. acuminata*, *M. balbisiana* and Australimusa (Careel 1994).

Fe'i bananas with a pendulous male bud, confirmed by molecular analysis to be a hybrid between Australimusa and Eumusa. (J. Daniells, QDPI)

Historical importance

There are few historical reports about the Fe'i bananas in the Pacific, but it is certain that such fruit were bartered for nails, hatchets and other goods by explorers of the time, in exchange for fresh food. In the accounts of Wallis (1773) and Cook (1893), bananas and plantains were always amongst the important fresh supplies obtained in Tahiti, and it is believed that the term plantain was applied to all types of bananas that required cooking before eating, including Fe'i bananas.

Banks and Solander (1769) observed 28 kinds of banana and plantain in Tahiti, five of which were called collectively 'Fe'i' by the natives. Ellis (1859) noted in the Society Islands "nearly 20 kinds, very large and serviceable that grow wild in the mountains". He also refers to the native name Fe'i and remarks on the plant's habit of bearing the fruit cluster erect. He states that in several of the islands the Fe'i is the principal food source of the inhabitants.

During his passage to Tahiti in 1835, Darwin noted "I could not look upon the surrounding plants without admiration. On every side were forests of 'bananas' (Fe'i) the fruit of which, though serving for food in various ways lay in heaps on the ground." The rich orange colours of the Fe'i bananas also attracted the attention of Paul Gauguin, a French impressionist painter who visited the Society Islands, including Tahiti, in the late 19th century. Three of Gauguin's canvasses feature Fe'i bananas, suggesting their importance in these islands a century ago: Les Bananes, 1891; La Orana Maria, 1891 and Passage de Tahiti, 1892.

In 1927, when MacDaniels carried out his survey in Tahiti, he noted that the Fe'i banana was still the staple carbohydrate food of the native Society Islanders, although breadfruit, taro and sweet potatoes were also eaten. At this time, the Fe'i banana was more abundant in the local markets than any other foodstuff, with Fe'i types accounting for at least ninety five per cent of bananas on sale. In the villages near where the Fe'i bananas were available, MacDaniels reported that every Saturday, the men and older boys (professional Fe'i hunters) would go into the valleys for the week's supply. They would follow recognised hunter's trails into the upper parts of the valleys to gather the fruit, and would return laden with bunches swinging on a pole carried across the shoulders. These loads were estimated

to weigh as much as 70kg. Such expeditions were observed by Wallis (1773), Darwin (1889) and Moseley (1879).

At the time of his visit (1927), MacDaniels reported that the bananas were sometimes, but not commonly, planted in gardens. The crop was more often found growing 'wild' in the forests. However, if it is accepted that these bananas are not truly 'wild', as in the sense of being self-established by seed, then the question arises as to who planted them and how did they persist so long in the forest. MacDaniels also noted that at the time of Tahiti's discovery (18th century), the Tahitian valleys were populated far up into the hills, beyond the present limits of occupation. Whatever the cause of this – a larger human population than now, or a change in the pattern of occupation – it is clear that people once lived where Fe'i bananas are now only gathered from the 'wild'. However, if each original household maintained a dozen or so plants in its neighbourhood, and if a proportion of these survived after the end of habitation, then the present pattern of distribution is more easily understood. MacDaniels also noted that the Fe'i bananas survived best on talus slopes at the foot of precipitous cliffs. Such habitats are ideal for bananas, which do not compete well with forest species. The instability of talus slopes limits the growth of woody species and such slopes also provide abundant moisture, good drainage and shelter from the wind – features particularly favourable for banana growth (Stover and Simmonds 1987).

Elsewhere in the Pacific, although the Fe'i bananas are much less important, the same general picture emerges, with the crop usually being gathered in the bush from old established plants and occasionally being brought into cultivation if needed.

The fruit of Fe'i varieties, short, round and about the size of a mango. (S. Sharrock, INIBAP)

Uses of Fe'i bananas

As a food

As a food, Fe'i bananas must be cooked, as the ripe raw fruit is unpleasantly astringent. In the past they were usually cooked by roasting in a pit with other food items, but by the early 20th century it was becoming more common for the fruit to be boiled in water. The flesh even after cooking is distinctly starchy, though it may be sweetish if the fruit is allowed to soften before cooking. MacDaniels reported that the sweet pulp of the variety 'Afara' was considered of the highest quality and was sometimes cooked and fed to infants at the time of weaning. According to Stover and Simmonds (1987), sugars account for less than 50 per cent of the total carbohydrate in the ripe fruit. This compares with 73-95 per cent in other bananas. Even the plantains, which are generally considered starchy, are much sweeter than Fe'i bananas

Other uses

In Tahiti, the Fe'i banana has many other uses beyond a foodstuff. MacDaniel described the use of the leaves as plates or trays for cooked food. The leaves were also used as thatching for temporary shelters made in the forest. Darwin stayed in such a hut when he visited Tahiti in 1835. The midribs of the leaves contain long fibres, which can be stripped off and used to make ropes. The Fe'i 'hunters' used these ropes to bind bunches of fruit to the carrying poles.

The dried leaves were used as bedding and for packing, and also made a good fuel for starting fires. Furthermore, small thin pieces of the dried leaves could be used as cigarette papers and MacDaniel reported that the Tahitians appeared to prefer these to the prepared rice papers.

Freshly cut pseudostems are very buoyant and were sometimes pegged and lashed together to make temporary rafts for crossing inland streams and lakes. Fibrous material from the leaves and pseudostem was also stripped off, dried and used to make plaited articles, such as fans and mats.

The reddish-violet sap of the Fe'i bananas is very distinctive and, perhaps due to the presence of stabilizing substances, unusually

stable under exposure to light. This sap is used as a dye and ink. Thus Pétard (1955) noted that, in Tahiti, an early missionary bible was copied with bamboo pens in ink made from Fe'i sap. Similarly, the Samoans decorate the edges of mats with thin strips of banana fibre died pink with the sap.

Australimusa species and cultivars produce red sap. (S. Sharrock, INIBAP)

*An unusual physiological effect of eating the fruit is that the yellow flesh discolours the urine of those who eat it. Reports of the colour vary, with Rumpius reporting it to be "red", Macdaniels "reddish amber" and Pétard "yellow-green". In the original description by Rumpius of a species from Amboina, which he named "*Musa uranoscopus*", he writes: "It is sometimes eaten to provoke urination, which it does without causing pain. As it colours the urine red, however, it is seldom eaten. The Amboinese natives have a superstition that while they cut the stem they must keep still for if they talk the stem will emit blood."*

Present status

It is clear that Fe'i bananas were once an extremely important source of food in the Society Islands. However in recent years their importance has declined considerably, and this is largely attributed to destruction by cattle and pigs, competition from introduced species and the ravages of the banana weevil (Stover and Simmonds 1987). In 1947, MacDaniels reported that the giant morning glory in many places in Tahiti was smothering the Fe'i, and other vegetation, and he considered that even the gathering methods used by the hunters could be in part responsible for the decline of the crop. Apparently no efforts are taken by the hunters to encourage the growth of the Fe'i bananas and frequently young developing shoots are cut back at the same time as the bunch is harvested. Elsewhere in the region, Fe'i bananas are now only found occasionally. However they continue to persist. In Papua New Guinea for example, Fe'i bananas are not a popular food source, but are kept as a back up for when other food is scarce. The varieties tend to be vigorous, resistant to many pests and diseases and require little attention.

Recent advances in biotechnology have made it possible to access a much broader range of diversity. The hardy, disease resistant Fe'i bananas may therefore yet prove to have a valuable role to play in the future of banana production.

References

Argent G.C.G. 1976. The wild bananas of Papua New Guinea. Notes Roy. Bot. Gard. Edinburgh 35: 77-114.

Banks J. 1896. Journal of the Right Hon. Sir Joseph Banks during Captain Cook's first voyage in H.M.S. Endeavour in 1768-71 to Terra del Fuego, Otahite, New Zealand, Australia, the Dutch East Indies, etc. (Sir Joseph D. Hooker, ed.). Macmillan, London, New York.

Carreel F. 1994. Etude de la diversité des bananiers (genre *Musa*) à l'aide des marqueurs RFLP. Thèse INA, Paris-Grignon. 90pp.

Cheesman E.E. 1950. Classification of the bananas. III: Critical notes on species. Kew Bulletin 5:27-28.

Cook J. 1893. Captain Cook's journal during his first voyage around the world made on H.M.S. Endeavor, 1768-71. (Wharton, ed.). London.

Darwin C. 1889 Journal of researches into the natural history and geology of the countries visited during the voyage of H.M.S. "Beagle" round the world. Ward, Lock and Co, London, New-York.

Ellis W. 1859. Polynesian researches during a residence of nearly eight years in the Society and Sandwich Islands. H.G. Bohn, London.

Gawel N., R.L. Jarret & A. Whittemore. 1992. Restriction fragment length polymorphism (RFLP) based phylogenetic analysis of *Musa.* Theor. Appl. Genet. 82:286-290.

Jarret R.L., N. Gawel, A. Whittemore & S. Sharrock. 1992. RFLP-based phylogeny of *Musa* species in Papua New Guinea. Theoretical and Applied Genetics 84:579-584.

MacDaniels L.H. 1947. A study of the Fe'i banana and its distribution with reference to Polynesian migrations. Bernice P. Bishop Museum Bulletin 190. Honolulu, Hawaii. 56pp.

Moseley H.N. 1879. Notes by a naturalist on the "Challenger"… during the voyage… round the world… 1872-1876… London.

Pétard P.H. 1955. Les plantes tinctoriales polynésiennes. J. Agr Trop. Bot Appl. 2:193-199.

Rumpius G.E. 1750. Herbarium Amboinense 5, Amsterdam.

Seeman B. 1865-1873 *Flora vitiensis*. London.

Sharrock S. 1989. Report on the fourth IBPGR/QDPI banana collecting mission to Papua New Guinea. IBPGR Internal Report.

Shepherd K. 1988. Observations on *Musa* taxonomy. Pp. 158-165 *in* Identification of genetic diversity in the genus *Musa* (R.L. Jarret, ed.). Proceedings of an international workshop held at Los Baños, Philippines, 5-10 September 1988. INIBAP, Montpellier, France.

Simmonds N.W. 1956. Botanical results of the banana collecting expedition 1954-5. Kew Bull. 11(3):463-489

Simmonds N.W. & S.T.C. Weatherup 1990. Numerical taxonomy of the cultivated bananas. Trop. Agric. (Trinidad) 67:90-92.

Smith N.J.H., J.T. Williams, D.L. Plucknett & J.P. Talbot. 1992. Tropical forests and their crops. Cornell University Press.

Solander D.C. 1769. *Primitiae florae insularum Oceani Pacifici, sivi catalogus Plantarum in Otaheite, Eimeo*. Botanical manuscript in British Mus. (Nat. Hist.) p. 344.

Stover R.H & N.W. Simmonds. 1987. Bananas. Longmans, London, UK.

Wallis S. 1773. An account of a voyage around the world. *In* Hawkesworth, J. An account of the voyages undertaken for making discoveries in the Southern Hemisphere 1, London.

Wilder G.P. 1931. Flora of Rarotonga. B.P. Bishop Museum Bull. 86.

Musa germplasm improvement

How to improve a banana

The hundreds of banana varieties consumed worldwide represent the reward of a long heritage of small-scale farming. Improved varieties have become obtainable in the last few years. However, crop improvement and the tripling in yields which it has brought to crops like rice, has yet to make an impact in the banana-growing world. The formal breeding of bananas, which began in the 1920s was unproductive until the 1980s, this being reflected in present-day ailing yields.

The need for improvement of banana as a crop for smallholder farmers was the founding stone on which INIBAP was built. Some twenty years ago the international agricultural community realized that if no progress was made to improve this primary crop, then the food security of more than 400 million people would be challenged and the incomes of many more would be eroded.

In the last 10 years new improved varieties have appeared on the scene. Through the International *Musa* Testing Programme (IMTP), INIBAP has coordinated the evaluation of these varieties over a wide geographical and agro-environmental range (see p. 25). The results have been promising enough to persuade farmers and governments to begin adopting them.

Meanwhile the search for future varieties continues. In recent years, advanced breeding has lent on scientific research and new technologies to shortcut the route. Biotechnology opens the way by allowing the speedy incorporation of individual genes from one variety or species into another. INIBAP supports the initiatives of various breeding efforts. However, conducting no research of its own, it has devoted its energies to giving strength to and advancing existing expertise and capacities.

One of the notable achievements of the past 15 years is the establishment of PRO*MUSA* as an arena for world experts to discuss, prioritize and plan projects to solve the most pressing problems affecting banana production through genetic improvement. In 2000, over 100 members of PRO*MUSA* met and exchanged information and opinions (see p. 22-25). In its three years of functioning, PRO*MUSA* has spurred the development of a number of new research initiatives. Perhaps one of the most promising is the Banana genomics consortium. While the rice genome is now being sequenced to loud fanfare, members of PRO*MUSA* recognize that progress on the banana genome trails far behind. Impetus is urgently needed and the new consortium intends to provide it. The platform of agricultural institutions in Montpellier, known as Agropolis, is supporting one of the first projects to contribute to the consortium's aims. A Brazilian scientist is unravelling the mystery behind the tendency for different parts of banana chromosomes to chop and change. He will do this by mapping the points in the genome where the so-called translocations occur (see p. 24-25). The work has just begun, but the inception of the Banana genomics consortium is another reason to be optimistic that banana and plantain will continue to fulfil their role in nourishing some of the poorest people in the world.

PROGRESS IN PRO*MUSA* 22

INTERNATIONAL *MUSA* TESTING PROGRAMME SWINGS INTO PHASE III 25

IMPROVEMENT THROUGH GENETIC TRANSFORMATION 25

Progress in PRO*MUSA*

PRO*MUSA*'s third meeting

The year 2000 marked the occasion for the biennial PRO*MUSA* meeting. The hosts in Thailand organized, in parallel, a unique International Banana Symposium, inspiring impressive participation from public and private sectors as well as interested members of the general public. A spectacular exhibition of products and information from banana industry and research took place, along with a competition for best-tasting and most unusual bananas and banana products and a technology transfer session. The occasion gave INIBAP, which acts as PRO*MUSA* Secretariat, ample context in which to review the past 15 years of networking.

The gathering of over 100 PRO*MUSA* members for the third global meeting of the programme, enabled informed reflection of the functioning of the working groups, convenors and executive bodies of the global programme. The chief aim of PRO*MUSA* in facilitating collaboration and partnerships was strongly emphasized. As from now, working group convenors will perform a more proactive function, encouraging the movement of news and information within and between working groups, meeting and reporting more regularly with each other and with the Secretariat. The electronic listservers, the publication of PRO*MUSA* news in INFO*MUSA* and the rapidly developing Web site also help to stimulate communication.

*Bananas in competition (S. Sharrock, INIBAP) and members of PRO*MUSA *gathered in Bangkok. (D. Mowbray, Baobab Productions)*

All five working groups of PRO*MUSA* met in Bangkok to discuss the latest research findings, establish joint activities and revisit defined research priorities:

Fusarium working group

The Fusarium working group agreed prime areas of work at their meeting in Malaysia in 1999. These are published in INFO*MUSA* 8(2). The standardization and evaluation of a plantlet-screening test for Fusarium wilt resistance is one of the chief priorities. A standard protocol for resistance evaluation should be developed and assessed in different laboratories, and also made available to breeding programmes. Equally the development of a DNA-based diagnostic system for detection and identification of all races and strains of *Fusarium oxysporum* f.sp. *cubense* (*Foc*) directly from plant and soil is important. Rapid diagnosis would help control disease outbreaks, ensure planting material is clean and aid research into the epidemiology and ecology of disease. It is also hoped that in the near future, resources would become available to establish a database of the isolates of *Foc* available in each of the major culture collections (CAB International (CABI); QDPI; Forestry and Agricultural Biotechnology Institute (FABI); *Instituto Canario de Investigaciones Agrarias* (ICIA); National Agricultural Research Organization (NARO); TBRI; University of Florida (UF); and Universiti Sains Malaysia (USM)).

Genetic improvement working group

The Breeding and genetics subgroup and Genetic engineering subgroup developed individual research priorities as follows:

- Establish a collaborative programme on genetic improvement of *Musa* in Asia
- Prospect for new wild/landraces types through explorations in areas of natural diversity especially in South and Southeast Asia
- Characterize and evaluate varieties for new sources of resistance to major pests and diseases; Sigatoka, nematodes, Fusarium wilt and weevils
- Compile information on existing global *Musa* genetic diversity
- Strengthen diploid breeding for developing new breeding stock
- Widening of genetic base using conventional and biotechnological approaches.

The Genetic engineering subgroup recognized a number of important developments. The methodology for establishing and maintaining embryogenic cell suspension cultures is being shared amongst laboratories. Markers are needed to indicate the most frequent off-types regenerated from suspension cultures. Transgenic banana plants have been obtained

in at least five public laboratories, generally through *Agrobacterium*-based protocols. The transformation of diploids and landraces should be undertaken. Physical mutagenesis through gamma irradiation has been successfully used in some research projects and several clones produced with agriculturally interesting traits (earliness, reduced height, disease resistance, increased yield). *In vitro* systems for rapid dissociation of chimeras as well as systems for early screening of desired characters are urgently needed. Fast neutron irradiation and chemical and insertional mutagenesis might also be investigated. Studies on *Musa* genomics are recognized as lagging behind those of other major crops. Collaboration and coordination in the development of genetic and physical maps is of paramount importance. Investment should be continued or increased in studies of *Musa* cytogenetics, aneuploidy, gene silencing and genome interaction, marker-assisted breeding, as well as general germplasm assessment.

Nematology working group

The Nematology working group is concentrating on three main areas: nematode communities and biodiversity, damage and yield loss potential of populations, and resistance screening. Knowledge on these topics will be gathered into three separate databases. Participation in IMTP phase III and a meeting to follow the Nematological Congress in May 2001 are also planned.

In the framework of PRO*MUSA,* a team at CIRAD has established the presence of two pools of genetic diversity in the nematode *Radopholus similis*, one covering populations in Zanzibar, India and Sri Lanka, the other extending over the Atlantic and linking populations from Nigeria with those of Costa Rica.

The European Union funded a comparative study of the performance of nematode populations from different geographical areas in the presence of mycorrhizae. Although nematodes from Côte d'Ivoire appear to develop significantly better than those from Australia, both populations are negatively influenced when inoculated on banana plants with the mycorrhiza, i.e. *Glomus intraradices*. Although the inhibitive effects of mycorrhizae can be variable, they may potentially contribute to integrated pest management.

Sigatoka working group

The distribution of banana leaf spot pathogens and the durability of genetic resistance were subjects of discussion of the Sigatoka working group. The group established the main areas of research that require instant action and formulated a project proposal incorporating them. Research priorities of the Sigatoka working group are to:

- Determine the distribution and relative incidences of *Mycosphaerella eumusae*, *M. fijiensis* and *M. musicola* in India, China and the countries of South East Asia.
- Develop appropriate diagnostic tools for the identification of *Mycosphaerella* leaf pathogens. A training course in basic fungal identification using morphological characters is necessary.
- Undertake a study of the basic biology of *M. eumusae* and the epidemiology of Septoria leaf spot.
- Develop a detailed understanding of the population structures of *M. fijiensis*, *M. musicola* and *M. eumusae* - existing studies should be extended, particularly to south and Southeast Asia.
- Develop methods to follow the change in pathogen populations in response to selection pressure from new banana genotypes.
- Identify new sources of resistance to banana leaf diseases.
- Develop a better understanding of the mechanisms of resistance, in particular partial resistance.
- Develop improved screening methods for evaluation of disease resistance in germplasm.
- Publish and distribute the leaf pieces method of screening, including isolation, culture and inoculum production for the different pathogenic organisms.

Funding is being sought. A training programme on the evaluation of resistance to leaf spot diseases as part of IMTP will take place in Asia in 2001.

Virology working group

The latest research on major banana viruses was presented for discussion and the current status of virus diagnostics was reviewed. Recommendations were agreed that BSV indexing should be routinely carried out in commercial AAA banana tissue culture production and that the role of mealybugs in BSV transmission in the field be examined as soon as possible. Recognized high priorities are to:

- Develop reliable diagnoses of BSV by developing a better understanding of BSV diversity
- Produce a PRO*MUSA* pamphlet on current procedures for virus diagnosis
- Establish a better understanding of B genome heterogeneity

- Establish a better understanding of the contribution of the A genome in activating virus integrants in advanced breeding lines
- Develop a mechanism to silence BSV integrants in the genome
- Research into the geographical diversity of BSV *vis-à-vis* movement of germplasm, particularly with respect to epidemiological information and risk assessment
- Develop resistance screening methods
- Secure supplies of diagnostics
- Explore the plausibility of producing virus-'free' plantlets, especially for BanMMV and BSV.

New initiatives: Banana genomics consortium

A *Musa* genomics 'master plan' is to be developed by a newly formed consortium of banana genomics experts. The races to sequence the human and rice genomes have publicized the significance of genomics research. The banana genome, although not harbouring the financial magnetism of the human equivalent, has a lot to offer as a model species, above and beyond *Arabidopsis* and rice. The consortium will focus on pre-competitive research and its results will be made freely available. However, in order to encourage maximum sharing of prepublication results, a degree of confidentiality may be maintained among consortium members. Although in this respect the group differs from other PRO*MUSA* groups, the Banana genomics consortium fosters the essential spirit of collaboration and therefore the group will now form an integral part of the PRO*MUSA* portfolio.

Adult banana weevil - a recognized major constraint to farming bananas. (C. Gold, IITA)

New initiatives: Weevils become new priority

Banana weevils are frequently underestimated as a global production constraint, partly because they affect small-scale farms more than commercial plantations. Their inclusion in genetic improvement initiatives has not been a strong priority. However in recent years new breeding tools have helped identify sources of resistance to weevils. This introduction of the pest into the remit of genetic improvement and the persistent demands for weevils to be put on the PRO*MUSA* agenda has convinced the steering committee to take preliminary steps to form a new working group devoted to weevils.

New initiatives: Latin American Biotechnology Network

A biotechnology network has been established in Latin America in the framework of *MUSA*LAC (Plantain and Banana Research and Development Network for Latin America and the Caribbean) with a focus on genetic transformation and molecular genetics. The initiative is now recognized under the umbrella of PRO*MUSA* and the Genetic improvement working group.

New initiatives: Joining forces in cytogenetics research

The natural structural rearrangements that frequently occur within and between banana chromosomes play havoc with attempts to map the genome. In some cases cytogenetic observations have found accessions of the same variety can differ in up to four translocations. The consequences are also unfortunate for breeding desired traits into new varieties.

In order to locate these points where DNA segments break off and translocate, the chromosomes of several banana clones are presently being mapped using a technique that has proved successful with animals and plants, such as wheat and rye. It involves a form of *in situ* hybridization, using probes from a Bacterial Artificial Chromosome (BAC) library, which

hybridize to corresponding parts of the banana chromosomes and fluoresce (see Focus Paper I in Annual Report 1998). The project is jointly supervised by INIBAP and CIRAD within the Advanced Platform of Agropolis, the group of agricultural research organizations based in Montpellier. Funding is provided by the French Government. A scientist from *Empresa Brasiliera de Pesquisa Agropecuaria* (EMBRAPA) in Brazil is carrying out the work as part of his Ph.D. thesis. The BAC library is currently under preparation.

Musa somatic hybrids

Protoplast fusion has only recently been attempted as a means to hybridize banana varieties. The methodology is still very much under development. As a contribution to the work, INIBAP and CIRAD evaluated the nature of a number of the somatic hybrids produced at the University of Paris XI, with financial support from the INCO Dev programme. Flow cytometry and microsatellite technology determined the ploidy level and molecular cytogenetic characteristics of the hybrids respectively. The results indicated that most of the plants were probably products of self-fusion and continued evaluation of the plantlets issued from the fusion experiments would be beneficial.

The 2nd International symposium on molecular and cellular biology on banana

Cornell University held the first forum for all scientists involved in molecular and cellular biology of banana in 1999. The event's success led to a second symposium, which took place in Australia in 2000 under the organization of INIBAP and Queensland University of Technology (QUT). Both meetings brought together researchers in companies, universities, national and international research institutes and equally were sponsored by a mixture of private and public enterprises.

International *Musa* Testing Programme swings into Phase III

TBRI has made available to INIBAP two somaclonal variants of Cavendish. The varieties, GCTCV-106 and GCTCV-247 are high-yielding and resistant to race 4 of Fusarium wilt disease. They will be added to the list of nearly 30 candidate varieties, including promising new varieties from CRBP, CIRAD, EMBRAPA, FHIA and IITA, available for trials in Phase III of IMTP.

The agronomic and pathological data for phase II varieties are now accessible in a database format. Information and individual results from the sites where evaluations have taken place are included. The user is able to produce reports, selecting data by site or by variety. The database, as well as the whole suite of related publications on IMTP, including evaluation guidelines and material transfer agreement are available on the IMTP 2000 CD-ROM.

Improvement through genetic transformation

The arguments for genetic transformation are particularly persuasive in a crop like the banana. Biotechnological tools present a novel solution to the problems presented by triploidy, sterility, long generation time and the need to cater for the regional diversification of bananas and plantain. Support from DGIC allows INIBAP to commission research on techniques to introduce genes into bananas. KUL has been carrying out this research over the past decade. The transformation of a plant involves a series of steps from developing the starting materials to observing the gene's function (see Annual Report 1997, p. 24). At each point of the procedure meticulous refinement is required in order to obtain repeatable and acceptable results.

Establishing embryogenic cell suspensions

A protocol was optimized in 1999 for the preparation of highly proliferating meristem cultures. The protocol avoids prolonged use of concentrated BA, a medium which helps to speed up the preparation time by elevating the proliferation rate of meristem shoots but which also can lead to reduced embryogenic response (see Annual Report 1999, p. 25).

During 2000, the protocol was tested on different banana varieties: Calcutta 4 (AA), Kamaramasenge (AB), Williams (AAA), Igisahira gisanzwe (AAA-h), Agbagba (AAB-p) and Bluggoe (ABB). By using: (i) freshly excised explants (preferably 5 mm or less in size), (ii) TDZ, instead of BA, as a form of cytokinin, the preparation period was cut from 14 months to just 4 months. The embryogenic capability of these cultures is now under examination. If they show good potential, this development will obviously help increase the pace of research significantly.

In total since January 1998, 13 944 scalps from the meristematic cultures of 13 cultivars have been subjected to embryogenesis induction. The results obtained for scalps longer than 3.5 months in culture (i.e. long enough for embryogenic complexes to form) are presented in Table 1. *En masse* induction of scalps has proved successful and the embryogenic response of Grande Naine has improved markedly. All three plantain varieties used in the trials: Agbagba, Obino l'Ewai and Orishele each produced complexes of distinct embryos in the presence of a small amount of embryogenic callus. Responses from most of these varieties, however, remain low (below 1%, see Table 1) and embryogenic induction of the wild diploid and highland bananas have not shown any success. Mbwazirume, a highland banana, produced an embryogenic response for the first time. This latter experiment was carried out in Uganda at IITA-East and Southern Africa Regional Centre (IITA-ESARC), using starting material excised from male flower buds instead of meristematic cultures.

power to regenerate once transferred to liquid medium. Obino l'Ewai and Orishele have, however, produced highly regenerable suspensions. The regeneration capacity of successfully established ECS, which have reached the stage of mass production is illustrated in Figure 1. All new suspensions have been cryopreserved and Grande Naine and Williams are being used for transformation purposes. Plantlets are also being grown and examined for somaclonal variation (Figure 2).

The possibility of inducing highly regenerable tissue on explants excised directly from *in-vitro* plantlets was investigated. Explants of the Williams variety, consisting of the apical dome and one leaf primordium, were exposed to BA, TDZ, 2iP, kinetin and zeatin at five concentrations (from 0 to 50µM) in combination with 2,4-D (at concentrations ranging from 0 to 5µM). TDZ proves to have the strongest influence. In some cases a distinct greyish explant with an irregular surface developed. The histology of these

Table 1. Preliminary results of scalps inoculated for more than 3.5 months (January 1998 to December 2000).

Cultivar	Genome	Type	ITC code	Number of inoculated scalps	Responsive scalps	% Scalps forming embryogenic complexes	Highest % scalps forming embryogenic complexes in a single trail	ECS	Ready for first applications (i.e. stage of mass multiplication has been reached)
Calcutta 4	AA	wild diploid	---	1392	-	-	-		
Grande Naine	AAA	Cavendish	1256	1080	58	5.4	10.4	yes	yes
GN FHIA	AAA	Cavendish	---	1296	11	0.8	2.9	yes	
GN JD	AAA	Cavendish	---	1440	6	0.4	1.2	yes	
Williams BSJ	AAA	Cavendish	0570	456	-	-	-		
Williams JD	AAA	Cavendish	---	2088	19	0.9	8.3	yes	yes
Ingarama	AAA-h	highland	0160	624	-	-	-		
Mbwazirume	AAA-h	highland	0084	888	-	-	-		
Nyamwihogora	AAA-h	highland	0086	624	-	-	-		
Agbagba	AAB-p	plantain	0111	576	3	0.5	0.5	yes	yes
Obino l'Ewai	AAB-p	plantain	0109	336	3	0.9	2	yes	yes
Orishele	AAB-p	plantain	0517	960	4	0.4	2.1	yes	yes
Burro CEMSA	ABB	cooking	1259	504	-	-	-		
Total				12 264	104				
Average						0.85			

Grande Naine clones and Williams JD are now represented in well established embryogenic cell suspensions (ECS). The quality and size of the embryogenic complex has played a major role in the successful establishment of ECS. The plantain and Mbwazirume suspensions are difficult to establish given the small amount of embryogenic callus. The embryos are more susceptible to dedifferentiation and loss of

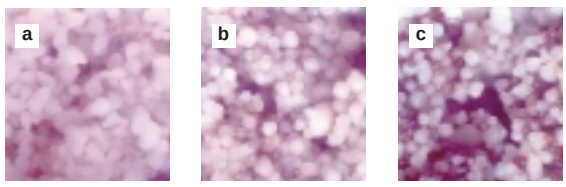


Figure 1. Germinating embryos produced after one month of culturing ECS in regeneration medium M3 a. Williams, b. Obino l'Ewai and c. Orishele. (H. Strosse and B. Paris, KUL)

explants and their regeneration capacity is being investigated. In general it is found that fresh explants appear to be more sensitive to growth regulators compared to scalps derived from highly-proliferating meristem cultures. At concentrations of growth regulator appropriate for the latter, the majority of fresh explants blacken and die.

Cell suspension derived plants grown in the greenhouse for first screening for somaclonal variation.(L. Sagi and S. Remy, KUL)

Transformation

The protocol for *Agrobacterium*-mediated transformation has been simplified and significantly improved, providing five times the expression of the target gene of the original procedure (see box and Figure 2). Increased and more uniformly distributed transient expression of the introduced gene, ß-glucuronidase (GUS), has been achieved with Grande Naine, Williams and Three Hand Planty. Whether this improved performance results in a better yield of stable transgenic plants is being determined.

Protocol for *Agrobacterium*-mediated transformation

- Agrobacterium *culture is grown*
- *Induction of vir genes into* Agrobacterium *culture*
- *ECS are infected with* Agrobacterium
- *The suspension is co-cultivated for T-DNA transfer*
- *Transformed cells are selected and regenerated*

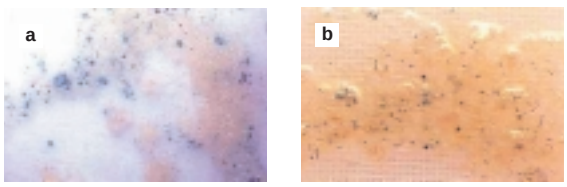


Figure 2. Increased rates of GUS expression in a cell suspension of Grande Naine using the improved protocol (a) compared to previous procedure (b). (L. Sagi and S. Remy, KUL)

In an attempt to by-pass the lengthy preparation of ECS, experiments to transform meristematic tissue directly were initiated. High levels of GUS expression were reported in meristematic scalps (Annual Report 2000, p. 27). However, results from the trials on 12 000 explants from Grande Naine and Williams varieties have shown consistently low levels of transformation after two or three months of selection and regeneration. The use of meristematic tissue as a target for transformation, therefore, is far from ideal.

Promoter research

Working with the Cooperative Research Centre for Tropical Plant Pathology at the University of Queensland (CRCTPP), the search for useful promoters to drive transgene expression has been fruitful. Two DNA fragments (My and Cv) have been identified and isolated from two strains of Australian BSV. Both fragments were found to have promoter activity in a range of plants, from ferns to flowering plants. In bananas, sugarcane and tobacco, high-level expression of GUS and green fluorescent protein (GFP) in various tissue types is observed using BSV-derived promoters. Transgenic Three Hand Planty with a My promoter expressed GUS at seven times the strength of the maize ubiquitin promoter in leaf tissue and at four times in root and corm tissue.

Interestingly, it seems that some non-transformed plants of Three Hand Planty, derived from ECS, may already contain a BSV sequence homologous to parts of the Cv isolate. Transformed plants with a Cv promoter, therefore, may not show any transgene activity because of the gene silencing effect caused by the interaction between multiple copies of the promoter sequence.

Building partnerships, 15 years of networking to improve food security

Charlotte Lusty, Suzanne Sharrock and Emile Frison, INIBAP, Montpellier, France.

Background

In 1983, a group of concerned donors and scientists met to consider the need for research on bananas and plantains, urged on by the ravages of black Sigatoka disease which were threatening production in an increasing number of countries. They came up with a novel idea. It involved the establishment of an international research network as opposed to the conventional CGIAR research centre, which would focus its efforts on supporting activities conducted by NARS. There would be no central research facility and therefore no major capital outlay and only a limited number of international staff. Research would be done by national institutions, south and north. One of the first priorities was to set up a means for germplasm conservation and distribution.

So INIBAP was conceived. The year 2000 marks its 15th anniversary. At such a time, it is a natural response to assess the effectiveness of this modern *modus operandi* and in doing so to sketch some of the trials and tribulations of networking.

Bananas from improved varieties grown by smallholder farmers in East Africa. Networking put together the supplier of the germplasm, the multiplier of the plants and the distributor to farmers. (Tine Hemelings, KCDP)

Networking creates opportunities

Operating by commissioning or outsourcing research gives a networking organization the freedom to call on the most appropriate and experienced research teams to address strategic problems. The independence from a structured research programme, also, is liberating in that initiatives may be focussed at all levels, from frontline science to farmer,

Linking with regional networks

INIBAP works with four regional NARS-based networks, which each come under the auspices of regional umbrella agricultural organizations. The focus within each region is quite unique. For instance, in Latin America many hundreds of technicians and farmers are being trained in a technical package to improve plantain production, in East and South Africa IPM options are under evaluation by smallholder farmers, in West and Central Africa an attempt is being made to improve peri-urban banana production, finally, in Asia and the Pacific banana germplasm is being collected and conserved in its centre of diversity.

Linking with partners globally

The International Musa *Testing Programme, a partnership between NARS breeding programmes, scientists and INIBAP, has amassed data on the performance of new improved varieties through testing in multiple locations around the world. A number of high-performing varieties, which respond well to the disease burdens that exist in different parts of the world have been identified. They are now being made available to smallholder farmers.*

which also helps to strengthen existing efforts and avoid duplication. Each level of collaboration, into which INIBAP has entered, has brought about very different results, forming a multifaceted approach (see the examples in the boxes) to a singular aim, that of improving smallholder banana production. In several cases the relationships have advanced little beyond a teething phase, however, in others such links have allowed the establishment of mechanisms for cooperation which now have a life of their own.

And networking has constraints

Although it is easy to proclaim the virtues of networking on paper, on the ground there are frequently frustrations and failures. Depending on a healthy spirit of collaboration in order to progress can prove prohibitive and there are a number of areas where pitfalls exist:

- Pursuing new ideas depends on developing consensus.

Linking with farmers in Uganda. Farmers are participating in research and receiving improved germplasm. (D. Karamura, INIBAP)

Linking with breeding programmes

INIBAP has long been linked with one of the major banana breeding programmes based at FHIA in Honduras. Through financial support INIBAP has assisted in the production of high performing banana varieties that are showing the first signs of promise in providing both acceptable fruit quality and improved yields for smallholder farmers.

Linking with farmers

INIBAP's involvement in farmer-participatory research is relatively recent, but demonstrates a continuing shift towards direct linkages with the end-users of research. Current projects on germplasm evaluation and conservation, and the testing of IPM options involve participating farmers in aspects of planning, implementation and data gathering. The fundamental role of farmers in the adoption of new technologies or new varieties is well recognized.

Linking with NGOs

Through a number of projects implemented by NGOs, INIBAP is supplying improved banana germplasm to smallholder farmers. Furthering links with NGOs is important because of their strong development focus and specific experience of working with people at the local level.

Linking with scientists

The advantages of networking, particularly that of enabling priorities to be set at a global level, are prominent in the global programme for Musa *improvement, PRO*MUSA*. This programme brings together all the major players in* Musa *improvement research through a framework of working groups, which share information and divide research responsibilities. Since the establishment of PRO*MUSA*, a new spirit of collaboration and sharing is evident in* Musa *research, resulting in increased efficiency and better progress.*

*Musa researchers from around the world. PRO*MUSA *brings partners together to enable priorities to be set at a global level.*

Women farmers' group in Bushenyi district, Uganda, where INIBAP is conducting an on-farm conservation project, left. Farmers participating in research on IPM options in East Africa, right. (S. Sharrock, INIBAP)

- Efforts may be misguided through domination of any one party.
- Communication technologies are advancing rapidly but are not equally distributed. The lack of the necessary tools can result in isolation or exclusion of certain partners.
- Little opportunity exists for networking organizations or their staff to enjoy recognition or ownership of results.
- Demonstrating and quantifying the beneficial impact of networking is not easy. Therefore the role of a networking organization can be difficult to understand and justify.
- The outcome of commissioned-research is harder to control.
- Coordination is an essential function of networking. However many donors are not keen to cover the transaction costs associated with such coordination.

In 15 years, INIBAP has faced several challenges of networking. The problems, however, have not been insurmountable. Quite the contrary, they are a necessary evil to effect a healthy organizational evolution. One example of how INIBAP has adapted because of past experiences, is evident in the evolution of IMTP. This programme is now in its third phase and although, the aims and objectives of the programme have remained unchanged since its initiation, there have been distinct changes in programme structure with each successive phase. On completion of each IMTP phase, successes and failures have been evaluated and changes to the programme have occurred to suit the changing needs of partners. Thus in the latest phase, and in contrast to previous phases, partners are now free to choose the level of evaluation they wish to undertake and the varieties they wish to include. Through employing a flexible approach it is intended that IMTP will respond to the partners as they themselves evolve.

A further area where change has been necessary concerns the regional networks. The first regional network, which was established in Latin America was very much an INIBAP initiative, mainly involving *Musa* scientists already working with INIBAP. In Africa however things were different. Lack of resources constrained INIBAP's activities here until the mid 1990s. However, African NARS became increasingly aware of the need to share resources to achieve common goals and took the initiative to form two networks themselves, with support from the sub-regional agricultural research fora (Association for Strengthening Agricultural Research in East and Central Africa, ASARECA and West and Central African Council for Agricultural Research and Development, WECARD/CORAF). The African networks, therefore, have always belonged to the NARS and the involvement of INIBAP as a coordinator and secretariat came about by request from the NARS, themselves. It is clear to INIBAP, that the NARS-led networks ensure better long term sustainability. INIBAP is therefore facilitating the reshaping of the Asian and Latin American networks according to the African model. In Latin America and the Caribbean, this has resulted in the re-launching of LACNET as *MUSA*LAC under the auspices of FORAGRO.

Beyond networking

In INIBAP's case, the aims it has set itself (which are found at the beginning of each section in the main text of the annual report)

cannot be fulfilled by networking alone. A number of services must be provided which demand physical resources and sustainable management, as well as networking. In some cases the service is housed by INIBAP itself, in others the work is outsourced. The International *Musa* germplasm collection is an example where the physical host is not INIBAP, but KUL. INIBAP manages and develops the collection and enables the safe movement of germplasm around the world. Only through bringing the collection into one place in the temperate zone, can the ambition be attained to provide disease-free material to smallholder farmers worldwide without restriction.

In-house, INIBAP manages databases, produces publications and administers the *Musa* Germplasm Information System (MGIS). These activities produce tangible products that complement well, if not are essential to, network activities. The dependency on collaborators for information or technical advice remains strong.

Has networking produced results after 15 years?

In an address by the chair of the Technical Advisory Committee (TAC) of CGIAR, Emil Javier, the practises of INIBAP were applied within the context of the seven operational elements of the new CGIAR strategy proposed by TAC:

1. Poverty focus
2. Priority for South Asia and Sub-Saharan Africa
3. Regional research planning
4. Bringing modern science to bear on CGIAR's goals
5. Closer integration of CGIAR activities with partners in the regions
6. Task force approach
7. Act as catalyst and integrator.

The manner in which INIBAP conducts business was recognised as incorporating each element very much into its agenda and providing, in some cases, a useful example. Also in 2000 a Centre-commissioned external review took place which looked deeply into the effectiveness of the *modus operandi,* this mixture of networking and service-providing. Its conclusion was that "INIBAP has found its niche in the global scientific community and… has proven that the network approach for banana and plantain is a valid approach satisfying a large number of producers, consumers and scientists in the world."

Such valuable reinforcement of INIBAP's achievement is highly useful in engineering good morale in the working organization, but more importantly provides gratification to INIBAP's collaborators and sends a message to all future collaborators that networking is working.

Phil Rowe, FHIA's expert banana breeder, with FHIA-25. (D. Jones, consultant)

Farmer in Davao, the Philippines. (D. Mowbray, Baobab Productions)

Inibap around the world

Integrating solutions to pests and diseases

During the past 50 years, any attempt to control pests and diseases has been fought almost solely by chemical biocides. Controlling black Sigatoka in Latin America demands US$1500 per hectare per year and 38-50 fungicide applications. The spread of pests and diseases, however, remains unabated and some millions of farmers are still living with damaged crops and low yields because they can't afford the pesticides. What's more, in many areas the use of pesticides is causing widespread damage to human and environmental health.

Are there alternatives? People farming in traditional style have generated sustained productivity through diversifying crops and cultural practises, incurring little expense except in labour. However measures such as these become less appropriate and often ineffective in the face of human population pressure and accelerated transmission of pests and diseases. Yet, now there are innovative cost-effective ways of circumventing the effects of pests and diseases without using chemicals, and bringing the different measures together can prove a potent strategy. Integrated pest management (IPM) is the formal term for incorporating several measures to control one or more pests and/or diseases according to the individual context.

INIBAP's activities and regional projects contribute in several ways to IPM. Two of the core propositions of IPM are to use varieties which have in-built resistance to disease and to ensure that planting material is clean of infection. INIBAP contributes to both by supporting *Musa* improvement and by supplying healthy germplasm from its collection.

Weevils are almost notorious for being left off the agenda of public and private research institutes, yet amongst the African smallholder farmer they are the most widely known of all pests and diseases because of their visibility and impact. In West Africa, INIBAP is sponsoring the exploration of strategies to control the weevil. Household ashes and neem (a natural extract from an Indian tree) have been shown to have potential impact for IPM, and this year, several sources of resistance have been found in rapid screening tests on greenhouse plants (see p. 42-43). In Costa Rica and Vietnam INIBAP-sponsored research is evaluating the resistance of both wild and cultivated bananas to nematodes. (see p. 37-38).

Bringing together in-built resistance and sanitation in the crop with forms of pest or disease control make an effective package. However if identified measures are to be successful, farmers must be trained and participate in IPM evaluation.

Transferring technology forms a strong component of networking in the regions. In Asia, expertise from Taiwan, where virus disease management is very successful, has been transferred through workshops and training to three other countries in the network, who are suffering immense virus disease pressure. This year it was the turn of Bangladesh (see p. 36). As a result of previous workshops, rehabilitation programmes have taken off in the Philippines and Sri Lanka (see p. 37).

Finally, an exciting collaboration with NARS is under way in East Africa. Diverse socioeconomic situations, agro-ecological environments, soil fertility and climate etc. are forming the backdrop for a comprehensive test of IPM options by the farmers themselves (see p. 40). This perhaps marks where the research ends and the turnaround in banana production in Africa begins.

LATIN AMERICA AND THE CARIBBEAN 34
ASIA AND THE PACIFIC 35
EASTERN AND SOUTHERN AFRICA 39
WEST AND CENTRAL AFRICA 41

Latin America and the Caribbean

The changing face of the network
*MUSA*LAC, the successor of LACNET (or the Regional Network for Latin America and the Caribbean), is formally established under its new name. As reported in the Annual Report 1999 (p. 34), the network functions under the auspices of *Foro Regional de Investigación y Desarrollo Tecnológico Agropecuario para América Latina y el Caribe* (FORAGRO) with INIBAP working as Secretariat. The constitutional agreement was signed in June by 14 National Agricultural Research Systems (NARS) and four international research organizations. At the first meeting four working groups were set up to focus on: socioeconomic development, integrated pest management, agronomy, and genetic improvement. The *Fundación para el Desarrollo Agropecuario* (FUNDAGRO) has provided seed money for a *MUSA*LAC fund to initiate activities on *Musa*.

Coordination across the continents
The activities of *MUSA*LAC are by no means limited to the region. In the course of 2000 there was a notable scientific exchange between countries within the region and outside, such as the Canary Islands, Ghana, South Africa, France, Belgium and Australia. The transfer of expertise covered a wide range of topics, from nematology to microsatellite technology. ICIA in Tenerife and *MUSA*LAC enjoy a particularly strong relationship. Spain is funding two of the four small projects which were initiated in 2000 (see Table 1). Coordination through *MUSA*LAC enabled several university students to be trained or to complete theses, including 24 students from the University of Gembloux who attended a course on agroforestry, plant protection and agroeconomy at CATIE. A trip was also organized for a group of plantain-growers from Panama to visit production areas in Costa Rica.

Small projects with a big impact
The UK Department for International Development (DFID) funded a number of small projects in 1999, including studies on nematode control, black Sigatoka and genetic improvement. Three of the projects came to an end in 2000, bearing two postgraduate theses and two undergraduate theses.

Genetic diversity of a destructive pathogen: genetic differentiation between *M. fijiensis* populations in Latin America and the Caribbean
Black Sigatoka is a disease of global proportions. The genetic diversity of the fungus causing it, *Mycosphaerella fijiensis,* is very high in its centre of origin in Asia. As the pathogen has moved from this region to Africa, America and most recently the Caribbean, some of this genetic diversity has been lost. However an important proportion still remains, and knowledge of the extent and distribution of this remaining variability provides important information to aid breeding and the management of disease resistance. For this reason, CATIE and CIRAD are conducting a study, with INIBAP support, of *M. fijiensis* samples from Honduras, Costa Rica, Panama, Colombia, Cuba, Jamaica and Dominican Republic, using eight cleaved amplified polymorphic sequences (CAPS), as molecular markers.

Initial results show that genetic diversity of *M. fijiensis* in Honduras and Costa Rica is relatively high compared to the populations elsewhere, suggesting that the pathogen first entered the continent in this area. A high level of genetic differentiation was detected between most of the populations analysed indicating that gene flow is limited. Meanwhile, there is sufficient differentiation between populations in the Caribbean islands to support a theory that more than one introduction occurred from Latin America. It is likely that the disease, therefore, has spread in the region through infected plants and/or through restricted dispersal of ascospores. Continued research at the country level will help to specify which means of

Table 1. Newly funded projects in Latin America and the Caribbean

Institute	Project
CORPOICA-ICIA	Growth, development and postharvest research of a semi-dwarf "Bocadillo" banana (*Musa* AA) in two production areas of Colombia
CATIE	Identification and selection of potential antifungal biological products to control black Sigatoka on plantain
CATIE-ICIA	Utilization of banana endophytic fungus as resistance inductors against *Radopholus similis* and Fusarium wilt on banana and plantain
INISAV	Genetic variability of *Foc* in Cuba: sensitivity determination of FHIA hybrids to *Foc*

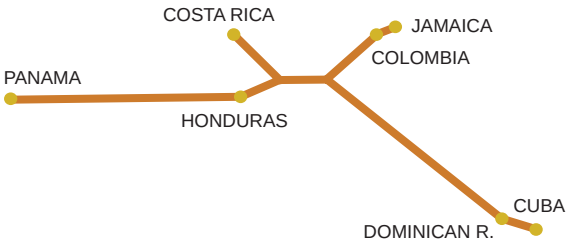


Figure 1. Preliminary indication of the genetic differentiation between populations of M. fijiensis *in Latin America and the Caribbean, helping to trace the pathway of the black Sigatoka. (The length of the line is proportional to the degree of genetic differentiation).*

transmission is the more important and how the spread of disease may be kept in check.

Mendelian science
The genetics of resistance to pests and diseases are under study in a return to the techniques used by Mendel in the nineteenth century. Ten lines of the hybrid progeny of the Calcutta 4x Pisang Berlin cross were planted and cross-pollinated at *Corporación Bananera Naciona* (CORBANA) in 2000. Morphological and bunch characteristics are showing evidence of segregation. Viable seeds are now being sought from the harvest. The populations are being followed for signs of resistance to nematodes and black Sigatoka.

Improved varieties in the backyard
Nearly 1000 families in Nicaragua are replanting their home gardens, destroyed by Hurricane Mitch in 1998, with improved bananas and plantains. *Vlaamse Vereniging voor Ontwikkelingsa-menwerking en Technische Bijstand* (VVOB) are supporting the project, KUL are providing the technical assistance and INIBAP are supplying the germplasm. The capacity of the tissue culture laboratory at the *Universidad de León* (UNAN-León) has been enlarged to produce 20 000 plants for distribution in 2000. Already 750 farmers have been involved in training or evaluating the varieties.

Changing plantain production practises
Last year over 200 researchers, extension workers, students and farmers in four countries were introduced to plantain production technology which has been developed over a lifetime's research by Sylvio Belalcázar at *Corporación Colombiana de Investigación Agropecuaria* (CORPOICA). This year Dr Belalcázar taught no less than 1505 people in 22 training courses. INIBAP directly supported seven of these courses. The technologies being taught are simple and robust, providing comprehensive cover of all aspects of plantain production; preparing the land, preparing and treating corms, distributing and planting suckers, weeding and caring for the plants, harvesting and sorting the fruit, recognising pests and diseases etc. Recognizing that production can be significantly improved through careful management is one of the strongest messages these courses intend to provide.

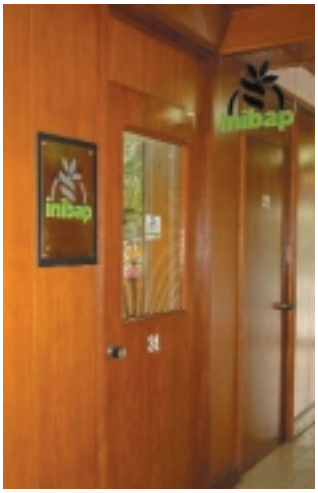
Asia and the Pacific

Accelerating the movement of improved varieties within Asia and the Pacific
Breakthroughs in banana breeding in recent years have delivered a number of high-performing varieties to the public sector. These varieties have the potential to supply smallholder farmers with sorely-needed capacity to deal with disease and improve yields. However one of the chief limiting factors is the supply of planting material. The INIBAP genebank, as international provider of banana germplasm for Asia, has the capacity to produce only five samples per requested accession.

Banana varieties are being crossed and segregating populations produced to help filter out genetic traits in a similar way as Mendel used when he crossed peas. (F. Rosales, INIBAP)

Sylvio Belalcázar, INIBAP's scientific advisor in Latin America and the Caribbean addresses a group of plantain-growers and researchers as part of his impressive training schedule in 2000. (F. Rosales, INIBAP)

Plantains are equally popular as the familiar Cavendish with consumers in Latin America and the Caribbean. (T. Lescot, CIRAD-FLHOR)



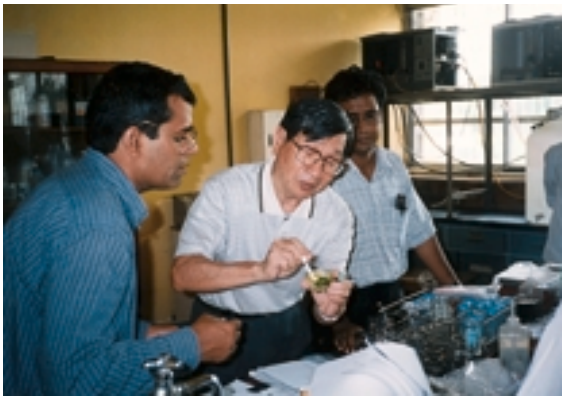
The Asia and Pacific office has moved to new quarters in the Collaborators' Center of the International Rice Research Institute in Los Baños, Philippines. INIBAP is deeply grateful for PCARRD's hospitality over the past 10 years. (A. Molina, INIBAP)

Various projects are in progress to catalyze the rate of distribution of improved varieties in Asia and the Pacific region. The members of the Asia and Pacific Regional Network (ASPNET) Steering Committee met at the International Banana Symposium in Bangkok and launched their plans to develop a network of national repository and dissemination centres in the region. Under these proposals participating governments would assign an institution with the responsibility to acquire banana germplasm, multiply and distribute it within the country.

In several countries a working system is already in place. For instance INIBAP has an agreement with the banana repository at NBPGR in India, which acts to disseminate planting material as well as conserve, maintain and develop banana varieties. The Philippines, Thailand, Vietnam, Malaysia, Bangladesh and Sri Lanka have responded positively to building further their national capacity.

In the South Pacific, the Secretariat of the Pacific Community (SPC) has developed a Regional *Musa* Germplasm Center with assistance from INIBAP. Several FHIA hybrids with resistance to black Sigatoka, the most prominent banana disease currently affecting the region, are under trial in American Samoa, Fiji, Federated States of Micronesia, Papua New Guinea, Samoa, New Caledonia, Wallis and Futuna. Preliminary results suggest that the improved varieties are highly productive in low input agricultural systems. The trials continue and the Regional Germplasm Center is instrumental in making the varieties accessible to all farmers who require them and in supplying new material for testing as it becomes available.

Banana bunchy top disease, transmitted through propagating diseased plants, has wiped out many crops. Since planting tissue culture plants this Philippine farmer has seen yields rise dramatically. The potential increased access to improved varieties provided by national multiplication centres should help lessen the impact of disease for smallholders. (A. Molina, INIBAP)



Professor Su from Taiwan training Bangladeshi scientists techniques in detecting viruses. (A. Molina, INIBAP)

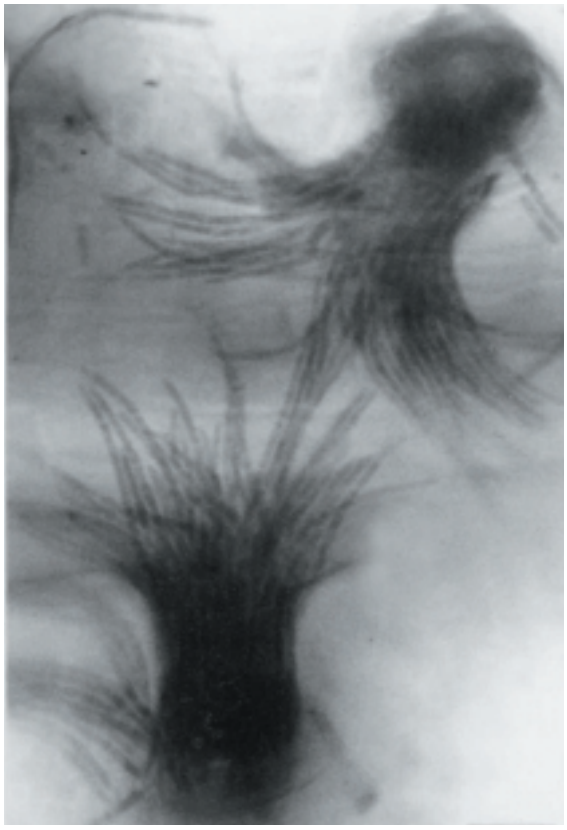
Bangladeshi scientists armed to fight virus diseases

The focus on building capacity to deal with virus diseases shifted in 2000 to Bangladesh. The Horticulture Research Centre of the Bangladesh Agricultural Research Institute (HRC/BARI) and INIBAP organized a workshop for 52 researchers, teachers and policymakers. Just as in Sri Lanka, where a similar workshop took place last year, a large majority of banana plantations and smallholdings throughout Bangladesh are infected with viral diseases. The technological capacity for growers and scientists in the country to deal with the diseases is severely limited.

However, the meeting, funded by DFID, allowed experts in the field to assess the severity of viral diseases affecting bananas in the country. Prof. H.J. Su, from the National Taiwan University, contributed to the workshop and was able to provide materials and training to allow nine scientific officers at BARI to become proficient in two techniques for detecting viruses in germplasm, enzyme-linked immunosorbent assay (ELISA) and PCR-based indexing.

Fungus finds – Septoria leaf spot

The presence of the leaf spot disease caused by *Mycosphaerella eumusae,* known as Septoria leaf spot, was confirmed by CIRAD in banana leaf samples from southern India, Sri Lanka, Thailand, Malaysia, Vietnam, Mauritius, Nigeria and most recently from Bangladesh. A morphological characterization of the species was carried out. Its sexual stage was found to be indistinguishable from other *Mycosphaerella* species causing similar leaf spot diseases. The anamorph stage, however, is very different and provides the only classical means of identifying the pathogen. A phylogenetic study of the ribosomal DNA placed *M. eumusae* as a distinct species on a family tree of banana leaf fungi belonging to *Mycosphaerella* and related anamorph genera. From this analysis, molecular tools for identification of the leaf spot pathogens will be developed. INIBAP, CIRAD and DFID continue to support surveys for leaf spot pathogens in India with National Research Centre on Banana (NRCB), in Malaysia with Malaysian Agricultural Research and Development Institute (MARDI), Sri Lanka with Regional Agricultural Research and Development Centre (RARDC), the Philippines with Institute of Plant Breeding/University of the Philippines at Los



View of the hyphae of the fungus causing Septoria leaf spot published in Phytopathology 90 (8) 2000 (Carlier, J. et al. *Septoria leaf spot of banana: A newly discovered disease caused by* Mycosphaerella eumusae *(Anamorph* Septoria eumusae*). (J. Carlier, CIRAD)*

Baños (IPB/UPLB) and China with South China Agricultural University (SCAU). The studies should also be expanded into other Asian countries.

Banana rehabilitation

In the last three years banana production by smallholder farmers in the northern Philippines has plummeted because of Banana bunchy top disease (BBTD). The virus, causing the disease, is easily spread through the use of infected planting material and insufficient management of the disease. INIBAP and PCARRD are working on an IPM pilot project in Quirino and Nueva Vizcaya, which will introduce a number of simple post-planting measures and encourage the use of clean planting material to farmers, whose crops have been affected by the disease.

With the similar aim of rehabilitating banana production, a clinic to provide guidance on banana pest problems took place in Baguio City. The Highland Agriculture and Resources Research and Development Consortium (HARRDEC) organized the one-day event in collaboration with the Bureau of Plant Industry - Bagiuo National Crop Research and Development Center (BPI-BNCRDC) and Food and Fertilizer Technology Center (FFTC). Around 80 farmers brought pest-infested bananas to the clinic for advice.

Bananas for auction at Trichy in India. (S. Sharrock, INIBAP)

BIN-ing banana information

Diverse groups in the Philippines banana industry are making new connections. Their idea is to form a Banana Information Network (BIN) under the framework of the Commodity Information Network of PCARRD. Individuals with a stake in the banana industry are invited to pool data holdings to create a resource that will provide information on all areas of production, from agronomic practises to marketing. INIBAP's databases, *MUSA*LIT and BRIS, will both contribute to the network's information sources. Participating groups, including exporters, growers, researchers and input suppliers, met in May to discuss their information needs. Common areas were identified, such as a comprehensive directory of services and experts. Moreover, by incorporating the different priorities of participating sectors, the network has the potential of bringing together as diverse subjects as soil science and funding bodies.

Nematodes in wild bananas

Banana yields in Vietnam are on average low, around 13.7 tons/ha. Pests and diseases are a strong contributory factor. Part of the clue to improving banana production may be found in wild habitats, where bananas and pests have evolved together. The INIBAP-sponsored associate scientist based at the Vietnam Agricultural Science Institute (VASI) conducted three surveys in northern Vietnam for nematodes. VVOB, *Vlaamse Interuniversitaire Raad* (VLIR) and the Australian Centre for International Agricultural Research (ACIAR) helped to finance the research. Samples of nematodes were taken from three wild banana varieties growing in Cuc Phuong National Park,

Ba Be National Park and Lai Chan. Levels of infection were relatively low, averaging at 67 nematodes per 10 g of fresh roots. The species *Pratylenchus coffeae* was found to be common to all areas, causing root necrosis in the host plant. *Meloidogyne* spp. infested plants exhibited root-galling and a reduction in number of fingers in the bunch. Searches for *Radopholus similis* were unproductive, supporting the results of surveys on cultivated bananas. This particularly destructive species has evidently yet to reach Vietnam, despite its prevalence in neighbouring countries. In 2001 the western highlands, where a *Radopholus*-like population has infested coffee, will be surveyed.

Joint initiative between IITA and INIBAP

The two Future Harvest centres carrying out *Musa* research and development (IITA and INIBAP as a programme of IPGRI) recently decided to integrate their *Musa*-related activities in Africa. The agreement to establish a joint programme for *Musa* in Africa was finalized at a meeting held in Uganda in September 2000.

IITA and INIBAP have been working together in Africa for many years. The new joint programme, which will be implemented under the umbrella of the two African regional networks, BARNESA and *MUSA*CO, incorporates strategy making, germplasm conservation, germplasm evaluation and public awareness. Both organizations will have joint responsibilities in all of these areas whilst their individual activities will be carefully planned to complement one another. The IITA newsletter, *Mus*Africa, will now be published jointly under both INIBAP and IITA, and starting this year the highlights of IITA's activities undertaken as part of the joint programme are published in the INIBAP annual report.

Highlights from IITA

Viruses

- *BDBV was detected with primers against nepoviruses using RT-PCR.*
- *The field spread of BSV and BDBV was confirmed using monoclonal antibodies.*
- *CMV (subgroups A and B) and associated symptoms are more prevalent than expected and may account for BSV-like symptoms.*

IPM

- *The prospect of developing a biological control for banana weevils has been laid open by the discovery of two species, one a hymenopteran and the other a dipteran, which parasitize the egg and the larva respectively.*

Improvement

- *Meiotic chromosomes may now be observed more efficiently using an improved procedure.*
- *Specific primers have been developed to identify A and B genomes using cloned RAPD fragments.*
- *An AFLP fragment related to parthenocarpy was identified using segregating populations of a diploid variety.*

Breeding

- *A triploid plantain has been produced from exclusively diploid parents through unilateral sexual polyploidization (2n gamete).*
- *Resistance to the nematode* Radopholus similis, *was identified in 12 diploid hybrids that had been selected for resistance to black Sigatoka and good plant and bunch characteristics.*
- *A high-yielding secondary triploid plantain variety (PITA26) has been produced with tolerance to BSV, resistance to black Sigatoka and excellent fruit characteristics using a BSV-susceptible primary tetraploid hybrid.*

Transformation

- *A genotype-independent protocol for regenerating apical shoot meristems has been developed.*
- *Expression of GUS was achieved through* Agrobacterium*-mediated transformation.*

Training and development

- *Researchers from Cameroon, Rwanda and Benin have been trained in virus diagnostics, nematode identification, and cultivar evaluation.*
- *A strategy has been formulated to deliver improved varieties to farmers in Nigeria.*
- *Different technologies for increasing banana production, through conserving soil fertility and controlling weevils, have been adopted by farmers in Uganda and Ghana.*

Eastern and Southern Africa

Conservation through farming

Farmers in the Great Lakes region have, at one time or another, made use of 145 varieties of cooking banana and a further 88 varieties of beer-making bananas. Part of this diversity may still be found in homesteads and fields today. However a continuous erosion of genetic diversity has occurred over the last few decades. INIBAP is executing a three-year project to document the Great Lake banana varieties, study the reasons for genetic erosion and provide support for conservation. The International Development Research Centre (IDRC) is funding the work.

Ibwera and Chanika sites in the Kagera region of Tanzania, and Masaka and Bushenyi sites in neighbouring Uganda are the focus of the project. Having identified the participating farmers and workplan in 1999, activities in 2000 brought together the first set of data. Surveys were carried out in 135 households from all four sites to establish which cultivars are available or have been grown in the past, their preferred characteristics and how they are being managed and used. A great deal of variability in the composition of cultivars is apparent between different sites. On average, each farmer held about 15 varieties (Figure 2).

The farmers' responses suggest that many have lost around 20-40% of the cultivars that were once grown. The reasons for this are no doubt complex. Farmers must respond to market preferences, and diminishing resources and land. Pests and diseases have also played a decisive role. Weevils, nematodes and Fusarium wilt were detected in all sites, which may also have contributed to a similar gradual decline seen in the national collections of Uganda and Tanzania.

Market forces can be observed in the criteria affecting farmers' decisions as to which cultivars to use (Table 2). Many farmers have removed non-marketable cultivars or have kept them apart from the more intensely-managed commercial varieties. Cultivars which have become less favourable are inevitably lost. Utilization is an integral part of long-term conservation and the aims of the project are to keep this link very much intact.

Many of the agricultural practises have been passed down the generations. In particular, planting suckers on a slant, debelling (cutting off the male bud) and planting new cultivars near the house are traditional habits which are localized to the area. Information continues to

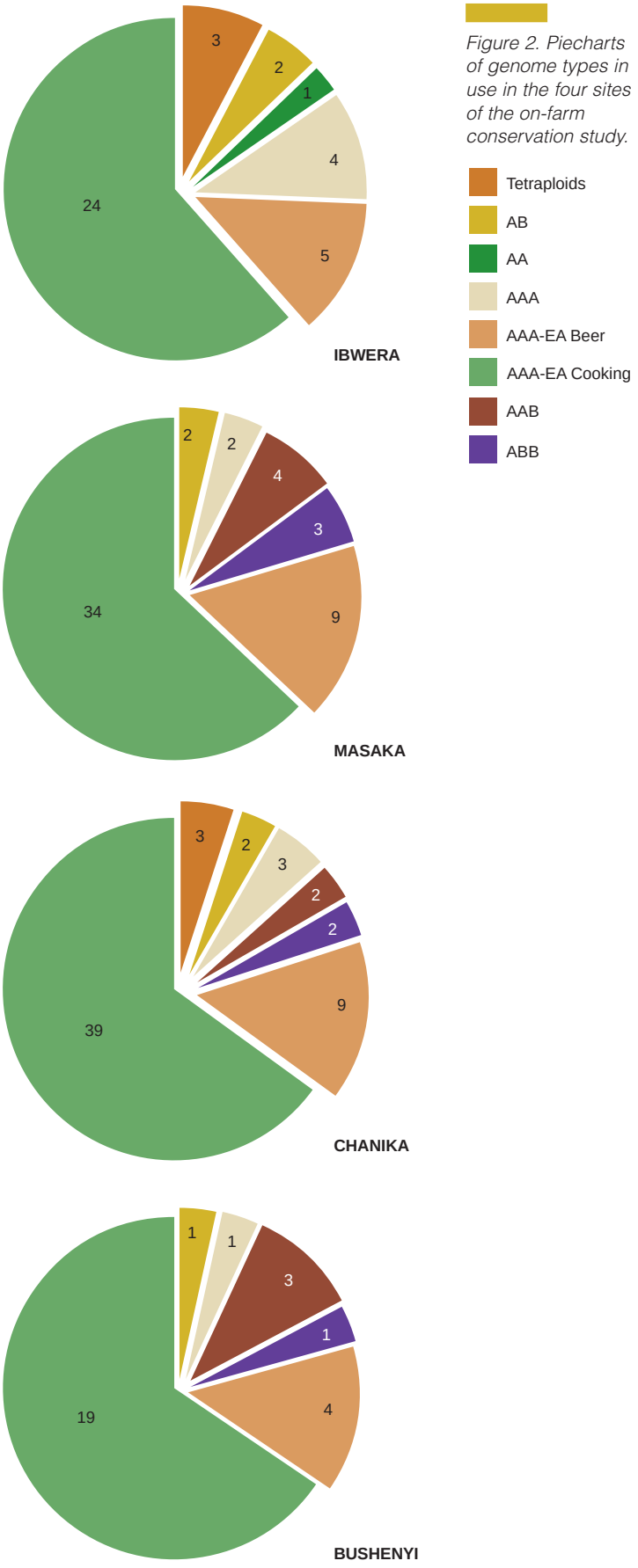


Figure 2. Piecharts of genome types in use in the four sites of the on-farm conservation study.

be gathered with the help of farmers and extension workers. Much of the responsibility for the running of the project has been placed in the hands of local committees at each site. Such a positive response from a large number of farmers in the community provides invaluable support to the project's aims.

Table 2. A subset of the criteria by which cultivars are selected for cultivation.

Criterion	% farmers using the criterion as a means for selecting planting material
Bunch size	95
Palatability	56
Maturity period	47
Resistance to diseases	42
Marketability	15
Plant vigour	7
Drought resistance	3
Adaptability to the soil	4
New cultivar	1
Food security	1
Cultural	1

Members of the Stakeholders' meeting at Chanika in Tanzania. Their aim is to investigate the diversity of banana varieties in their area and the reasons for its decline, in order to effect sound conservation measures. (D. Karamura, INIBAP)

One of the participating farmers talking about diversity and strategies to conserve it at an agricultural and educational show in Masaka, Uganda. (D. Karamura, INIBAP)

Cracking the pest problem

The ground has been laid for a farmer-participatory project on the use of different IPM options with the financial support of DFID. The factors affecting *Musa* diversity in the different project sites in Ibwera, Tanzania, Lwengo in Uganda and Bungoma in Kenya are being evaluated. The options for controlling weevils, nematodes, black Sigatoka and Fusarium wilt have been reviewed by the participating farmers in Tanzania and the following options chosen for investigation: neem powder, clean tools and planting material, mulch, pest-traps, and planting *Tephrosia* as a barrier crop. Some of the techniques are new to the farmers and both they and the participating NARS will receive full training in 2001. Experiments begin with the next rainy season.

IPM trials are underway in Uganda. (S. Sharrock, INIBAP)

Performing bananas

The Kagera Community Development Programme (KCDP) and KUL are partners in an initiative to deliver one million banana plants of high-performing varieties to farmers in Kagera, Tanzania. The INIBAP genebank is supplying the germplasm and the Belgian and Tanzanian governments are funding the project.

By July 2001 over 70 000 *in vitro* plants will have been supplied to be planted out in fields over a wide area in Kagera. The farmers in the region have had no experience of these varieties,

nor of *in vitro* plantlets. The plants are, therefore, grown and multiplied and provided to farmers for evaluation in a form with which they are familiar (i.e. 1-1.5 m suckers). This also helps to provide a sustainable source of the new varieties. Additional plots are planted within villages in order to demonstrate and test the performance of varieties to a wide audience.

Current estimates indicate that the multiplication fields will be producing around 120 000 suckers in 2001. KUL is adjusting supplies to cater for the keen demand for FHIA-17, FHIA-23, Pelipta and SH 3436-9 varieties. The new varieties are being successfully absorbed into farmers' fields, especially where yields have been poor in the past. Their impact is already evident. From initial data provided by farmers in some areas, the improved varieties are outperforming existing varieties, bunch weight having increased by over a third (Figure 3).

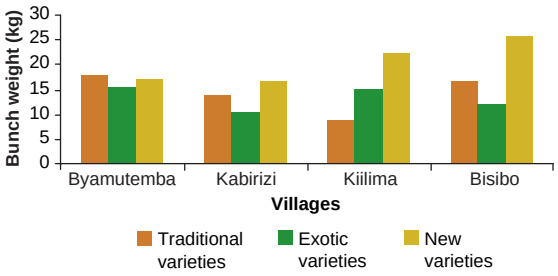


Figure 3. Preliminary results of bunch weights from traditional varieties and the new ones.

Novel ways to improve bananas in Uganda
Successful breeding essentially builds desired new traits and performance whilst retaining all of the favourable characteristics of existing varieties, postharvest and culinary qualities in particular. The Ugandan Government is putting its allocation of funds dedicated to the CGIAR into developing biotechnological capability in the country. The partners in the project are IITA, NARO, Makerere University, CIRAD, KUL and INIBAP, who is coordinating the project. The focus is specifically on improving the production of East African Highland banana varieties by enhancing their resistance to black Sigatoka, nematodes and weevils. Developing a centre of biotechnology competence and upgrading existing molecular biology facilities in Uganda will form an essential part of the project. Such a centre of excellence in biotechnology, working in the framework of BARNESA, will serve not just Uganda but the entire region.

West and Central Africa

City harvest
Banana and plantain are part of the landscape in and around many tropical cities. They grow easily in marginal or confined areas, and provide much-needed calories for growing populations. In West Africa the demand for plantain in the cities frequently outstrips supply and prices for them can soar. In an effort to target specifically urban populations, INIBAP is using funds from the French Government to improve production in four West African cities. Projects in Sekondi-Takoradi and Kumasi in Ghana and in Cotonou and Abomey-Calavi in Benin were initiated in 1999 and fully got under way in 2000.

Fields where banana plants are multiplied for supplying to peri-urban farmers in Kumasi, Ghana. (E. Akyeampong, INIBAP)

A mixture of cooking banana, dessert banana and plantain have been supplied from the INIBAP genebank, for multiplication at CRBP in Cameroon and at the Biotechnology and Nuclear Agriculture Research Institute (BNARI) in Ghana. FHIA-18, FHIA-23, FHIA-25 and CRBP 39 exhibit strong resistance to black Sigatoka, a disease which is limiting yields severely. Nursery facilities have been constructed in each area from which the plants are distributed. Four project staff have been trained in *in vivo* multiplication techniques, which they will teach to farmers where necessary. The banana-growers, 40 from each site, have also now been identified. Once the plants are in the field, their performance will be monitored by the farmers and the data fed into an evaluation of the varieties.

The supply of bananas and plantains in the cities in West Africa do not always meet demands. A banana seller in Douala. (E. Akyeampong, INIBAP)

Cooking improved varieties

Consumers in West Africa are well known for their preference for plantain. They appreciate the firmness of the plantain when cooked. Varieties of the softer-textured cooking banana, however, confer certain advantages in the field, such as higher yields and longer periods of productivity. There is evidence that cooking bananas may be acceptable for some foods. *Tatale* and *akrakro*, made from very ripe plantain, are eaten as snack foods in Ghana, Benin, Cameroon and Nigeria.

The Crop Research Institute (CRI) in Ghana is investigating the palatability of cooking bananas within the country in an INIBAP-funded initiative. High-yielding and disease-resistant varieties will be included in the study.

Improved germplasm is also under trial in other countries for their agronomic performance. In total NARS from nine countries have signed letters of agreement with INIBAP to carry out evaluation studies.

The market place in West Africa caters for the strong preference for plantains. (E. Akyeampong, INIBAP)

Getting to the core of the weevil problem

Of all the banana pests and diseases, perhaps the best known to farmers in Africa is the black banana weevil, *Cosmopolites sordidus*. The larvae of the beetle bore holes into the corm of the banana plant. Their attacks are not fatal but they severely weaken the plant so that it eventually topples over or succumbs to other pests and diseases. Resource-poor farmers are frequently vulnerable to serious yield losses through weevil attack. The costs of insecticides and labour to counteract the attack are too dear for them to afford. A safe and cheap control strategy is essential to sustainable banana production.

INIBAP supports a researcher at CRBP to test different mechanisms to control weevils as part of an integrated pest management plan. In the Annual Report 1999 (p. 42) the effects of neem solution and other natural repellents on weevils were described. In 2000 the results were obtained from trials on pheromone traps, chemical reagents, and entomopathogenic fungi, as well as from screening tests for resistance in banana varieties.

Pheromone lures

A pheromone produced from the male weevil, *C. sordidus,* was first reported in 1993. Isolated and named, sordidin, the chemical has the effect of attracting adult weevils of the same species. A mass trapping system, using four traps per hectare baited with a synthesized form of the pheromone, was tested in Costa Rica and Uganda. Some of the results were very promising, indicating a 70-75% reduction in weevil damage. Using the same parameters the pheromone traps were tested in a field of 70 plants in Cameroon. The weevil population in the plot was estimated at 1200 to 1400 individuals, or 20 to 23 weevils per mat. In contrast to the trials in Costa Rica and Uganda, the traps in Cameroon caught on average only 0.4-0.5% of the population at any one time. In fact, their effectiveness was only marginally better than classical unbaited traps.

A number of reasons might account for this poor performance, and further experiments may show a significant improvement. However the suitability of this form of control for smallholder farmers is questionable because of:

- Costs of materials and shipping, (the synthetic pheromone is unlikely ever to be made available locally in Africa)
- Costs of keeping the synthetic pheromone refrigerated
- Labour requirements
- Reinfestation from neighbouring fields.

Chemical control

Several insecticides have been used against weevils, including organochlorides and

organophosphates. Their use has declined either because they were taken off the market for environmental protection or their efficacy has diminished through the development of resistance. One of the current market products is a type of pyrazol called fipronil, or under its tradename, Regent 5G. This acts on the nervous system of adult weevils. Two or three applications a year of 20-30 g of the formula are necessary for each plant. In Cameroon fipronil is the only insecticide used in large-scale plantations. Its widespread use, however, may be jeopardizing its effectiveness against weevils. The evidence from tests by the INIBAP associate scientist indicates that resistance may be mounting.

A series of comparative studies was carried out of the effects of fipronil on populations of weevils, coming from smallholders plots and industrial plantations in different geographical areas. The first results showed a significant difference between the susceptibility of populations from smallholder crops compared to those from industrial plantations (Figure 4). Whilst weevil populations from small farms in d'Ekona and Njombé showed 52% and 72% mortality respectively, weevils from large plantations in Mantem and Nyombé showed levels of mortality between 2.5% and 40%. If these results are confirmed, the need to put in place alternative forms of pest control and decrease the levels of fipronil use in industrial plantations will be imperative.

Teaming up with fungi

Biological control of weevils may be effected through the introduction of an entomopathogenic fungus which parasitizes adult weevils. Mass production of the biological agent for use by farmers can be difficult because the virulence and viability of the fungus can decline over subsequent infections. Experiments in Cameroon on *Beauveria bassiana* have illustrated how rapidly virulence can diminish. Strains of the fungus were collected from infected weevils during surveys in Cameroon. After culturing they were applied to weevil hosts as conidial suspensions at a concentration of 10^8 conidia/ml. Whilst 92% mortality of weevils was observed in the first infection cycle, by the third cycle the level of mortality had dropped to 55%. This may be explained by a drop in viability as observed in germination rates. The conclusion was made that sporulation of the fungus was inadequate and that the culture medium, V8, may be to blame.

Resisting the attack

Rapid screening methods have been carried out to analyze the resistance to weevils in more than 80 varieties of *Musa.* Greenhouse and field experiments provided an assessment of varieties growing either in isolation or in varietal mixtures. In general, plantain types display the highest susceptibility in trials. In these tests, a large variety of responses to weevil attack existed both between and within genomic groups. Notable levels of resistance were found in nearly all groups, except the plantain.

Although resistance to weevils has yet to be incorporated into a breeding programme (CRBP is the first to lay down such plans), it is thought farmers would rapidly adopt weevil-resistant varieties because of the widespread awareness of the pest and the damage causes. Planting material is in short supply and exchanges between farmers often bring infestations of weevils with them. Resistant varieties, however, provide a long-term solution to this problem and have less environmental impact than chemical or biological controls.

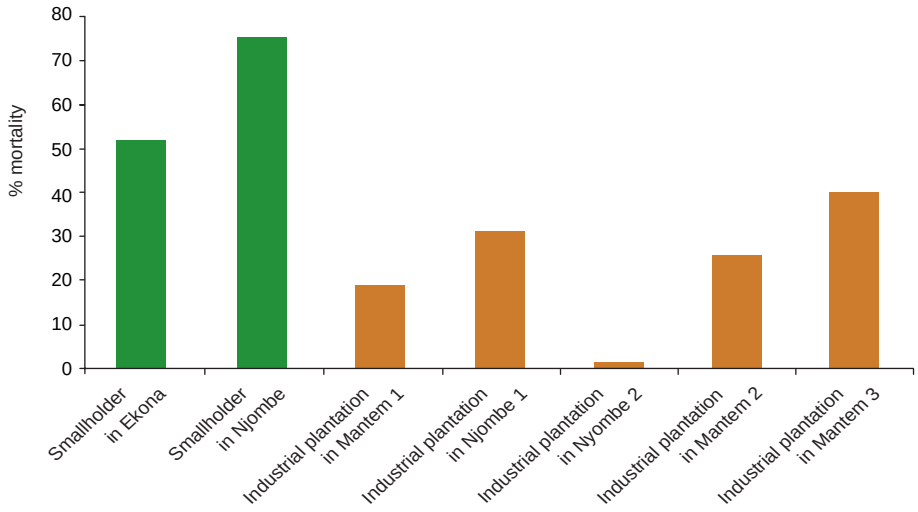


Figure 4. Evaluation of the susceptibility of seven populations of weevil to fibronil, Regent 5G.

Musa information and communications

15 years of fruitful networking

The mission of INIBAP is to bring about improvement in the production of bananas by smallholder growers. The aims and achievements of the past 15 years are measurable through progress in the work of the genebank, the release of improved varieties to farmers, the global partnerships of PRO*MUSA* and IMTP and in the building of capacity and projects in all banana-growing regions. One story that is harder to tell and difficult to measure in terms of impact is the effect of making information available.

In the course of its existence, INIBAP has produced around 300 publications and distributed about 135 000 copies of them freely around the world. Well over 4000 requests for information have been answered at the headquarters. The databases, *MUSA*LIT and BRIS, which are accessible in English, French or Spanish, have grown to become highly comprehensive reference systems for anyone wanting to identify expertise or literature in *Musa* research. Their use will be harder to estimate now that they are accessible on the Web. Nearly 7000 visits to the on-line versions of *MUSA*LIT and BRIS have been recorded since April 2000. In the pages of INFO*MUSA,* 176 articles have been published in 17 issues, around 90% of them coming from scientists in developing countries. Subscribers to the journal have risen to nearly 2000.

In one of the public awareness fact sheets we outline the experience of a Mr Buguma, who is a farmer in the village of Kiilima in the Kagera region of Tanzania. He started testing improved banana varieties in 1997 through the KCDP project, which uses germplasm from the INIBAP genebank. In 1999, at the wedding of his daughter, having benefited from improved banana yields, Mr Buguma was able to offer his guests the traditional *matooke* dish made from the fruit of the introduced variety, FHIA-01, grown on his own farm. This small success epitomizes the target of INIBAP's aims and strivings. Making information available and speeding its movement will make successes such as this possible on a wider scale.

WEAVING THE INIBAP WEB 46
THE BASIS OF DATABASES 46
PUBLICATIONS BROUGHT OUT IN 2000 46
REGIONAL INFORMATION NETWORKS 46
PUBLIC AWARENESS 47

Weaving the INIBAP Web

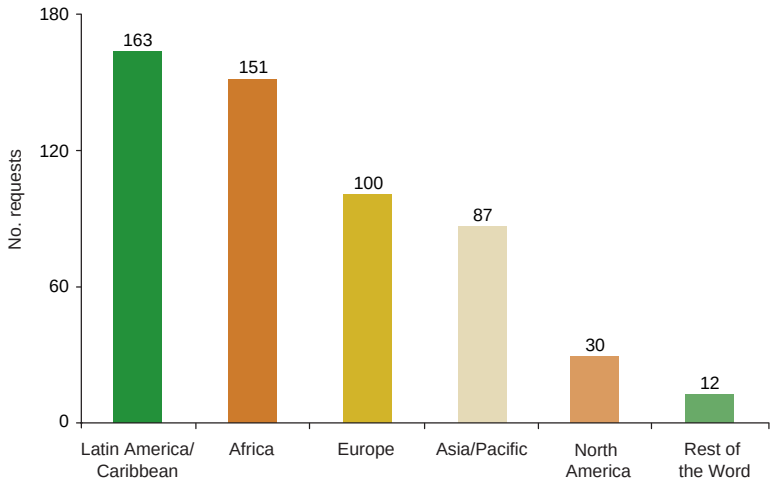
Roughly 18 000 visits were made by external users to the INIBAP Web site www.inibap.org between April and December in 2000. Somewhere between 50 and 100 visits are made daily, most of them taking more than a minute. The databases and publications have accumulated the most hits. During the year Spanish and French versions of the site were launched and new pages added featuring each of the regional networks. The INIBAP genebank site has also taken on the new look (see www.agr.kuleuven.ac.be/dtp/tro/itc.htm).

The Web site has become an incredibly useful reference tool. As well as providing access to the databases giving details of *Musa* researchers and their publications, the Internet allows users to download whole editions of INFO*MUSA*, proceedings of meetings, factsheets and other publications. The list of germplasm accessions in the INIBAP genebank is available for reference and soon the MGIS database will be on-line too. This projection of information isn't just aimed at the world outside INIBAP, but it is proving to be invaluable within the organization. To the six INIBAP offices, ten IPGRI offices, staff on travel and the dozens of project partners, the Web site is a home ground and reference point, communicating large amounts of information anywhere in the world.

The basis of databases

*MUSA*LIT, the bibliographic database, now includes 5887 bibliographic abstracts in three languages, 634 new records having been added in 2000. Up-to-date versions of both *MUSA*LIT and BRIS, the database on *Musa* researchers, were reformatted for inclusion in the second trilingual *Musa*Doc CD-ROM, which is disseminated as an alternative to the Web site including all the various publications, fact sheets and technical documents that were available in 2000. The steady rise in requests for publications, bibliographic references and information continues, individuals in Latin America and Africa accounting for a large part of the demand (Figure 1).

Figure 1. Requests received at HQ from the different regions.



Publications brought out in 2000

Publications continue to be made available in three main forms; as electronic pdf files on the Web and on CD-ROM, and in printed form. A second edition of *MUSA*DOC was pressed in October, providing access, just as the Web does, to all of the latest documents and publications but in a trilingual CD-ROM. No Internet connection is therefore necessary. *MUSA*DOC 2000 includes "Organic bananas 2000: Towards an organic banana initiative in the Caribbean", the proceedings of the meeting on the production and marketing of organic bananas by smallholder farmers held in Dominican Republic in November 1999 and "Evaluating bananas: a global partnership. Results of IMTP Phase II". More recently, the first pest factsheet on weevils has been published. *Cosmopolites sordidus* is the case study.

A number of books were published from the INIBAP office in the Asia and Pacific region, including the proceedings of four meetings. "Advancing banana and plantain R&D in Asia and the Pacific" provides the presentations of the 9th Steering Committee meeting of ASPNET in China. "Highlights of *Musa* Research and Development in Vietnam" contains the essential elements of a national symposium held in Hanoi, Vietnam, in June 2000. The findings of the regional workshop on disease management of banana and citrus through the use of disease-free planting materials held in the Philippines in 1998 were published in "Managing banana and citrus diseases". Finally the agreed taxonomy of the landmark meeting on Southeast Asian varieties was made available in a booklet called "Banana cultivar names and synonyms in Southeast Asia".

Regional information networks

Since 1991 the Latin America and Caribbean region has enjoyed their own regional *Musa* information system (S*istema de Información y Documentación sobre Banano y Plátano* - SIDBAP) housed by the Union of Banana Exporting Countries (UPEB). The system

comprises a bibliographic database, related primary documents, and an information service. It also coordinates data gathering from national centres, training, and the provision of information to the INIBAP bibliographic database. The history of SIDBAP has been somewhat chequered with periods of scarce funding and in April 2000 the agreement between its supporting bodies, IICA and UPEB, terminated, throwing its future into question.

The members of SIDBAP remain enthusiastic to keep the service going. They have worked together with INIBAP, IICA and UPEB representatives to identify the most urgent areas requiring action. The first priority is to ensure the preservation of all the primary documents, of which there are more than 12,000, whilst ensuring that they may be made freely available.

Public awareness

In its 15 years of networking INIBAP has introduced the notion that bananas are more than just a dessert fruit to many minds around the world through articles, posters, presentations and television. However in its 15th year INIBAP may have reached as many people in the one year as it has in all the previous fourteen.

At INIBAP's disposal are a number of new additions to the array of public awareness materials, including a series of 12 fact sheets with colour illustrations, 25 poster panels, and an English version of the CD-ROM 'Bananas'. All have helped to depict the aims and images of INIBAP during the various events that have taken place in the course of the year. Moving into another medium, INIBAP has embarked on a project to take video footage of some of the projects taking place in different parts of the world. The experiences of researchers, partners, students and most importantly farmers as told in a moving image will hopefully convey a very powerful message of the banana's importance in global development.

The largest audience was probably reached during the World Exposition, EXPO 2000, in Hanover, Germany. The topic of "Conservation and distribution of *Musa* germplasm from the INIBAP genebank" was selected to be included in the portfolio of 767 Projects around the World. This precipitated a surge of interest in bananas and the work of the genebank. Articles were published in the German and Belgian press, including a feature in *Lufthansa* magazine, and film footage was broadcast by *Deutsh Welle* in Germany and *Arte* in France and Germany. A Belgian day was marked, during which the Prime Minister and Prince Philippe of Belgium were briefed on the INIBAP project on display in the Belgian Pavilion. INIBAP's work was presented on the EXPO Web site, in the catalogue and CD-ROM, and also provided a point of reference in the Global Dialogue on "The role of the village in the 21st century: crops, jobs and livelihoods". The latter involved a debate and various other forms of dialogue with an invited audience of international leaders in business, politics, advocacy groups, grassroots organizations and the general public.

The conservation and distribution of banana and plantain genetic resources was included as one of the Projects around the World at EXPO 2000. (I. van den Houwe, INIBAP)

On the other side of the world an equally unique exhibition took place. The PRO*MUSA* meeting was planned so that it coincided with the ASPNET Steering Committee meeting. To mark the occasion and INIBAP's 15th anniversary the hosts in Thailand, the Department of Agricultural Extension and Naresuan University, organized a spectacular suite of events, including a competition and technology transfer session. There was a luxuriant living display of bananas and the banana products of different growers and traders, open to the public, in Queen Sikirit's conference centre in downtown Bangkok. Her

Royal Highness Maha Chakri Sirindhorn, Princess of Thailand, opened the four-day event and toured the displays, taking a marked interest in the INBAP genebank.

Finally in the seat of its headquarters in Montpellier, INIBAP enjoyed more small-scale celebrations. The staff joined together with the community of Agropolis, the group of agricultural research organizations based in Montpellier, for an afternoon of presentations on “Bananas and food security”. The event was graced by the Chairman of CGIAR’s Technological Advisory Committee (TAC), Emil Javier, who gave a keynote address, providing warm support for INIBAP’s networking philosophy. As well as representatives from Agropolis, CIRAD, the University of Montpellier and the Government of France, the eminent academic and father of banana research in France, Jean Champion, contributed to the discussions. At the same time in the Agropolis museum, the concept of biodiversity and its value to humankind was introduced to schoolchildren using bananas as a key example. INIBAP provided visual displays, different varieties of banana fruit and plants, a multimedia display and a teacher in the form of Jean-Vincent Escalant, Senior Scientist and Secretary of PRO*MUSA*. Particular impact was made by the plantains, cooked for the children during the two-hour session, which were eaten with surprised approval.

Bananas and banana products: images from the International Symposium in Thailand. (S. Sharrock, INIBAP)

The display of bananas open to the public in Queen Sikirit’s Conference Centre in Bangkok. (J.V. Escalant, INIBAP)

INIBAP publications 2000

Global publications

M. Holderness, S. Sharrock, E. Frison & M. Kairo (eds). Organic banana 2000: Towards an organic banana initiative in the Caribbean. Report of the international workshop on the production and marketing of organic bananas by smallholder farmers. 31 October-4 November 1999, Santo Domingo, Dominican Republic.

Networking banana and Plantain – INIBAP Annual Report 1999.

Bananas. English version of the booklet “Les bananes”

G. Orjeda (compil.). Evaluating bananas: a global partnership. Results of IMTP Phase II.

Regional publications

V.N. Roa & A.B. Molina (eds). Advancing banana and plantain R & D in Asia and the Pacific. Proceedings of the 9th INIBAP/ASPNET Regional Advisory Committee meeting held at South China Agricultural University, Guangzhou, China – 2-5 November 1999.

A.B. Molina, V.N. Roa, J. Bay-Petersen, A.T. Carpio & J.E.A Joven (eds). Managing banana and citrus diseases. Proceedings of a regional workshop on disease management of banana and citrus through the use of disease-free planting materials, Davao City, Philippines, 14-16 October 1998.

R.V. Valmayor, S.H. Jamaluddin, B. Silayoi, S. Kusumo, L.D. Danh, O.C. Pascua & R.R.C. Espino. Banana cultivar names and synonyms in Southeast Asia.

H.H. Nhi, A.B. Molina, I. Van den Bergh & P.T. Sen (eds). Highlights of *Musa* research and development in Vietnam. Proceedings of a meeting held in Hanoi, Vietnam on 7-8 June 2000 (co-funded with VASI, Hanoi, Vietnam and printed in Vietnam).

H.P. Singh & K.L. Chadha (eds). Banana: improvement, production and utilization. Proceedings of the Conference on challenges for banana production and utilization in 21st century (co-funded with ICAR, India and printed in India). Association for the Improvement and Utilization of Bananas (AIPUB), National Banana Research Institute (NRCB), Trichy, India.

Factsheets

C. Gold & S. Messiaen. *Musa* Pest Fact Sheet No. 4. The Banana weevil *Cosmopolites sordidus.*

C. Gold & S. Messiaen. Parasites et ravageurs des *Musa*, Fiche technique n° 4. Le charançon du bananier *Cosmopolites sordidus.*

C. Gold & S. Messiaen. Plagas de *Musa* - Hoja divulgativa No. 4. El picudo negro del banano *Cosmopolites sordidus.*

Serials

Musarama Vol. 13, No. 1 & 2 (English, French and Spanish).

Musarama Annual Indexes Vol. 13 (English, French and Spanish).

INFO*MUSA* Vol. 9, No. 1 & 2 (English, French and Spanish).

RISBAP Bulletin Vol. 4, No. 1, 2, 3 & 4.

Web pages

INIBAP web page (English, French, Spanish).

CD-ROMs

*Musa*Doc 2000

IMTP 2000

Staff presentations in 2000

Escalant J.V. Les bananes, leur origine et leur diversité. Paper presented at a workshop ‘La biodiversité expliquée aux enfants’ in the framework of a week on ‘Biodiversity/Biosecurity’ at Agropolis Museum, 11-16 December 2000.

Escalant J.V. The Global Programme for *Musa* Improvement (PRO*MUSA*): presentation, advances and results. Paper presented at the 2nd meeting of *MUSA*LAC. Cartagena de Indias, Colombia, 6-7 June 2000.

Escalant J.V. Networking banana and plantain in the 21st century. Paper presented during a visit at the Institute of Experimental Botany, Czech Republic, March 2000.

Eskes B. & *E.A. Frison*. Cocoa germplasm conservation, a global approach. Paper presented at ICCO meeting. Santo Domingo, April 2000.

Frison E.A. Accomplishments of INIBAP. Paper presented at the seminar 'Bananas and food security' organized at the occasion of INIBAP's 15th anniversar. Montpellier, 14 December 2000.

Frison E.A. Banana as a world crop. Paper presented at the Banana international symposium, Technology transfer session, Bangkok, Thailand, 7 November 2000.

Frison E.A. A new Future Harvest programme for *Musa* in Africa. Paper presented at the ICW meeting, October 2000.

Frison E.A. A Global Programme for *Musa* Improvement (PRO*MUSA*). Paper presented at the Global Forum on Agricultural Research 2000: Strengthening partnership in agricultural research for development in the context of globalization. Dresden, Germany, 21-23 May 2000.

Frison E.A., D. Despreaux & J. Waage. Towards a global programme on sustainable cocoa. Paper presented at ICCO meeting. Santo Domingo, April 2000.

Frison E.A. & H. Omont. Proposal for a global research programme for coconut "Prococos". Paper presented at the XXXVII Cocotech meeting – International coconut conference 2000. Chenniai, India, 24-28 July 2000.

Frison E.A. & H. Omont. International cooperation on commodity chains. Paper presented at the Global Forum on Agricultural Research 2000: Strengthening partnership in agricultural research for development in the context of globalization. Dresden, Germany, 21-23 May 2000.

Frison E.A. & S. Sharrock. Networking and Partnerships: a way forward for International agricultural research. Paper presented at the meeting: Sustainable agriculture in the new millennium. The impact of biotechnology on developing countries. Brussels, Belgium, 28-31 May 2000.

Molina A.B. Banana industry in the Philippines: Role of INIBAP. Invited lecturer at monthly seminar of the Dept. of Agriculture - Bureau of Agricultural Research (DA-BAR) on 11 July 2000.

Molina A.B. Concerns and opportunities of banana industry in the Cagayan Valley: Role of INIBAP-ASPNET. Guest speaker during the Cagayan Valley Agriculture and Resources Research and Development (CVARRD) consortium meeting at Nueva Vizcaya State Institute of Technology (NVSIT), Philippines, 28-29 August 2000.

Molina A.B. INIBAP activities in Asia and the Pacific: Opportunities of collaboration. Paper presented at the planning sessions of IPGRI-APO. Kuala Lumpur, Malaysia, 25-26 September 2000.

Molina A.B. Activities of INIBAP: Opportunities of developing banana industry through adoption of new varieties and superior landraces. Paper presented during a seminar at the Malaysian Agricultural Research and Development Institute (MARDI), 28 September 2000.

Molina A.B. Update on INIBAP-ASPNET operations. Paper presented at the Tenth INIBAP-ASPNET Regional advisory committee meeting. Bangkok, Thailand, 10-11 November 2000.

Panis B*., R. Swennen* & F. Engelmann. Cryopreservation of plant germplasm. Paper presented at the 4th International symposium on *in vitro* culture and horticultural breeding. Tampere, Finland, 2-7 July 2000

Pérez Hernández J.B., *R. Swennen*, V. Galán Saúco & L. Sági. *Agrobacterium*-mediated transformation for the generation of transgenic banana (*Musa* spp.). Paper presented at the 2nd International symposium on the molecular and cellular biology of banana. Byron Bay, Australia, 29 October - 3 November 2000.

Pérez Hernández J.B., *R. Swennen* & L. Sági. A novel PCR-based method for the characterization of transgene insertion in transgenic plants. Paper presented at the 2nd International symposium on the molecular and cellular biology of banana. Byron Bay, Australia, 29 October - 3 November 2000.

Picq C. Ultimos avances de la red de información de INIBAP. Paper presented at the 2nd meeting of *MUSA*LAC. Cartagena de Indias, Colombia, 6-7 June 2000.

Remans T., L. Sági, A.R. Elliott, R.G. Dietzgen, *R. Swennen*, P. Ebert, C.P.L. Grof, J.M. Manners & P.M. Schenk. Banana streak virus promoters are highly active in banana and other monocot and dicot plants. Paper presented at the 2nd International symposium on the molecular and cellular biology of banana. Byron Bay, Australia, 29 October - 3 November 2000.

Roa V.N. INIBAP InfoDoc Activities. (includes the presentation of the various INIBAP publications and a demonstration of the *Musa*Doc Cd-Rom).

Presented during PCARRD Directors' Council meeting in Los Baños on 18 April 2000, the Banana needs assessment workshop in Davao City on 23 May 2000 and monthly seminar of the Dept. of Agriculture-Bureau of Agricultural Research (DA-BAR) in Manila, Philippines on 11 July 2000.

Swennen R., S. Sharrock & E.A. Frison. Biotechnology in support of smallholders cultivating bananas in the tropics. Paper presented at the meeting: Sustainable agriculture in the new millennium. The impact of biotechnology on developing countries. Brussels, Belgium, 28-31 May 2000.

INIBAP staff publications in 2000

Blomme G. 2000. The interdependence of root and shoot development in banana (*Musa* spp.) under field conditions and the influence of different biophysical factors on this relationship. Ph.D. thesis N° 421. K.U.Leuven. Faculteit Landbouwkundige en Toegepaste Biologische Wetenschappen. Belgium. 183 pp.

Blomme G., X. Draye, G. Rufyikiri, S. Declerck, D. De Waele, A. Tenkouano & *R. Swennen*. 2000. Progress in understanding the roots of *Musa* spp. Pp. 14-19 *in* Networking Banana and Plantain: INIBAP Annual Report 1999. INIBAP, Montpellier, France.

Blomme G., R. Swennen & A. Tenkouano. 2000. Assessment of variability in the root system characteristics of banana (*Musa* spp.) according to genome group and ploidy level. INFO*MUSA* 9(2): 4-7.

Blomme G., R. Swennen, A. Tenkouano, R. Ortiz & D. Vuylsteke. 2000. Early assessment of root system development in banana and plantain (*Musa* spp.). *Mus*Africa 14:7-10.

Draye X., *R. Swennen* & B. Delvaux (*in press*). Evaluation préliminaire de la variabilité génétique pour l'architecture racinaire chez les bananiers et bananiers plantain. Annals of Botany.

Draye X., B. Delvaux & *R. Swennen*. (*in press*). Breeding for root architecture: first lessons from banana (*Musa* spp.). Molecular Physiology II: Engineering crops for hostile environments. Rothamsted, UK.

Elsen A., R. Stoffelen, *R. Swennen* & D. De Waele. *(in press*). Development of aseptic culture systems of *Radopholus similis* for *in vitro* studies. Report of the 3rd FAO/IAEA research coordination meeting on the collaborative research project on "Cellular biology and biotechnology including mutation techniques for creation of new useful banana genotypes". Colombo, Sri Lanka, 4-8 October 1999. IAEA, Vienna, Austria.

Elsen A., P.R. Speijer, R. *Swennen* & D. De Waele. (*in press*). Nematode species densities, root damage and yield of bananas (*Musa* spp.) cultivated in Uganda. African Plant Protection.

Engelborghs I., R. *Swennen* & L. Sági. 2000. Fluorescent AFLP analysis on azacytidine and gibberellin treated banana (*Musa* spp.) plants to assess differences in cytosine methylation and the mechanism of dwarfism. Med. Fac. Landbouww. Univ. Gent 65(3b):387-396.

Frison E.A. & S.L. Sharrock. 2000. The potential for use of disease-resistant varieties as organic bananas. Pp. 143-150 *in* Organic banana 2000: Towards an organic banana initiative in the Caribbean. (M. Holderness, S. Sharrock, E. Frison and M. Kairo, eds). INIBAP, Montpellier, France; CABI, Wallington, U.K.; CTA, Wageningen, The Netherlands.

Gold C. & S. *Messiaen*. *Musa* Pest Fact Sheet No. 4. The Banana weevil *Cosmopolites sordidus.*

Holderness M., S. *Sharrock, E. Frison* & M. Kairo (eds). Organic banana 2000: Towards an organic banana initiative in the Caribbean. Report of the international workshop on the production and marketing of organic bananas by smallholder farmers. 31 October-4 November 1999, Santo Domingo, Dominican Republic. INIBAP, Montpellier, France; CTA, Wageningen, The Netherlands.

Horry J.P. 2000. Status and characterization of banana genetic resources. Pp. 117-127 *in* Banana: Improvement, Production and Utilization (H.P. Singh and K.L. Chadha, eds). Proceedings of the Conference on Challenges for Banana Production and Utilization in 21st century, National Research Centre on Banana (NRCB), Trichy, India, 24-25 September 1996.

Horry J.P., S. Sharrock & E. Frison. 2000. Banana research and development: an international perspective. Pp 1-5 *in* Banana: Improvement, Production and Utilization (H.P. Singh and K.L. Chadha, eds). Proceedings of the Conference on Challenges for Banana Production and Utilization in 21st century, National Research Centre on Banana (NRCB), Trichy, India, 24-25 September 1996.

Kaemmer D., C. Neu, G. Farashahi, R.L. Jarret, A. James, R. *Swennen*, C. Pasberg-Gauhl, F. Gauhl, D. Fischer, G. Kahl & K. Weising.

(*in press*). Microsatellite markers for genome analysis in *Musa* and *Mycosphaerella*. Report of the 3rd FAO/IAEA research coordination meeting on the collaborative research project on "Cellular biology and biotechnology including mutation techniques for creation of new useful banana genotypes". Colombo, Sri Lanka, 4-8 October 1999. IAEA, Vienna, Austria.

Mbida Mindzie C., H. Doutrelepont, L. Vrydaghs, *R. Swennen*, R.J. Swennen, H. Beeckman, E. De Langhe & P. De Maret. (*in press*). First archaeological evidence of banana cultivation in central Africa during the third millenium before present. Vegetation History and Archaeobotany.

Moens T.A.S., M. Araya & D. De Waele. (*in press*). Correlation between nematode numbers and root necrosis and damage in banana (*Musa* AAA) roots under commercial production circumstances. Nematropica.

Molina A. 2000. Highlights and accomplishments of INIBAP-ASPNET 1999. Pp. 9-16 *in* Advancing banana and plantain R & D in Asia and the Pacific (A.B. Molina and V.N. Roa, eds). Proceedings of the 9th INIBAP-ASPNET Regional Advisory Committee meeting held at South China Agricultural University, Guangzhou, China, 2-5 November 1999.

Molina A.B. & V. *Roa* (eds). 2000. Advancing banana and plantain R&D in Asia and the Pacific. Proceedings of the 9th INIBAP-ASPNET Regional Advisory Committee meeting held at South China Agricultural University, Guangzhou, China, 2-5 November 1999. 154p.

Molina A.B., V.N. Roa, J. Bay-Petersen, A.T. Carpio & J.E.A Joven (eds). Managing banana and citrus diseases. Proceedings of a regional workshop on disease management of banana and citrus through the use of disease-free planting materials, Davao City, Philippines, 14-16 October 1998.

Nhi H.H., *A.B. Molina, I. Van den Bergh &* P.T. Sen (eds). Highlights of *Musa* research and development in Vietnam. Proceedings of a meeting held in Hanoi, Vietnam on 7-8 June 2000 (co-funded with VASI, Hanoi, Vietnam and printed in Vietnam).

Orjeda G. (compil.). Evaluating bananas: a global partnership. Results of IMTP Phase II.

Orjeda G. 2000. International *Musa* testing programme - a worldwide effort of *Musa* scientific community. Pp. 6-10 *in* Banana: Improvement, Production and Utilization (H.P. Singh and K.L. Chadha, eds). Proceedings of the Conference on Challenges for Banana Production and Utilization in 21st century, National Research Centre on Banana (NRCB), Trichy, India, 24-25 September 1996.

Panis B., H. Schoofs, S. Remy, L. Sági & *R. Swennen*. 2000. Cryopreservation of banana embryogenic cell suspensions: an aid for genetic transformation. Pp. 103-109 *in* Cryopreservation of tropical plant germplasm, Current research progress and applications (F. Engelmann and H. Takagi, eds). JIRCAS/IPGRI joint international workshop, Tsukuba, Japan, 20-23 October 1998.

Panis B., H. Schoofs, N.T. Thinh & *R. Swennen*. 2000. Cryopreservation of proliferating meristem cultures of banana. Pp. 238-244 *in* Cryopreservation of tropical plant germplasm, Current research progress and applications (F. Engelmann and H. Takagi, eds). JIRCAS/IPGRI Joint International Workshop, Tsukuba, Japan, 20-23 October 1998.

Panis B., N.T. Thinh & *R. Swennen*. (*in press*). Long-term conservation of banana germplasm through cryopreservation: A practical approach. International Congress of Cryobiology. Marseille, France, 12-15 July 1999. Abstract.

Remy S., L. François, A. Buyens, I. Holsbeeks, *R. Swennen*, L. Sági & B.P.A. Cammue. (*in press*). Genetic transformation of banana for disease resistance. 5th International Congress of Plant Molecular Biology. Singapore, 12-27 September 1997. Abstract.

Remy S., L. Sági, B.P.A. Cammue & *R. Swennen*. (*in press*). Genetic transformation of banana and plantain with genes coding for antifungal proteins (AFPs). Proceedings of the 12th ACORBAT Meeting. Santo Domingo, Dominican Republic, 27 October -2 November 1996. Abstract.

Sági L., S. Remy, B. Cammue, K. Maes, T. Raemaekers, B. Panis, H. Schoofs & *R. Swennen.* 2000. Production of transgenic banana and plantain. Acta Horticulturae 540:203-206.

Sági L., S. Remy, J.B. Pérez Hernández, B.P.A. Cammue & *R. Swennen*. 2000. Transgenic banana (*Musa* species). Pp. 255-268 *in* Biotechnology in Agriculture and Forestry, Transgenic Crops II. Vol. 47. (Y.P.S Bajaj, ed.). Springer, Berlin, Heidelberg, New York.

Sharrock S.L. 2000. *Musa* – eine vielseitige pflanze. Pp. 11-14 *in* Bananen. Buko Agrar Dossier 22. Schmetterling Verlag, Stuttgart, Germany.

Sharrock S.L. & C. Lusty. 2000. Nutritive value of banana. Pp. 28-31 *in* Networking Banana and

Plantain: INIBAP Annual Report 1999. INIBAP, Montpellier, France.

Speijer P.R., C. Gold, B. Goossens, *E. Karamura*, A. Elsen & D. De Waele. 2000. Rate of nematode infestation of clean banana planting material (*Musa* spp. AAA) in Uganda. Acta Horticulturae 540:461-470

Stoffelen R., R. Verlinden, J. Pinochet, *R. Swennen* & D. De Waele. 2000. Host plant response of Fusarium wilt resistant *Musa* genotypes to *Radopholus similis* and *Pratylenchus coffeae*. International Journal of Pest Management 45.

Stoffelen R., R. Verlinden, J. Pinochet, *R. Swennen* & D. De Waele. 2000. Screening of Fusarium wilt resistant bananas to root-lesion nematodes. INFO*MUSA* 9(1):6-8.

Swennen R., S. *Sharrock* & *E.A. Frison*. (*in press*). Biotechnology in support of smallholders cultivating bananas in the tropics. Sustainable Agriculture in the New Millennium. The Impact of Biotechnology on Developing Countries. Brussels, Belgium, 28-31 May 2000.

Valmayor R.V. 2000. Cooking bananas – Classification, production and utilization in Southeast Asia. INFO*MUSA* 9(1):28-30.

Valmayor R.V. 2000. Genetic resources of banana in Asia and Pacific region: present status and future strategy. Pp. 105-116 *in* Banana: Improvement, Production and Utilization (H.P. Singh and K.L. Chadha, eds). Proceedings of the Conference on Challenges for Banana Production and Utilization in 21st century, National Research Centre on Banana (NRCB), Trichy, India, 24-25 September 1996.

Valmayor R.V. 2000. Banana cultivar names and synonyms in Southeast Asia. Pp. 55-66 *in* Advancing banana and plantain R & D in Asia and the Pacific: Proceedings of the 9th INIBAP-ASPNET Regional advisory committee meeting, South China Agricultural University, Guangzhou, China, 2-5 November 1999.

Valmayor R.V., S.H. Jamaluddin, B. Silayoi, S. Kusumo, L.D. Danh, O.C. Pascua & R.R.C. Espino. Banana cultivar names and synonyms in Southeast Asia. INIBAP, Los Baños, Philippines.

Van den Bergh I., D. De Waele, N. Ho Huu, N. Dung Thi Minh, T. Nguyen Thi & T. Doan Thi. 2000. Screening of Vietnamese *Musa* germplasm for resistance and tolerance to root-knot and root-lesion nematodes in the greenhouse. INFO*MUSA* 9(1):8-11.

Van den Houwe I., B. Panis & *R. Swennen*. 2000. The *in vitro* germplasm collection at the *Musa* INIBAP Transit Centre and the importance of cryopreservation. Pp. 255-260 *in* Cryopreservation of tropical plant germplasm, Current research progress and applications (F. Engelmann and H. Takagi, eds). JIRCAS/IPGRI joint international workshop, Tsukuba, Japan, 20-23 October 1998.

Van den Houwe I. & B. Panis.2000. *In vitro* conservation of banana: medium term storage and prospects for cryopreservation. Pp. 225-257 *in* Conservation of Plant Genetic Resources *in vitro*. Vol. 2. (M.K. Razdan and E. Cocking, eds). M/S Science Publishers, U.S.A.

Van den Houwe I. & *R. Swennen*. (*in press*). Characterization and control of bacterial contaminants in *in vitro* cultures of banana (*Musa* spp.). Acta Horticulturae.

Wiame I., S. Remy, *R. Swennen* & L. Sági. 2000. Irreversible Heat Inactivation DNase I without RNA Degradation. BioTechniques 29(2):252-256.

Wiame I., *R. Swennen* & L. Sági. 2000. PCR-based cloning of candidate disease resistance genes from banana (*Musa acuminata*). Acta Horticulturae 521:51-57.

INIBAP 2000

Financial Highlights

Revenue	Research Agenda		
US $	**Unrestricted**	**Restricted**	**Total**
Australia	140	24	164
Belgium	192	926	1 118
Canada	185		185
European Union		340	340
France	166	95	261
India	25		25
Netherlands	66		66
Peru		14	14
Philippines		12	12
South Africa	30		30
Spain	40	52	92
Switzerland		1	1
Uganda		319	319
United Kingdom	61	68	129
USA	100		100
Various Asian Institutions	19		19
AfDB		27	27
CFC		2	2
CIRAD		60	60
CTA		35	35
IBRD	664		664
IDRC		63	63
Rockefeller		41	41
TBRI		25	25
UNDP		46	46
VVOB		199	199
Other Income	164		164
Total Revenues	**1 852**	**2 349**	**4 201**

As at December 31, 2000 - US$000.

Expenditures	Research Agenda		
	Unrestricted	**Restricted**	**Total**
Research Programme			
Germplasm and Breeding	532	2 225	2 757
Conferences and Training	195	61	256
Information Services	444	63	507
General Administration	479	0	479
Total Expenditures	**1 650**	**2 349**	**3 999**
Recovery of Indirect Costs	(184)	0	(184)
	1 466	2 349	3 815

As at December 31, 2000 - US$000.

Board of Trustees

Board Chair
Dr Marcio de Miranda Santos
Head of Research
Embrapa Recursos Genéticos e Biotecnologia
SAIN Parque Rural
Final W/5 Norte
70 770-901 Brasilia - DF - Brazil

Members

Prof. Thomas Cottier
Director
Institute of European
& International Economic Law
Hallerstrasse 6/9
CH-3012 Bern - Switzerland

Dr Mahmoud Duwayri
Director
AGP Division
FAO
Viale delle Terme di Caracalla
00100 Rome - Italy

Dr Geoffrey C. Hawtin
Director General
IPGRI
Via dei Tre Denari 472/a
00057 Maccarese (Fiumicino)
Rome - Italy

Dr Malcolm Hazelman
Senior Extension, Education
and Communications Officer,
FAO Regional Office for Asia and the Pacific,
Mailwan Mansion,
39 Phra Atit Road,
Bangkok, 10200 - Thailand

Prof. Marianne Lefort
Head of Plant Breeding Department
Institut National de la Recherche Agronomique
INRA-DGAP
RD 10 – Route de St Cyr
78 026 Versailles Cedex - France

Prof. Luigi Monti
Department of Agronomy
and Plant Genetics
Università di Napoli
Via dell'Università 100
80055 Portici, Napoli - Italy

Dr Masahiro Nakagahra
Director General,
Society for Techno-Innovation of Agriculture,
Forestry and Fisheries
446-1 Ippaizuka, Kamiyokoba
Ibaraki 305-0854 - Japan

Dr Gene Namkoong
P.O. Box 763
157 Early's Mountain Road
Leicester, NC 28748 - USA

Prof. Ivan Nielsen
Department of Systematic Botany
University of Aarhus
Nordlandsvey 68
8340 Risskov - Denmark

Dr Nohra Pombo De Junguito
4425 MacArthur Boulevard
Washington D.C. 20007 - USA

Dr Rene Salazar
Chair Person, Philippines
Programme Coordinating Committee
Community Biodiversity Conservation
Developemnt Programme
Quezon City - Philippines

Dr Theresa Sengooba
Senior Principal Research Officer
Namulonge Agricultural and Animal Production
Research Institute
P.O. Box 7084
Kampala - Uganda

Dr Benchaphun Shinawatra
Multiple Cropping Centre
Faculty of Agriculture
Chiang Mai University
Chiang Mai 50002 - Thailand

Staff list 2000

Name	Position	Nationality	Joined	Stationed
E.A. Frison	Director	Belgium	01-10-95	Montpellier
E. Akyeampong	Regional Coordinator WCA	Ghana	01-06-97	Cameroon
E. Arnaud	Info/Doc Specialist	France	01-10-89	Montpellier
G. Blomme	Associate Scientist, Technology Transfer	Belgium	01-01-00	Uganda
G. Boussou	Info/Doc Specialist	France	07-09-00	Montpellier
R. Bogaerts	Technician	Belgium	12-02-88	ITC, Belgium
A. Causse	Programme Assistant	France	01-11-99	Montpellier
H. Doco	Info/Com Specialist	France	15-09-98	Montpellier
C. Eledu	GIS Expert	Uganda	01-06-00	Uganda
J.V Escalant	*Musa* Genetic Resources Scientist	France	01-04-99	Montpellier
S. Faure	Senior Programme Assistant	UK	01-06-88	Montpellier
E. Gonnord	Accounting Assistant	France	17-08-98	Montpellier
C. Jonkers	Intern, Biotechnology	Belgium	19-07-99	Costa Rica
D. Karamura	*Musa* Germplasm Specialist	Uganda	01-01-00	Uganda
E. Karamura	Regional Coordinator ESA	Uganda	01-04-97	Uganda
E. Kempenaers	Research Technician	Belgium	15-10-90	ITC, Belgium
E. Lipman	Scientific Assistant	France	01-07-99	Montpellier
C. Lusty	Impact Assessment and PA Specialist	UK	05-06-00	Montpellier
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
J. Mertens	Technician	Belgium	21-10-98	Belgium
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. Moffatt	Programme Assistant	Ireland	11-10-99	Montpellier
C. Picq	Head, Information/ Communications	France	01-04-87	Montpellier
L. Pocasangre	Associate Scientist, Technology Transfer	Honduras	01-07-00	Costa Rica
G. Ponsioen	Info/Com Specialist	Netherlands	12-04-99	Montpellier
V. Roa	Programme Assistant ASP	Philippines	01-01-91	Philippines
F. Rosales	Regional Coordinator LAC	Honduras	01-04-97	Costa Rica
M. Ruas	Computer Service Assistant	France	28-02-00	Montpellier
J. Schurgers*	Intern, Biotechnology	Belgium	01-11-98	Cameroon
S.L. Sharrock	Germplasm Conservation Scientist	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
R. Valmayor	Honorary Research Fellow	Philippines	01-01-97	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

** left during the year.*
List indicates members of the INIBAP programme of IPGRI. In addition, staff within other programmes of IPGRI contributed to the INIBAP programme during 2000.

Dr Florence Wambugu
Director, Regional Office
International Service for the Acquisition
of Agri-biotech Applications
ILRI Campus
Old Naivasha Road
Kabete
Nairobi - Kenya

Acronyms and abbreviations

ACIAR	Australian Centre for International Agricultural Research
AfDB	African Development Bank
ASPNET	Asia and Pacific Regional Network, The Philippines
BA	benzyladenine
BAC	bacterial artificial chromosomes
BARNESA	Banana Research Network for Eastern and Southern Africa, Uganda
BBTV	banana bunchy top virus
BDBV	banana dieback virus
BIN	Banana Information Network, The Philippines
BNARI	Biotechnology and Nuclear Agriculture Research Institute, Ghana
BPI	Bureau of Plant Industry, the Philippines
BPI-DNCRDC	BPI-Davao National Crop Research and Development Center, the Philippines
BRIS	Banana Research Information System, INIBAP
BSV	banana streak virus
CABI	CAB International, UK
CAPS	cleaved amplified polymorphic sequences
CATIE	Centro Agronómico Tropical de Investigación y Enseñanza, Costa Rica
CFC	Common Fund for Commodities, The Netherlands
CIRAD	Centre de coopération internationale en recherche agronomique pour le développement, France.
CIRAD-FLHOR	CIRAD-Département des productions fruitières et horticoles, France
CGIAR	Consultative Group for International Agricultural Research
CMV	cucumber mosaic virus
CORBANA	Corporación Bananera Nacional, Costa Rica
CORPOICA	Corporación Colombiana de Investigación Agropecuaria, Colombia
CRBP	Centre régional de recherches sur bananiers et plantains, Cameroon
CRCTPP	Cooperative Research Center for Tropical Plant Pathology, Australia
CRI	Crop Research Institute, Ghana
CTA	Technical Centre for Rural and Agricultural Cooperation, The Netherlands
DFID	Department for International Development, UK
DGIC	Directorate General for International Cooperation, Belgium.
DNA	deoxyribonucleic acid
DPI	Department of Primary Industries, Australia
DsRNA	double-stranded ribonucleic acid
ECS	embryogenic cell suspensions
ELISA	enzyme-linked immunosorbent assay
EMBRAPA	Empresa Brasiliera de Pesquisa Agropecuaria, Brazil
FABI	Forestry and Agricultural Biotechnology Institute, South Africa
FAO	Food and Agriculture Organization of the United Nations, Italy
FFTC	Food and Fertilizer Technology Center, The Philippines
FHIA	Fundación Hondureña de Investigación Agrícola, Honduras
FORAGRO	Foro Regional de Investigación y Desarrollo Tecnológico Agropecuario para América Latina y el Caribe, Costa Rica
FUNDAGRO	Fundación para el Desarrollo Agropecuario, Ecuador
GFP	green fluorescent protein
GUS	*glucuronidase gene*
HARRDEC	Highland Agriculture and Resources Research Development Consortium, The Philippines
HRC/BARI	Horticulture Research Centre of the Bangladesh Agricultural Research Institute
IBRD	International Bank for Reconstruction and Development (USA)
ICAR	Indian Council for Agricultural Research
ICIA	Instituto Canario de Investigaciones Agrarias, Spain
IDRC	International Development Research Centre, Canada
IEB	Institute of Experimental Botany, Czech Republic
IICA	Instituto Interamericano de Cooperación para la Agricultura, Costa Rica
IITA	International Institute of Tropical Agriculture, Nigeria
IITA - ESARC	IITA - East and Southern Africa Regional Center, Uganda
IMTP	International *Musa* Testing Programme
INISAV	Instituto de Investigaciones de Sanidad Vegetal, Cuba
IPGRI	International Plant Genetic Resources Institute, Italy
IPM	integrated pest management
IPB/UPLB	Institute of Plant Breeding/UPLB, Philippines
KCDP	Kagera Community Development Programme, Tanzania
KULeuven	Katholieke Universiteit Leuven, Belgium
LACNET	Regional Network for Latin America and the Caribbean, Costa Rica
MARDI	Malaysian Agricultural Research and Development Institute
MGIS	*Musa* Germplasm Information System
MS	Murashige and Skoog medium (1962)
*MUSA*CO	*Musa* Research Network for West and Central Africa, Cameroon
*MUSA*LAC	Plantain and Banana Research and Development Network for Latin America and the Caribbean, Costa Rica
*MUSA*LIT	INIBAP bibliographic database
NARO	National Agricultural Research Organization, Uganda
NARS	National Agricultural Research Systems
NBPGR	National Board for Plant Genetic Resources, India
NGO	Non-governmental organization
NRCB	National Research Centre on Banana, India
PCARRD	Philippine Council for Agriculture, Forestry and Natural Resources Research and Development
PCR	polymerase chain reaction
PPRI	Plant Protection Research Institute, South Africa
PRO*MUSA*	Global Programme for *Musa* Improvement
QDPI	Queensland Department of Primary Industries, Australia
QUT	Queensland University of Technology, Australia
RARDC	Regional Agricultural Research and Development Centre, Sri Lanka
RISBAP	Regional Information System for Banana and Plantain in Asia and the Pacific
SCAU	South China Agricultural University
SIDBAP	Servicio de Información y Documentación sobre Banano y Plátano, Panama
SINGER	CGIAR-System-wide Information Network for Genetic Resources
SPC	Secretariat of the Pacific Community, Fiji
TAC	Technical Advisory Committee of the CGIAR
TBRI	Taiwan Banana Research Institute
TDZ	thiadiazuron
UF	University of Florida, USA
UNAN-LEON	Universidad de León, Nicaragua
UNDP	United Nations Development Programme
UPEB	Union of Banana Exporting Countries, Panama
USM	Universiti Sains Malaysia
VASI	Vietnam Agricultural Science Institute
VLIR	Vlaamse Interuniversitaire Raad, Belgium
VVOB	Vlaamse Vereniging voor Ontwikkelingsamenwerking en Technische Bijstand, Belgium

L'INIBAP en 2000

L'année 2000 a été marquée par le démarrage de nouveaux projets prometteurs et par une réflexion positive sur les événements et les évolutions survenus depuis les débuts du réseau INIBAP, il y a 15 ans. Les objectifs et les progrès de l'INIBAP se sont vus consacrés cette année par différents évènements tels que la sélection de la conservation et de la distribution des bananiers en tant que « Projet autour du monde » à l'EXPO 2000, la réunion de haut niveau de PRO*MUSA* (Programme mondial d'amélioration des *Musa*) en Thaïlande, et des avancées capitales comme le projet financé par le gouvernement ougandais pour l'amélioration des bananiers d'altitude d'Afrique de l'Est par la biotechnologie, le partenariat approfondi entre l'INIBAP et l'Institut international d'agriculture tropicale (IITA, Nigeria), et la création d'un consortium sur la génomique du bananier.

La quantité de matériel génétique distribuée par la banque de gènes de l'INIBAP s'est maintenue à un niveau élevé en 2000. Aujourd'hui, presque toutes les accessions ont été indexées pour les virus au moins une fois, et 72 % de la collection sont disponibles pour la distribution. Des protocoles de cryoconservation et d'éradication des virus ont donné de bons résultats et des recherches sur le vieillissement prématuré des cultures de tissu et leur rajeunissement ont été entreprises. A l'occasion de la troisième réunion mondiale des membres de PRO*MUSA* en Thaïlande, le Département de la vulgarisation agricole (*Department of Agricultural Extension)* et l'Université de Naresuan ont organisé une exposition et des manifestations exceptionnelles. Une réflexion élaborée sur le fonctionnement du programme mondial et de ses organes exécutifs a permis la mise en place de mesures efficaces visant à améliorer la communication au sein de chaque groupe et entre les différents groupes. Chacun des cinq groupes de travail s'est réuni pour planifier les activités communes et revoir les priorités de recherche. Le développement de recherches sur la génomique du bananier a été considéré comme une nécessité. Un nouveau consortium d'experts sur la génomique du bananier a été instauré; il sera l'un des acteurs de PRO*MUSA*.

En impulsant l'établissement de centres nationaux de multiplication et de diffusion de matériel génétique, le Réseau régional pour l'Asie et le Pacifique (ASPNET) a fortement contribué au développement et au soutien de la capacité de multiplication et de diffusion du matériel génétique afin d'éviter les goulets d'étranglement dans le processus de la mise à disposition des variétés améliorées. Dans toutes les régions, diverses activités ont contribué au développement de la lutte intégrée contre les ravageurs: formation à l'indexation des virus au Bangladesh, cours sur la production de bananes plantain en Amérique latine, projet participatif d'évaluation des options de lutte intégrée en Afrique orientale et recherches sur la lutte contre le charançon du bananier en Afrique occidentale. De nouvelles recherches sur les maladies des taches foliaires, effectuées par le Centre de coopération internationale en recherche agronomique pour le développement (Cirad, France), ont permis de retracer la progression de la cercosporiose noire en Amérique latine et l'apparition de *Septoria* en Asie.

Faits saillants des activités du programme INIBAP en 2000

Gestion du matériel génétique de bananier

La banque de gènes de l'INIBAP

Le matériel génétique disponible à la banque de gènes de l'INIBAP, localisée à l'Université catholique de Leuven (KUL, Belgique), est maintenant répertorié sur le Web à l'adresse www.inibap.org/research/itctable_fre.htm. La collection comprend à l'heure actuelle 1143 accessions. Des recherches sur les causes du vieillissement prématuré des cultures tissulaires, survenant sur une faible proportion des génotypes de la collection, ont été entreprises. Presque toutes les accessions (plus de 90 %) ont subi un dépistage complet des contaminations virales et bactériennes et 64,3 % d'entre elles sont parfaitement saines et disponibles pour la distribution.

La quantité de matériel génétique distribuée par la banque de gènes de l'INIBAP est restée importante en 2000; au total, 5791 échantillons issus de 705 accessions distinctes ont

quitté la banque de gènes dans le courant de l'année à destination de plus de 30 pays différents. Environ 85 % des accessions sont maintenus en culture depuis plus de 10 ans et ont subi plus de 10 cycles de sous-culture. Ces cultures seront rajeunies et observées au champ pour la détermination de conformité. Le Directorat général belge pour la coopération internationale (DGIC) finance une grande partie des travaux sur la gestion du matériel génétique de bananier.

L'Inde, foyer de diversité du bananier

La diversité génétique des bananiers du nord-est de l'Inde est exceptionnelle. Les sources de matériel génétique sauvage et cultivé ont été prospectées au Tripura, dans le sud de l'Assam et au Mizoram par des équipes du *National Research Centre on Banana* (NRCB, Inde). Un total de 28 accessions a été collecté. Les données de caractérisation ont été réunies pour 20 variétés et enregistrées dans le système d'information sur le matériel génétique de *Musa* (MGIS).

La conservation à long terme

Le protocole permettant la cryoconservation à long terme du matériel génétique de bananier continue à être affiné. Les expérimentations effectuées en 2000 ont porté sur la cryoconservation de deux types de matériels: les amas méristématiques en prolifération et les méristèmes apicaux issus de vitroplants enracinés. Le remplacement de 100 µM de benzyladénine (BA) par 1 µM de thidiazuron (TDZ) a permis une production plus rapide de scalps parfaits et des taux de survie supérieurs du matériel végétal après la cryoconservation. Ce résultat encourageant a ouvert la voie à la culture d'autres cultivars sur milieu TDZ.

Une procédure expérimentale basée sur l'utilisation de méristèmes apicaux issus de plantules enracinées a été étudiée en détail dans le courant de l'année 2000. Un résultat particulièrement prometteur a été obtenu en exposant le matériel à des vitesses très élevées de refroidissement et de décongélation. Jusqu'ici, seul le cultivar Williams a été testé, mais des essais supplémentaires sont de toute évidence nécessaires.

Depuis le début des recherches sur la cryoconservation des bananiers entreprises à la KUL, 42 accessions ont été placées en stockage à long terme à la banque de gènes de l'INIBAP. De plus, 224 cryotubes de suspensions cellulaires embryogéniques issues de six cultivars ont été cryoconservés dans l'azote liquide.

Recherches sur les virus du bananier

Le virus de la mosaïque en tirets du bananier (*Banana streak virus* - BSV)

Dans le cadre d'une étude commanditée par l'INIBAP, l'Université du Minnesota a découvert que la souche du BSV qui apparaît à partir de séquences intégrées activées chez les hybrides de plantain tétraploïdes se manifeste largement chez les races locales de bananiers plantain. Par conséquent, le BSV était probablement présent dans les pays où le bananier plantain était cultivé avant l'introduction des hybrides améliorés. L'identification du reste de la section de l'intégrant du BSV contenant le segment viral activable a progressé.

Un facteur de libération qui transmet la maladie durant l'hybridation a été identifié au Cirad. Sept marqueurs potentiels du virus ont été isolés par croisement interspécifique entre les variétés de *M. acuminata* et *M. balbisiana*. Ils ont été localisés sur une carte génétique du locus BSV, le marqueur le plus proche de la maladie se trouvant à côté du facteur de libération. La séquence semble être homologue à 86 % au rétrotransposon 'Monkey' identifié chez *M. acuminata*.

Eradication des virus

Les études financées par l'INIBAP en 1999 à l'Université de Gembloux (Belgique) ont permis l'éradication complète du virus du bunchy top par le développement de cultures de méristèmes. Des méthodes d'élimination du virus de la mosaïque du concombre (CMV) et du BSV des cultures de tissus sont en cours. Le traitement par la chaleur avant l'excision des méristèmes permet l'éradication du CMV à 91 %. La cryoconservation de méristèmes de type "chou-fleur" pendant une heure a éliminé le CMV de 42 % des échantillons.

Le développement de cultures de méristèmes en prolifération a permis d'obtenir un taux d'éradication virale égal ou supérieur à 50 %. Les taux obtenus pour les plants issus de méristèmes individualisés (60 %) ont été supérieurs à ceux des plants issus de bourgeons contenant plusieurs dômes méristématiques (51 %). La cryoconservation a donné de bons résultats pour l'élimination du BSV, 94 % des plants régénérés se révélant négatifs aux tests d'indexation.

Le virus du flétrissement du bananier (*Banana dieback virus* - BDBV)

L'IITA, le *Plant Protection Research Institute* (PPRI, Afrique du Sud), le *Queensland Department of Primary Industries* (QDPI, Australie) et l'INIBAP collaborent dans le cadre de recherches sur le BDBV. Des amorces identifiées contre les nepovirus ont été utilisées pour détecter le virus et des enquêtes effectuées au Nigeria ont confirmé sa distribution naturelle. Cependant, on ne connaît pas encore le vecteur de la maladie. Des bandes d'ARNdb (acide ribonucléique double brin) ont été obtenues au PPRI à partir de rejets infectés par le BDBV. Bien qu'elles semblent trop petites pour représenter une proportion significative du génome viral, elles pourront servir à générer des données de séquence, à élucider les relations entre le BDBV et d'autres virus et à mettre au point une réaction de polymérisation en chaîne (PCR) spécifique.

Caractérisation – études morphologiques et chromosomiques

Détermination du niveau de ploïdie

La caractérisation de 729 accessions issues de la banque de gènes de l'INIBAP a été confirmée par des analyses par cytométrie en flux effectuées à l'Institut de botanique expérimentale (IEB, République Tchèque). Quelque 68 accessions semblent présenter un niveau de ploïdie non confirmé par les données de l'INIBAP. L'histoire de ces variétés doit maintenant être étudiée avec attention afin de déterminer s'il s'agit réellement d'une erreur d'identification.

Le système d'information sur le matériel génétique de *Musa* (MGIS)

La base de données MGIS sur les accessions de bananiers, maintenue par l'INIBAP, s'est beaucoup étoffée en 2000 avec la préparation d'un second *Musa*logue. Cette édition du catalogue comprendra des informations concernant des variétés et des espèces représentatives de tout le genre *Musa*. Des données actualisées ont été transmises par les partenaires. On dispose ainsi pour la première fois d'informations sur les bananiers d'altitude d'Afrique de l'Est de la collection ougandaise de Kawanda et de données sur les bananiers plantain de l'IITA.

Les liens entre MGIS et la base de données SINGER (*System-wide Information Network for Genetic Resources*/Réseau d'information à l'échelle du système pour les ressources génétiques) du GCRAI (Groupe consultatif pour la recherche agricole internationale) ont été renforcés. Ces données, ainsi que celles fournies par tous les centres de '*Future Harvest*' détenant du matériel génétique en fidéicommis, permettent au réseau SINGER d'offrir, en accès

libre, l'ensemble des informations sur les ressources génétiques disponibles dans les centres du GCRAI (singer.cgiar.org).

Amélioration du matériel génétique de bananier

Les avancées de PRO*MUSA*

La réunion bisannuelle de PRO*MUSA* s'est tenue en Thaïlande. En parallèle, nos hôtes avaient organisé un Symposium international sur les bananiers, auquel étaient associés une exposition exceptionnelle et un concours de bananiers et de produits dérivés, ainsi qu'une session sur le transfert de technologie. Ces manifestations ont réuni plus de 100 membres de PRO*MUSA*. Le rôle de PRO*MUSA* et de ses organes exécutifs a été réexaminé. Il a été décidé que les facilitateurs devaient faire preuve de plus d'initiative pour encourager une meilleure communication au sein de chaque groupe et entre les différents groupes de travail, tenir des réunions et adresser des rapports d'activités aux autres groupes et au Secrétariat de façon plus régulière. Les membres des cinq groupes de travail de PRO*MUSA* se sont réunis pour discuter des résultats récents de la recherche, définir des activités communes et réexaminer les priorités de recherche.

Le groupe de travail sur la fusariose

La standardisation et l'évaluation d'un test de criblage des plantules pour la résistance à la fusariose sont des priorités majeures. Le développement d'un système de diagnostic basé sur l'ADN pour la détection et l'identification de toutes les races et souches de *Fusarium oxysporum* (*Foc*) directement à partir de la plante et du sol est également important. On espère aussi que des financements seront prochainement disponibles pour constituer une base de données recensant les isolats de *Foc* disponibles dans chacune des principales collections de culture: *CAB International* (CABI, Royaume Uni); *Department of Primary Industries* (DPI, Australie); *Forestry and Agricultural Biotechnology Institute* (FABI, Afrique du Sud); *Instituto Canario de Investigaciones Agrarias* (ICIA, Iles Canaries); *National Agricultural Research Organization* (NARO, Ouganda); *Taiwan Banana Research Institute* (TBRI, Taiwan); *University of Florida* (UF, USA) et *Universiti Sains Malaysia* (USM, Malaisie).

Le groupe de travail sur l'amélioration génétique

Les priorités de recherche du sous-groupe sur la génétique et l'amélioration ont été révisées pour inclure la mise en place d'un partenariat sur l'amélioration génétique en Asie, l'élargissement de la base génétique sur laquelle portent les efforts de sélection, et le renforcement de l'amélioration génétique des diploïdes afin de développer un nouveau stock de sélection.

Le sous-groupe sur le génie génétique a reconnu que la génomique du bananier est moins avancée que celle des autres plantes cultivées importantes. Il est absolument essentiel de travailler en collaboration et de façon coordonnée pour la mise au point de cartes physiques et génétiques. Il faut augmenter les investissements dans les études sur les bananiers portant sur la cytogénétique, l'aneuploïdie, le silençage génique et l'interaction du génome, la sélection assistée par marqueurs et l'évaluation globale du matériel génétique.

Le groupe de travail sur la nématologie

Le groupe a décidé de rassembler dans des bases de données distinctes les connaissances sur la diversité des nématodes, sur les risques de dommages et de perte au rendement que représentent les populations et sur le criblage pour la résistance. Le programme du groupe inclut également la participation à la phase III de l'IMTP et une réunion faisant suite au Congrès de nématologie en mai 2001.

Une équipe du Cirad soutenue par l'INIBAP a établi la présence de deux groupes de diversité génétique chez le nématode *Radopholus similis*. Le premier comprend les populations de Zanzibar, de l'Inde et du Sri Lanka, tandis que l'autre franchit l'Atlantique, reliant les populations du Nigeria à celles du Costa Rica. L'Union européenne finance des recherches portant sur les caractéristiques des différentes populations et sur l'effet inhibiteur des mycorhizes.

Le groupe de travail sur les cercosporioses

Les principaux domaines de recherche sur *Mycosphaerella eumusae, M. fijiensis* et *M. musicola* ont été définis; ils comprennent l'emploi de la résistance partielle et l'approfondissement des connaissances de la réponse des populations pathogènes aux nouveaux génotypes de bananiers. Un avant-projet a été rédigé et la recherche de financement est en cours. Un programme de formation à l'évaluation de la résistance aux maladies des taches foliaires se déroulera en Asie.

Le groupe de travail sur la virologie

Les recommandations suivantes ont été adoptées: l'indexation du BSV doit être effectuée de façon systématique lors de la production de cultures de tissus de bananiers AAA à usage commercial; le rôle de *Pseudoccocus* dans la transmission du BSV au champ doit être étudié dans les plus brefs délais. D'autres activités importantes ont été programmées, notamment la rédaction d'une brochure PRO*MUSA* sur les procédures actuelles de diagnostic des virus.

Nouvelles initiatives

Un schéma directeur pour la génomique du bananier doit être élaboré par le nouveau consortium d'experts en génomique du bananier. L'accent sera mis sur la recherche pré-compétitive et tous les résultats seront mis à disposition gratuitement. Le groupe sera placé sous l'égide de *PROMUSA*.

La découverte de sources de résistance génétique aux charançons et les demandes réitérées d'intégrer cet aspect dans le programme de PRO*MUSA* ont convaincu le comité de pilotage de prendre les premières mesures nécessaires à la formation d'un nouveau groupe de travail consacré aux charançons.

Les points de translocation sur les chromosomes des bananiers sont cartographiés par hybridation fluorescente *in situ*, en utilisant des sondes provenant d'une bibliothèque de chromosomes bactériens artificiels (CAB). Le projet est supervisé conjointement par l'INIBAP et le Cirad dans le cadre de la plate-forme de recherches avancées d'Agropolis, le pôle d'organismes de recherche agronomique basé à Montpellier. Le financement est assuré par le gouvernement français. La bibliothèque CAB est en cours de préparation.

Le programme international d'évaluation des *Musa* (IMTP) entre dans sa phase III

Près de trente variétés candidates, incluant de nouvelles variétés prometteuses issues du Centre régional de recherche sur bananiers et plantains (CRBP, Cameroun), de la FHIA (*Fundación Hondureña de Investigación Agrícola*, Honduras), de l'IITA, du Cirad, de l'EMBRAPA et du TBRI, sont

disponibles pour les essais en phase III de l'IMTP. Les données agronomiques et pathologiques des essais des variétés en phase II sont maintenant disponibles dans une base de données qui contient également les résultats des sites d'évaluation. L'utilisateur peut effectuer une recherche par site ou par variété et produire des fiches d'état. La base de données et l'ensemble des publications concernant l'IMTP sont rassemblés dans le Cd-Rom « IMTP 2000 ».

Amélioration par transformation génétique

Le soutien apporté à la KUL par le DGIC lui permet d'affiner ses protocoles pour la production de matériels initiaux et d'entreprendre la transformation des bananiers.

Etablissement de suspensions cellulaires embryogéniques (SCE)

Le protocole pour la production de culture de méristèmes en prolifération, optimisé en 1999, évite l'emploi prolongé de BA concentrée. Au cours de l'année 2000, le protocole a été testé sur différents types génomiques: Calcutta (AA), Kamaramasenge (AB), Williams (AAA), Igisahira gisanzwe (AAA-h), Agbagba (AAB-p) et Bluggoe (ABB). L'emploi (i) d'explants fraîchement excisés (si possible d'une taille inférieure ou égale à 5 mm) et (ii) de TDZ utilisé comme cytokinine à la place de la BA, a réduit le temps nécessaire à la préparation de quatorze mois à quatre mois.

Au total, depuis janvier 1998, 13 944 scalps issus de cultures méristématiques de 13 cultivars ont été soumis à une induction embryogénique. L'induction de scalps en masse s'est révélée efficace et la réponse embryogénique de Grande Naine a été nettement améliorée. Les trois variétés de bananier plantain testées et Mbwazirume, un bananier d'altitude, ont fourni une réponse embryogénique. Cependant, la réponse de la plupart de ces variétés reste faible. L'induction embryogénique de diploïdes sauvages et d'autres bananiers d'altitude n'a donné aucun résultat.

Les clones Grande Naine et Williams JD sont maintenant représentés sous forme de SCE bien établies mais les suspensions des bananiers plantain et de Mbwazirume sont difficiles à établir compte tenu de la faible quantité de cals embryogéniques. Obino l'Ewai et Orishele ont cependant produit des suspensions hautement régénérables. Toutes les nouvelles suspensions ont été cryoconservées et celles de Grande Naine et Williams sont utilisées à des fins de transformation. Des plantules sont aussi cultivées et leur variation somaclonale étudiée.

Transformation

Le protocole de transformation par *Agrobacterium* a été simplifié et grandement amélioré, l'expression du gène cible de l'original étant multipliée par cinq. Une expression transitoire du gène introduit (GUS, gène de la ß-glucuronidase), accrue et distribuée de façon plus uniforme, a été obtenue pour les cultivars Grande Naine, Williams et Three Hand Planty.

Recherche de promoteurs

En collaboration avec le *Cooperative Research Centre for Tropical Plant Pathology* de l'Université du Queensland (CRCTPP, Australie), deux promoteurs potentiels (fragments My et Cv) ont été identifiés et isolés à partir de deux isolats de BSV australien. Des bananiers transgéniques du cultivar Three Hand Planty, dotés du promoteur My, ont exprimé GUS avec une intensité sept fois supérieure à celle du promoteur de l'ubiquitine du maïs dans le tissu foliaire, et quatre fois supérieure dans les tissus de corme et de racine.

Il est intéressant de noter que certains plants non transformés de Three Hand Planty, issus de SCE, sembleraient déjà posséder une séquence BSV homologue à celle de certaines parties de l'isolat Cv. Les plants transformés à l'aide d'un promoteur Cv ne présentent aucune activité transgénique en raison de l'effet de silençage génique de l'interaction entre les multiples copies de Cv.

L'INIBAP à travers le monde

Amérique latine et Caraïbes

Un réseau en évolution

Le Réseau de recherche et de développement sur les bananiers et les bananiers plantain pour l'Amérique latine et les Caraïbes (*MUSA*LAC) a été établi officiellement sous les auspices du *Foro Regional de Investigación y Desarrollo Tecnológico Agropecuario para América Latina y el Caribe (*FORAGRO). L'INIBAP en assure le secrétariat. L'accord constitutionnel a été signé en juin par 14 Systèmes nationaux de recherche agricole (SNRA) et quatre organisations internationales de recherche. La première réunion a vu la constitution de quatre groupes de travail consacrés respectivement au développement socio-économique, à la lutte intégrée contre les ravageurs, à l'agronomie et à l'amélioration génétique.

Diversité génétique d'un pathogène mortel

La différentiation génétique au sein des populations de l'agent causal de la cercosporiose noire, *Mycosphaerella fijiensis,* de différentes régions d'Amérique latine et des Caraïbes, est en cours d'analyse. L'INIBAP, le CATIE (*Centro Agronómico Tropical de Investigación y Enseñanza*, Costa Rica) et le Cirad collaborent dans l'étude d'échantillons de *M. fijiensis* au Honduras, au Costa Rica, au Panama, en Colombie, à Cuba, à la Jamaïque et en République dominicaine, en utilisant comme marqueurs moléculaires huit marqueurs CAPS (*cleaved amplified polymorphic sequences*).

La diversité génétique des populations de *M. fijiensis* du Honduras et du Costa Rica étant relativement élevée, l'on peut supposer que c'est dans cette région que le pathogène a pénétré pour la première fois sur le continent. La forte différentiation génétique entre la plupart des populations indique que le flux de gènes est limité. Par ailleurs, la différenciation entre les populations des îles caraïbes est suffisamment élevée pour étayer la théorie selon laquelle le pathogène aurait pénétré en plusieurs points distincts.

Populations ségrégeantes

Dix lignées de la descendance hybride du croisement Calcutta 4 x Pisang Berlin ont été plantées et fécondées par pollinisation croisée à la *Corporación Bananera Nacional* (CORBANA, Costa Rica) en 2000. Les caractéristiques morphologiques et celles du régime divergent nettement. On cherche maintenir à obtenir des graines viables au moment de la récolte. Les signes de résistance aux nématodes et à la cercosporiose noire sont recherchés parmi ces populations.

Des variétés améliorées dans les jardins familiaux

Près de 1000 familles du Nicaragua replantent actuellement des bananiers et des bananiers plantain améliorés dans leurs jardins détruits par l'ouragan Mitch en 1998. La *Vlaamse Vereniging voor Ontwikkelingsamenwerking en Technische Bijstand* (VVOB, Belgique) finance ce projet, la KUL fournit l'assistance technique et l'INIBAP fournit le matériel génétique. La capacité du laboratoire de culture *in vitro* de l'*Universidad de León* (UNAN-León, Nicaragua) a été accrue afin de produire 20 000 plants devant être distribués en 2000. A l'heure actuelle, 750 agriculteurs ont déjà participé à des formations ou à l'évaluation des variétés.

Formation à de nouvelles pratiques de culture du bananier plantain

Sylvio Belalcázar, de la *Corporación Colombiana de Investigación Agropecuaria* (CORPOICA, Colombie), a formé 1505 personnes à la production de bananes plantain. L'INIBAP a financé directement sept des 22 cours, qui couvraient de manière détaillée les thèmes suivants: préparation du sol, préparation et traitement des cormes, distribution et plantation des rejets, désherbage et soins à apporter aux plantes, récolte et tri des fruits, reconnaissance des maladies et des ravageurs, etc.

Asie et Pacifique

Accélérer la diffusion de variétés améliorées en Asie et dans le Pacifique

Les avancées récentes de l'amélioration des bananiers ont permis de fournir au secteur public plusieurs variétés très performantes. Cependant, la capacité de production à grande échelle de matériel de plantation reste insuffisante. Les membres du comité de pilotage d'ASPNET se sont réunis durant le Premier symposium international sur les bananiers à Bangkok et ont jeté les bases d'un nouveau réseau de centres nationaux de dépôt et de distribution dans la région. Dans le cadre de ces propositions, les gouvernements participants devraient assigner à une institution la responsabilité d'acquérir, de multiplier et de distribuer le matériel génétique de bananier dans le pays.

Un système opérationnel est déjà en place en Inde. Les Philippines, la Thaïlande, le Viêt-Nam, la Malaisie, le Bangladesh et le Sri Lanka ont répondu positivement à l'accroissement de la capacité de distribution nationale. Dans le Pacifique Sud, le Secrétariat de la communauté du Pacifique (SPC) a mis en place un centre régional de matériel génétique avec l'assistance de l'INIBAP. Les résultats préliminaires des essais sur les hybrides de la FHIA sont prometteurs.

Les scientifiques du Bangladesh armés pour lutter contre cinq maladies virales

L'*Horticulture Research Centre of the Bangladesh Agricultural Research Institute* (HRC/BARI, Bangladesh) et l'INIBAP ont organisé un atelier de travail à l'intention de 52 scientifiques, enseignants et décideurs. La réunion, financée par le *Department for International Development* (DFID, Royaume Uni), a permis aux experts d'évaluer sur le terrain la gravité des maladies virales sur les bananiers dans le pays. L'un des participants à cet atelier, le Professeur H.J. Su, de l'Université nationale de Taiwan, a fourni des supports de formation et enseigné à neuf scientifiques du BARI deux techniques de détection de virus dans le matériel génétique (ELISA et indexation par PCR).

Découverte mycologique – la maladie des taches foliaires dues à *Septoria*

Grâce au financement du DFID, la présence de la maladie des taches foliaires nouvellement identifiée, causée par *Mycosphaerella eumusae* et connue sous le nom de taches foliaires dues à *Septoria*, a été confirmée dans des échantillons de feuilles de bananiers originaires du sud de l'Inde, du Sri Lanka, de Thaïlande, de Malaisie, du Viêt-Nam, de l'Ile Maurice, du Nigeria et plus récemment du Bangladesh. Le Cirad a procédé à la caractérisation morphologique. Le stade sexuel s'est révélé indiscernable de ceux des autres espèces de *Mycosphaerella.* En revanche, le stade anamorphe est très différent et procure les seuls moyens classiques d'identification du pathogène. Selon l'étude phylogénique de son ADN ribosomal, le pathogène est une espèce distincte sur l'arbre phylogénique de *Mycosphaerella.* Des outils moléculaires permettant d'identifier les pathogènes des taches foliaires vont être mis au point.

Création d'un réseau d'information sur les bananiers (BIN)

Les particuliers concernés par l'industrie bananière ont été invités à mettre en commun les données qu'ils possèdent sur tous les aspects de la production, des pratiques agronomiques jusqu'à la commercialisation, afin de créer un réseau d'information des bananiers (BIN) dans le cadre du Réseau d'information sur les produits de base du *Philippine Council for Agriculture, Forestry and Natural Resources Research and Development* (PCARRD, Philippines). Les groupes participants, qui comprennent des exportateurs, des producteurs, des chercheurs et des fournisseurs d'intrants se sont réunis en mai pour déterminer leurs besoins en information.

Populations naturelles de nématodes

Le chercheur associé à l'INIBAP, basé à l'Institut des sciences agricoles du Viêt-Nam (VASI), a effectué trois missions d'observation des nématodes dans le nord du Viêt-Nam. Le VVOB, le *Vlaamse Interuniversitaire Raad* (VLIR, Belgique) et l'*Australian Centre for International Agricultural Research* (ACIAR, Australie) ont participé au financement de ces recherches. L'espèce *Pratylenchus coffeae* s'est révélée commune à toute les zones, causant des nécroses racinaires chez la plante hôte. Les plantes infestées par *Meloidogyne* spp. présentaient des galles racinaires et une réduction du nombre de doigts du régime. Les recherches de *Radopholus similis* se sont révélées vaines, confirmant les résultats d'observations analogues sur les bananiers cultivés.

L'IITA et l'INIBAP s'associent. Les deux Centres *Future Harvest* impliqués dans la recherche-développement sur les bananiers (l'IITA et l'INIBAP en tant que programme de l'IPGRI) ont décidé récemment d'intégrer leurs activités relatives aux bananiers en Afrique. L'accord pour la mise en place d'un programme commun sur les bananiers en Afrique a été conclu lors d'une réunion tenue en Ouganda en septembre 2000.

Afrique orientale et australe

Conservation *in situ*

L'INIBAP conduit un projet participatif sur trois ans visant à rassembler les données sur les variétés de bananiers de la région des Grands Lacs, à étudier les raisons de l'érosion génétique et à appuyer leur conservation. Le Centre de recherches pour le développement international (CRDI, Canada) finance ce travail. Des enquêtes ont été effectuées sur 135 exploitations à Ibwera et Chanika en Tanzanie, et à Masaka et Bushenyi en Ouganda afin de recenser les cultivars existant actuellement ou cultivés par le passé, leurs caractéristiques les plus appréciées et leur modes de gestion et d'utilisation. Les réponses des cultivateurs suggèrent que chaque exploitation a perdu environ 20-40 % des cultivars autrefois cultivés.

Des bananiers performants

Le *Kagera Community Development Project* (KCDP, Tanzanie) et la KUL distribuent actuellement un million de plants de variétés de bananiers très performantes aux agriculteurs de la région de la Kagera en Tanzanie. La banque de gènes de l'INIBAP fournit le matériel génétique et les gouvernements belge et tanzanien financent le projet. Plus de 70 000 vitroplants seront ainsi fournis jusqu'en juillet 2001 pour être plantés sur une grande partie de la région. Sur la base de l'évaluation des variétés par les agriculteurs, la KUL ajuste le type de matériel fourni afin de satisfaire la demande enthousiaste pour les variétés FHIA-17, FHIA-23, Pelipita et SH 3436-9. A certains endroits, le rendement obtenu avec les variétés améliorées dépasse de plus d'un tiers celui des variétés cultivées localement.

Nouvelles méthodes d'amélioration des bananiers en Ouganda

Le gouvernement ougandais consacre les fonds destinés au GCRAI au développement des compétences nationales en matière de biotechnologie. Les partenaires du projet sont l'IITA, la *National Agricultural Research Organization* (NARO, Ouganda), l'Université de Makerere, le Cirad, la KUL et l'INIBAP, ce dernier étant chargé de la coordination. L'accent est mis sur l'amélioration de la production des variétés de bananiers d'altitude d'Afrique de l'Est en accroissant leur résistance à la cercosporiose noire, aux nématodes et aux charançons.

Afrique occidentale et centrale

Culture en zone urbaine

En vue de cibler spécifiquement les populations urbaines, l'INIBAP emploie les fonds alloués par le gouvernement français à l'amélioration de la production de bananiers dans quatre villes d'Afrique de l'Ouest. Les projets, initiés en 1999 à Sekondi-Takoradi et Kumasi au Ghana et à Cotonou et Abomey-Calavi au Bénin, ont pris leur plein essor en 2000. Des variétés de bananiers à cuire, dessert et plantain ont été fournies par la banque de gènes de l'INIBAP pour être multipliées au CRBP, au Cameroun, et au *Biotechnology and Nuclear Agriculture Research Institute* (BNARI), au Ghana. Des serres ont été construites dans chacune des zones à partir desquelles les plantes seront distribuées. Quatre membres du projet ont été formés aux techniques de multiplication *in vivo,* qu'ils enseigneront aux agriculteurs.

Au cœur du problème des charançons

L'expert associé de l'INIBAP basé au CRBP étudie différents mécanismes de lutte contre les charançons dans le cadre d'un plan de lutte intégrée contre les ravageurs. En 2000, les essais ont porté sur les pièges à phéromone, les agents chimiques et les champignons entomopathogènes. Des tests de criblage rapide ont aussi été entrepris sur plus de 80 variétés de *Musa* en serre et au champ. Les réponses à l'attaque des charançons varient énormément selon les groupes génomiques et à l'intérieur de chacun des groupes. De remarquables niveaux de résistance ont été découverts chez presque tous les groupes, à l'exception des bananiers plantain.

Information et communication

Le site Web de l'INIBAP s'étoffe

De mai à décembre 2000, près de 18 000 utilisateurs externes ont visité le site Web de l'INIBAP (www.inibap.org), les bases de données et les publications bénéficiant de la fréquentation la plus élevée. Le site Internet permet le téléchargement d'éditions complètes d'INFO*MUSA*, d'actes de colloques, de fiches et guides techniques et d'autres publications. La liste des accessions de matériel génétique de la banque de gènes de l'INIBAP est disponible pour référence, et la base de données MGIS sera elle aussi accessible en ligne prochainement.

Sensibilisation

L'INIBAP a touché un large public lors de l'exposition universelle, EXPO 2000, qui s'est déroulée à Hanovre en Allemagne. Le sujet 'Conservation et distribution du matériel génétique de bananiers par la banque de gènes de l'INIBAP' a été sélectionné comme l'un des 767 « Projets autour du monde ». Ceci a suscité un vif intérêt pour les bananiers et le travail de la banque de gènes et donné lieu à la publication d'articles dans les presses allemande et belge, notamment un article de fond dans le magazine de la *Lufthansa*.

Le *Department of Agricultural Extension* et l'Université de Naresuan, qui accueillaient les réunions des comités de pilotage de PRO*MUSA* et de l'ASPNET en Thaïlande, ont organisé une exposition exceptionnelle de bananiers et de produits dérivés présentés par différents cultivateurs et commerçants. L'exposition, ouverte au public au Centre de conférence de la reine Sikirit dans le centre de Bangkok, a été inaugurée par Son Altesse Royale Maha Chakri Sirindhorn.

Enfin, l'INIBAP a célébré discrètement ses 15 ans d'existence au siège de Montpellier. Le personnel de l'INIBAP et des membres de la communauté scientifique d'Agropolis se sont réunis pendant un après-midi consacré à des présentations sur le thème 'les bananiers et la sécurité alimentaire'. Le président du Comité consultatif technique (*Technical Advisory Committee*, TAC) du GCRAI, Emil Javier, a honoré la manifestation de sa présence, et exprimé dans son discours introductif son soutien enthousiaste à la philosophie de travail en réseau pratiqué par l'INIBAP.

INIBAP en 2000

El año 2000 trajo nuevas y excitantes iniciativas y reflexión positiva sobre los eventos y desarrollos que acontecieron desde que la Red de INIBAP empezó a funcionar hace 15 años. El reconocimiento de la conservación y distribución de *Musa* como "Proyecto alrededor del mundo" en la EXPO 2000, el alto perfil de la reunión de PRO*MUSA* (Programa mundial de mejoramiento de *Musa*) en Tailandia y los desarrollos claves, como el proyecto financiado por el gobierno de Uganda para mejorar los bananos de altiplano de Africa oriental a través de la biotecnología, la intensificación de la colaboración entre INIBAP y el Instituto Internacional para Agricultura Tropical (IITA, Nigeria), y la creación de un consorcio de Genómica del banano, traen con ellos la aprobación de los objetivos y el progreso de INIBAP.

Los altos niveles de distribución de germoplasma del banco genético de INIBAP continuaron creciendo en 2000. Actualmente, casi todas las accesiones han sido indizadas para detectar la presencia de los virus al menos una vez, y el 72% de la colección está disponible para la distribución. Los protocolos para la crioconservación y erradicación de los virus han logrado buenos resultados y la investigación del envejecimiento prematuro y rejuvenecimiento de los tejidos de cultivos ya ha empezado.

Un espectacular despliegue de eventos fue organizado conjuntamente por el Departamento de capacitación agrícola *(Department of Agricultural Extension*) y la Universidad Naresuan en Tailandia, en ocasión de la tercera reunión global de miembros de PRO*MUSA*. Las reflexiones sobre el funcionamiento del programa global y sus partes ejecutivas han ayudado a establecer medidas eficaces para una mejor comunicación entre y dentro de los grupos de trabajo. Cada uno de los grupos de trabajo se reunió para planificar actividades conjuntas y revisar prioridades de investigación. Hubo un fuerte apoyo a la necesidad de aumentar la investigación de la genómica de *Musa*. Se ha establecido un nuevo consorcio de expertos en genómica del banano que desempeñará un papel importante en PRO*MUSA* .

Los objetivos de desarrollar y apoyar la capacidad de multiplicar y distribuir el germoplasma con el fin de evitar los cuellos de botella en la entrega de variedades mejoradas fueron apoyados por la Red regional para Asia y el Pacífico (*Asia and Pacific Regional Network*, ASPNET), que puso en movimiento planes para establecer centros nacionales de multiplicación y distribución. Diversas actividades en todas las regiones contribuyeron al desarrollo del manejo integrado de plagas (MIP), incluyendo la capacitación sobre la indización para detectar la presencia de los virus en Bangladesh, cursos sobre la producción de plátanos en América Latina, un proyecto participativo para evaluar las opciones de MIP en Africa oriental y la investigación del control del picudo negro en Africa occidental.

Las nuevas investigaciones sobre las enfermedades de la mancha foliar realizadas por el Centro de cooperación internacional de investigación agronómica para el desarrollo (*Centre de coopération internationale en recherche agronomique pour le développement* - Cirad, Francia) han trazado el camino de la Sigatoka negra a través de América Latina y la emergencia de *Septoria* en Asia.

Momentos culminantes de las actividades de INIBAP durante 2000

Manejo del germoplasma de *Musa*

Banco genético de INIBAP

El germoplasma disponible en el banco genético de INIBAP en la *Katholieke Universiteit Leuven* (KUL, Belgium) actualmente está en la red en la siguiente dirección http://www.inibap.org/research/itctable_spa.htm. La colección de germoplasma actualmente alcanza 1143 accesiones. Se lleva a cabo la investigación para examinar las causas del envejecimiento en cultivos de tejidos, que ocurre en una pequeña proporción de los genotipos en colección. Casi todas las acciones (mas del 90 %) han completado pruebas para detectar la contaminación viral o bacteriana y el 64.3 % de la colección es totalmente sana y disponible para la distribución.

Los altos niveles de distribución de germoplasma del año 1999 se mantuvieron en el año 2000; un total de 5791 muestras de 705 accesiones diferentes salieron del banco genético en el transcurso del año para más de 30 países. Actualmente, alrededor del 85 % de las accesiones han estado en cultivo por más de 10 años y se les han practicado más de 10 ciclos de subcultivo. Estos cultivos serán rejuvenecidos y observados en el campo para determinar si siguen siendo cultivos normales. El Directorio General Belga para la Cooperación Internacional (*Directorate General for International Cooperation*, DGIC) financia una gran parte del trabajo del manejo de germoplasma de *Musa*.

Explorando el punto caliente del banano en India

El nordeste de India alberga una concentración peculiar de diversidad genética de banano. Fuentes de germoplasma silvestre y cultivada en Tripura, sur de Assam y Mizoram fueron exploradas por los equipos del Centro Nacional de Investigación de Banano (*National Research Centre on Banana*, NRCB, India). Se recolectó un total de 28 accesiones. Sin embargo, se recopilaron los datos de caracterización para 20 variedades, los cuales luego fueron ingresados en el Sistema de Información sobre el Germoplasma de *Musa* (Musa *Germplasm Information System*, MGIS).

Conservación a largo plazo

El protocolo mediante el cual el germoplasma de banano es crioconservado para el almacenamiento a largo plazo, continúa refinándose. Los experimentos en 2000 se concentraron en la crioconservación de dos materiales: meristemas proliferantes y meristemas apicales de las plántulas enraizadas *in vitro*. El uso de 1 µM de tidiazuron (TDZ) en vez de 100 µM de benziladenina (BA) causó una producción más rápida de material ideal para cortes y tasas de supervivencia del material vegetal más altas después de la crioconservación. Este descubrimiento alentador ha proporcionado nuevas fuerzas para colocar otros cultivares en el medio TDZ.

En el transcurso de 2000, se examinó ampliamente un procedimiento poco habitual que involucra el uso de meristemas apicales de las plántulas enraizadas. Se obtuvo un resultado especialmente prometedor después de exponer el material a tasas ultra altas de congelación y descongelación. Hasta la fecha, se examinó sólo el cultivar Williams pero está claro que se necesita realizar más ensayos.

Desde que empezó la investigación de crioconservación de banano en la KUL, 42 accesiones del banco genético de INIBAP han sido almacenados a largo plazo. En adición, 224 criotubos de suspensiones de células embriogénicas de seis cultivares fueron crioconservados en nitrógeno líquido.

Investigación de los virus de banano

Virus del rayado del banano (BSV)

En el transcurso de la investigación delegada por INIBAP, la Universidad de Minnesota ha descubierto que la cepa del BSV que surge de las secuencias integradas activadas en los híbridos tetraploides de plátano, ocurre ampliamente en las especies indígenas de plátano. Por lo tanto, es probable que el BSV ha estado presente en los países productores de plátano antes de la introducción de los híbridos mejorados de plátano. Se ha hecho progreso en la identificación de la sección restante del integrante del BSV que contiene el segmento viral activable.

En Cirad se ha identificado un “factor de expresión” que dispara la enfermedad durante la hibridación. Siete marcadores potenciales para el virus han sido aislados a partir de los cruzamientos interespecíficos entre variedades de *M. acuminata* y *M. balbisiana*. Ellos han sido trazados en un mapa genético del locus del BSV, donde el marcador más próximo para esta enfermedad se localiza cerca del ‘factor de expresión’. La secuencia parece ser homóloga con el retrotransposon “Monkey” identificado en *M. acuminata* en un 86 %.

Erradicación de los virus

La investigación apoyada por INIBAP realizada en 1999 por la Universidad de Gembloux (Bélgica), alcanzó un éxito de 100 % en la erradicación del virus bunchy top del banano, a través del desarrollo de los cultivos de meristemas. Continúan desarrollándose métodos para la eliminación del virus del mosaico del pepino (CMV) y BSV de los cultivos de tejidos. El tratamiento con calor del cultivo de tejidos previo a la extracción de meristemas dio como resultado un 91 % de eliminación del CMV. La crioconservación de los meristemas ‘parecidos al coliflor’, por el período de una hora eliminó la infección con el CMV en un 42 % de las muestras.

Una tasa de erradicación del virus de 50 % o más fue lograda a través del desarrollo de un cultivo de meristemas proliferantes. Las tasas fueron más altas en las plantas derivadas de los meristemas individuales (60 %), en comparación con aquellas derivadas de los brotes que contenían varios domos meristemáticos (51 %). La crioconservación dio buenos resultados para la eliminación del BSV, con un 94 % de plantas regeneradas, que resultaron sanas al examinarlas.

Virus dieback (enfermedad degenerativa) del banano (BDBV)

El IITA, el *Plant Protection Research Institute* (PPRI, Sudáfrica), el *Queensland Department of Primary Industries* (QDPI, Australia) e INIBAP están colaborando en la investigación sobre el BDBV. Se utilizaron los iniciadores contra los nepovirus para detectar el virus, y las encuestas realizadas en Nigeria, han confirmado su propagación natural. Sin embargo, el vector que transmite la enfermedad aún se desconoce. En el PPRI se obtuvieron las bandas del DsRNA (ácido ribonucléico bicatenario) a partir de los retoños infectados con el BDBV. Aunque estas bandas parecen ser muy pequeñas para representar una porción significativa del genoma del virus, ellas serán muy útiles para generar los datos de secuencias y aclarar las relaciones entre el BDBV y otros virus y para el desarrollo específico de una reacción en cadena de polimerasa (PCR).

Caracterización, estudios cromosómicos y morfológicos

Determinación de los niveles de ploidia

La caracterización de 729 accesiones del banco genético de INIBAP ha sido confirmada por los análisis mediante citometría de flujo en el *Institute of Experimental Botany* (IEB, República checa). Unas 68 accesiones parecen mostrar un nivel de ploidia que no está respaldado por los registros de INIBAP. La historia que rodea estas variedades ahora debe ser examinada cuidadosamente con el fin de determinar si hubo una verdadera equivocación en la identificación.

Sistema de Información sobre el Germoplasma de *Musa* (MGIS)

La base de datos sobre las accesiones de banano mantenida por INIBAP, MGIS, ha sido ampliamente

expandida en 2000 en el curso de la preparación de la publicación de un segundo *Musa*logue. Esta edición del catálogo abarcará las accesiones y datos relacionados de las variedades y especies representativas de todo el género *Musa*. Se obtuvo información actualizada de los socios; la información sobre los bananos de altiplano de Africa oriental de la colección de Kawanda en Uganda y los datos sobre los plátanos del IITA se ponen a disposición por primera vez.

El enlace entre las bases de datos MGIS y SINGER (Red de Información del Sistema Amplio para los Recursos Genéticos del CGIAR, *System-wide Information Network for Genetic Resources*) se fortaleció significativamente. Estos datos, conjuntamente con los datos de los Centros de *Future Harvest* que mantienen germoplasma en depósito, permiten a SINGER ofrecer un acceso gratuito a toda la información sobre los recursos genéticos disponibles dentro de la red CGIAR (visite singer.cgiar.org).

Mejoramiento del germoplasma de *Musa*

Progreso en PRO*MUSA*

La reunión bianual de PRO*MUSA* tuvo lugar en Tailandia. Paralelamente, los anfitriones organizaron un Simposio internacional sobre el banano, que incluyó una exhibición espectacular y competencia entre los bananos y sus productos, así como una sesión sobre la transferencia de tecnología. Se reunieron más de 100 miembros de PRO*MUSA*. Se revisaron los papeles que desempeñan PRO*MUSA* y sus cuerpos ejecutivos. Se decidió que los facilitadores deberían estar más activos en el fortalecimiento de la circulación de noticias e información dentro y entre los grupos de trabajo, que deberían reunirse unos con otros y con el secretariado e informar con mayor regularidad. Todos los cinco grupos de trabajo de PRO*MUSA* se reunieron para discutir los últimos descubrimientos de las investigaciones, para establecer actividades conjuntas y revisar las prioridades de investigación definidas.

Grupo de trabajo sobre el Fusarium

La normalización y evaluación de una prueba para el cribado de plántulas con el fin de determinar la resistencia al marchitamiento por Fusarium es la principal prioridad. El desarrollo de un sistema de diagnóstico basado en el ADN para la detección e identificación de todas las razas y cepas de *Fusarium oxysporum* f.sp. *cubense* (*Foc*) directamente de la planta y del suelo, es igualmente importante. También se espera que en un futuro cercano estarán disponibles los recursos para establecer una base de datos de los aislamientos de *Foc,* disponibles en cada una de las principales colecciones de este cultivo: *CAB International* (CABI, Reino Unido); *Department of Primary Industries* (DPI, Australia); *Forestry and Agricultural Biotechnology Institute* (FABI, Súdafrica); *Instituto Canario de Investigaciones Agrarias* (ICIA, Islas Canarias); *National Agricultural Research Organization* (NARO, Uganda); *Taiwan Banana Research Institute* (TBRI, Taiwan); *University of Florida* (UF, EEUU) y *Universiti Sains Malaysia* (USM, Malasia).

Grupo de trabajo sobre el mejoramiento genético

Se revisaron las prioridades de investigación del subgrupo de Mejoramiento y genética, incluyendo el establecimiento de un programa colaborativo sobre el mejoramiento genético en Asia, ampliando la base genética de los esfuerzos de mejoramiento y fortaleciendo el mejoramiento de los diploides para el desarrollo de una nueva reserva de variedades mejoradas.

El subgrupo de Ingeniería genética reconoció que los estudios de la genómica de *Musa* están retrasados en comparación con los de otros cultivos importantes. Es de máxima importancia la colaboración y coordinación en el desarrollo de los mapas genéticos y físicos. Se debe aumentar la inversión en los estudios de la citogenética de *Musa*, aneuploidia, silenciación de los genes e interacción del genoma, mejoramiento asistido por marcadores, así como la evaluación general de germoplasma.

Grupo de trabajo en nematología

El conocimiento de la diversidad de nematodos, daños y potencial de pérdida de rendimiento de las poblaciones, así como los tópicos de cribado para la detección de resistencia, serán reunidos en bases de datos separadas. También se planearon la participación en la fase III del IMTP y una reunión después del Congreso Nematológico en mayo de 2001.

Con el apoyo de INIBAP, un equipo en Cirad ha establecido la presencia de dos acervos de la diversidad genética en el nematodo *Radopholus similis*; uno cubre las poblaciones en Zanzíbar, India y Sri Lanka y el otro se extiende sobre el Atlántico y enlaza las poblaciones desde Nigeria con aquellas de Costa Rica. La Unión Europea está financiando las investigaciones sobre la naturaleza de diferentes poblaciones y el efecto inhibitorio de la micorriza.

Grupo de trabajo en Sigatoka

Se establecieron las principales áreas de investigación sobre *Mycosphaerella eumusae, M. fijiensis* y *M. musicola*, incluyendo el uso de la resistencia parcial y el desarrollo de un entendimiento de la respuesta de la población del patógeno a nuevos genotipos de banano. Se formuló una propuesta de proyecto y se busca su financiamiento. Un programa de capacitación sobre la evaluación de la resistencia a las enfermedades de las manchas foliares tendrá lugar en Asia.

Grupo de trabajo en virología

Se acordó que la indización para la detección del BSV se debe realizar habitualmente en la producción comercial de los cultivos de tejidos de los bananos AAA y que el papel de los chinches harinosos en la transmisión del BSV en el campo se debe examinar lo más pronto posible. Se planearon otras iniciativas, incluyendo un folleto de PRO*MUSA* sobre los procedimientos corrientes en el diagnóstico de los virus.

Nuevas iniciativas

Un 'plan maestro' para la genómica de *Musa* debe ser desarrollado por un consorcio de expertos en esta área, formado recientemente. El enfoque se concentrará en la investigación precompetitiva y los resultados estarán disponibles gratuitamente. El grupo formará parte del portofolio de PRO*MUSA*.

El descubrimiento de los recursos genéticos de la resistencia a los picudos negros y la demanda persistente de los picudos, que deben ponerse en la agenda de PRO*MUSA* han convencido al Comité guía para tomar pasos preliminares para formar un nuevo grupo de trabajo dedicado a los picudos negros.

Los puntos de translocación en los cromosomas de banano están siendo puestos en el mapa a través de la hibridación fluorescente *in situ*, utilizando sondas de una biblioteca de cromosomas bacterianas artificiales (*Bacterial Artificial Chromosomes* - BAC). El proyecto es supervisado conjuntamente por INIBAP y Cirad dentro de la plataforma avanzada de Agropolis, un grupo de organizaciones de investigación agrícola con base en Montpellier. El financiamiento proviene del gobierno francés. Actualmente, la biblioteca de BAC se encuentra en preparación.

El Programa Internacional de Evaluación de *Musa* (IMTP) pasa a la fase III

Cerca de 30 variedades candidatas, incluyendo nuevas variedades prometedoras del *Centre régional de recherches sur bananiers et plantains* (Centro regional de investigaciones sobre bananos y plátanos, CRBP, Camerún), FHIA, IITA, Cirad, EMBRAPA y TBRI, están disponibles para ensayos en el marco de la fase III del IMTP. Actualmente, los datos agronómicos y patológicos del ensayo de variedades en la fase II están disponibles en una base de datos. También se incluyen los resultados de los sitios donde se realizaron las evaluaciones. El usuario puede generar informes, seleccionando datos por sitio o por variedad. La base de datos, así como toda una serie de publicaciones sobre el IMTP se encuentran en el Cd-Rom "IMTP 2000".

Mejoramiento a través de transformación genética

El apoyo del DGIC permite a KUL refinar los protocolos para producir el material de iniciación y realizar la transformación de los bananos.

Establecimiento de las suspensiones de células embriogénicas (ECS)

El protocolo para la producción de los cultivos de meristemas proliferantes, optimizado en 1999, evita el prolongado uso de BA concentrado. Durante el año 2000, el protocolo fue probado en diferentes tipos genómicos de banano: Calcutta (AA), Kamaramasenge (AB), Williams (AAA), Igisahira gisanzwe (AAA-h), Agbagba (AAB-p) y Bluggoe (ABB). El uso de (1) explantes seccionados recientemente (preferiblemente con tamaño de 5 mm o menos), y (2) TDZ, en vez de BA, como una forma de citoquinina, ha disminuido el período de preparación de 14 meses, a sólo 4 meses.

Desde el mes de enero de 1998, en total, 13 944 cortes de cultivos meristemáticos de 13 cultivares han sido sometidos a la inducción de embriogénesis. La inducción *en masse* de 'scalps' ha mostrado ser exitosa y la respuesta embriogénica de Grande Naine ha mejorado de una forma marcada. Las tres variedades de plátano que participaron en los ensayos, y el Mbwazirume, un banano de altiplanos, produjeron respuestas embriogénicas. Sin embargo, las respuestas de la mayoría de estas variedades siguen siendo bajas. La inducción embriogénica del diploide silvestre y otros bananos de altiplanos no ha mostrado éxito alguno.

Actualmente, los clones Grande Naine y Williams JD se encuentran representados en ESC bien establecidas, pero las suspensiones del plátano y de Mbwazirume son difíciles de establecer, dada la pequeña cantidad de callos embriogénicos. Sin embargo, Obino l'Ewai y Orishele han producido suspensiones con un alto poder de regeneración. Todas las nuevas suspensiones han sido crioconservadas y Grande Naine y Williams están siendo utilizados para los propósitos de transformación. También las plántulas se están cultivando y examinando para detectar la variación somaclonal.

Transformación

El protocolo para la transformación mediante *Agrobacterium* ha sido simplificado y mejorado significativamente, proporcionando cinco veces la expresión del gen designado del original. Incrementada y distribuida más uniformemente, la expresión transitoria del gen introducido, ß-glucuronidase (GUS), ha sido lograda en Grande Naine, Williams y Three Hand Planty.

Investigación de promotores

Trabajando con el *Cooperative Research Centre for Tropical Plant Pathology* en la Universidad de Queensland (CRCTPP, Australia), dos promotores potenciales (fragmentos My y Cv) han sido identificados y aislados a partir de aislados del BSV australianos. El Three Hand Planty transgénico con un promotor My expresó el GUS siete veces más fuerte que el promotor de maíz ubiquitina en el tejido foliar y cuatro veces más fuerte en los tejidos de las raíces y del cormo.

Curiosamente, parece que algunas de las plantas no transformadas de Three Hand Planty, derivadas de las ECS, ya pueden contener una secuencia del BSV homóloga a las partes del aislado Cv. Las plantas transformadas con un promotor Cv pueden no mostrar cualquier actividad transgénica debido al efecto de silenciamiento de genes sobre la interacción entre las múltiples copias del Cv.

INIBAP alrededor del mundo

América Latina y el Caribe

La cara cambiante de la red

La Red de Investigación y Desarrollo de Banano y Plátano para América Latina y el Caribe (*MUSA*LAC) fue establecida formalmente bajo los auspicios del Foro Regional de Investigación y Desarrollo Tecnológico Agropecuario para América Latina y el Caribe *(*FORAGRO), donde INIBAP se desempeña como secretariado. El acuerdo constitutivo fue firmado en junio por 14 Sistemas Nacionales de Investigación Agrícola (SNIA) y cuatro organizaciones internacionales de investigación. En la primera reunión se establecieron cuatro grupos de trabajo para concentrarse en las siguientes tareas: desarrollo socioeconómico, manejo integrado de plagas, agronomía y mejoramiento genético.

Diversidad genética de un patógeno mortal

La diferenciación genética dentro de las poblaciones de Sigatoka negra procedente de diferentes partes de América Latina y del Caribe está siendo analizada. INIBAP, CATIE (Centro Agronómico Tropical de Investigacíon y Enseñanza, Costa Rica) y Cirad están colaborando en el estudio de muestras de *Mycosphaerella fijiensis* en Honduras, Costa Rica, Panamá, Colombia, Cuba, Jamaica y República Dominicana, utilizando ocho secuencias polimórficas amplificadas partidas (*cleaved amplified polymorphic sequences* - CAPS) como marcadores moleculares.

La diversidad genética en las poblaciones de Honduras y Costa Rica de *M. fijiensis* es relativamente alta, sugiriendo que el patógeno penetró por primera vez en el continente en esta área. El alto nivel de diferenciación genética entre la mayoría de la poblaciones indica que el flujo de genes esta limitado. Existe también suficiente diferenciación entre las poblaciones en las islas del Caribe para apoyar la teoría indicando que mas de una introducción tuvo lugar en esta parte del mundo.

Poblaciones segregantes

Diez líneas de la progenie híbrida del cruzamiento Calcutta 4 x Pisang Berlin fueron sembradas y polinizadas en la Corporación Bananera Nacional (CORBANA, Costa Rica) en 2000. Existe una clara divergencia entre las características morfológicas y del racimo. Actualmente, semillas viables están siendo cosechadas. Las poblaciones están siendo observadas para los signos de resistencia a los nematodos y la Sigatoka negra.

Variedades mejoradas en los patios traseros

Alrededor de 1000 familias en Nicaragua están sembrando nuevamente sus huertos caseros, destruidos por el Huracán Mitch en 1998, con bananos y plátanos mejorados. El *Vlaamse Vereniging voor Ontwikkelingsamenwerking en Technische Bijstand* (VVOB) están apoyando este proyecto, la KUL está proporcionando asistencia técnica e INIBAP está suministrando el germoplasma. La capacidad del laboratorio de cultivo de tejidos en la Universidad de León (UNAN-León, Nicaragua) ha sido ampliada para producir 20000 plantas para la distribución en 2000. Ya 750 agricultores han sido involucrados en la capacitación o evaluación de las variedades.

Cambio de las prácticas de producción de plátano

Sylvio Belalcázar de la Corporación Colombiana de Investigación Agropecuaria (CORPOICA, Colombia) enseño a más de 1505 personas en la producción de plátano. INIBAP apoyó directamente siete de 22 cursos, proporcionando una cobertura amplia de la preparación de la tierra, preparación y tratamiento de los cormos, distribución y siembra de los retoños, deshierbe y cuido de las plantas, cosecha y clasificación de la fruta, reconocimiento de plagas y enfermedades, etc.

Asia y el Pacífico

Acelerando el movimiento de variedades mejoradas en Asia y el Pacífico

Los avances en el mejoramiento de banano en años recientes han producido una cantidad de variedades de alto desempeño para el sector público. Sin embargo, la capacidad de producir la cantidad suficiente del material de siembra en gran escala es limitada. Los miembros del Comité guía de ASPNET se reunieron durante el Simposio bananero internacional en Bangkok y lanzaron sus planes para desarrollar una red de centros nacionales de depósito y distribución en la región. Bajo estas propuestas los gobiernos participantes asignarían a una institución la responsabilidad de adquirir, multiplicar y distribuir el germoplasma de banano dentro de su país.

En India ya se ha establecido un sistema de trabajo. Filipinas, Tailandia, Vietnam, Malasia, Bangladesh y Sri Lanka han respondido positivamente a construir su propia capacidad nacional. En el Pacífico Sur, el Secretariado de la Comunidad del Pacífico (SPC) ha desarrollado un Centro regional de germoplasma con asistencia de INIBAP. Los resultados preliminares de los ensayos de los híbridos de la FHIA son prometedores.

Científicos de Bangladesh armados para luchar contra las enfermedades virales

El Horticulture Research Centre del *Bengladesh Agricultural Research Institute* (HRC/BARI, Bangladesh) e INIBAP organizaron un taller para 52 investigadores, educadores y políticos. La reunión, financiada por el *Department for International Development* (DFID, Reino Unido), permitió a los expertos de campo proponer una evaluación de las enfermedades virales de banano en el país. El Prof. H.J. Su, de la Universidad Nacional de Taiwan contribuyó materiales y capacitación para nueve oficiales científicos de BARI, para que se especialicen en dos técnicas de detección de los virus en germoplasma, ensayo inmunoabsorción con enzimas ligadas (ELISA) e indización basada en PCR.

Descubrimiento del hongo - mancha foliar por Septoria

A través del financiamiento por parte del DFID, la recientemente identificada enfermedad de la mancha foliar causada por *Mycosphaerella eumusae*, conocida como mancha foliar por *Septoria*, ha sido confirmada en las muestras de las hojas de banano procedentes del sur de la India, Sri Lanka, Tailandia, Malasia, Vietnam, Mauricio, Nigeria y, más recientemente, de Bangladesh. El Cirad realizó la caracterización morfológica. Se descubrió que su etapa sexual no se distingue de otras especies de *Mycosphaerella*. Sin embargo, la etapa anamorfa es muy diferente y proporciona únicamente los medios clásicos para la identificación del patógeno. Un estudio filogenético de su ADN ribosomal clasificó el patógeno como una especie distinta en el árbol familiar de *Mycosphaerella*. Las herramientas moleculares para la identificación de los patógenos de la mancha foliar están para ser desarrollados.

Creación de una red de información sobre el banano

Los individuos con intereses en la industria bananera han sido invitados para concentrar datos en todas las áreas de producción, desde las prácticas agronómicas hasta la comercialización, para crear una Red de información bananera (*Banana Information Network*, BIN) en el marco de la Red de información sobre productos (*Commodity Information Network*) del *Philippine Council for Agriculture, Forestry and Natural Resources Research and Development* (PCARRD, Filipinas). Los grupos participantes, incluyendo a los exportadores, productores, investigadores y abastecedores de insumos se reunieron en mayo para discutir sus necesidades de información.

Nematodos en la naturaleza

El científico asociado patrocinado por INIBAP y basado en el *Vietnam Agricultural Science Institute* (VASI) realizó tres encuestas en el norte de Vietnam con respecto a los nematodos. VVOB, *Vlaamse Interuniversitaire Raad* (VLIR, Bélgica) y el *Australian Centre for International Agricultural Research* (ACIAR, Australia) ayudaron a financiar la investigación. Se descubrió que la especie *Pratylenchus coffeae* es común en todas las áreas, causando necrosis radical en la planta hospedante. *Meloidogyne* spp. infesta plantas y muestra la formación de agallas en las raíces y la reducción de la cantidad de dedos en el racimo. La búsqueda de *Radopholus similis* fue improductiva, lo que apoya los resultados de encuestas similares en bananos cultivados.

IITA e INIBAP son socios. Los dos Centros *Future Harvest* que realizan investigación y desarrollo en *Musa* (IITA e INIBAP como un programa de IPGRI) decidieron recientemente integrar sus actividades relacionadas con los bananos y plátanos en Africa. El acuerdo para establecer un programa conjunto para *Musa* en Africa fue finalizado en una reunión celebrada en Uganda en septiembre de 2000.

Africa oriental y del Sur

Conservación en finca

INIBAP está ejecutando un proyecto participativo de tres años para documentar las variedades de banano de la región de los Grandes Lagos, estudiar las razones para la erosión genética y proporcionar apoyo a la conservación. El Centro de Investigaciones Internacionales para el Desarrollo (CIID, Canada) está financiando este trabajo. Se realizaron encuestas en 135 familias en Ibwera y Chanika en Tanzania, y Masaka y Bushenyi en Uganda con el fin de establecer cuales cultivares están disponibles o han sido cultivados en el pasado, sus características preferidas y cuanto tiempo estos han sido manejados y utilizados. Las respuestas de los agricultores sugieren que cada uno ha perdido alrededor del 20-40 % de los cultivares cultivados en el pasado.

Bananos de alto rendimiento

El *Kagera Community Development Project* (KCDP, Tanzania) y la KUL están entregando un millón de plántulas de banano de variedades con alto rendimiento, a los agricultores de la región de Kagera en Tanzania. El banco genético de INIBAP está proporcionando el germoplasma y los gobiernos de Bélgica y Tanzania están financiando el proyecto. Para el mes de julio de 2001 más de 70 000 plantas *in vitro* serán suministradas para ser plantadas en los campos en una amplia área de Kagera. Siguiendo la evaluación de las variedades por parte de los agricultores, la KUL está ajustando el suministro para abastecer la anhelante demanda de las variedades FHIA-17, FHIA-23, Pelipita y SH 3436-9. En algunas áreas, el rendimiento de las variedades mejoradas supera el de las variedades existentes en más de un tercio.

Nuevas vías para mejorar bananos en Uganda

El Gobierno de Uganda está destinando el financiamiento dedicado al CGIAR en el desarrollo de la capacidad biotecnológica del país. Los socios en el proyecto son el IITA, la *National Agricultural Research Organization* de Uganda (NARO), la Universidad de Makerere, el Cirad, KUL e INIBAP que proporciona la coordinación. El enfoque se concentra específicamente en el mejoramiento de la producción de las variedades de los bananos de altiplanos de Africa Oriental perfeccionando su resistencia a la Sigatoka negra, nematodos y picudos negros.

Africa occidental y central

Cosecha citadina

En un esfuerzo de alcanzar específicamente las poblaciones urbanas, INIBAP está utilizando fondos del gobierno francés para mejorar la producción bananera en cuatro ciudades de Africa occidental. Los proyectos en Sekondi-Takoradi y Kumasi en Ghana y en Cotonou y Abomey-Calavi en Benin, se iniciaron en 1999 y llegaron a su máximo en 2000. Las variedades de los bananos de cocción, bananos de postre y plátano han sido suministradas del banco genético de INIBAP, para ser multiplicadas en el CRBP en Camerún y en el *Biotechnology and Nuclear Agriculture Research Institute* (BNARI) en Ghana. En cada área se han construido invernaderos de los cuales se distribuyen las plantas. Cuatro miembros del personal del proyecto han sido capacitados en las técnicas de multiplicación *in vivo*, las cuales ellos enseñarán a los agricultores.

Llegando al corazón del problema de los picudos negros

El experto asociado de INIBAP basado en el CRBP está evaluando diferentes mecanismos para controlar los picudos negros, como parte del plan del manejo integrado de plagas. En 2000 se obtuvieron resultados de los ensayos con trampas de feromonas, reagentes químicos y hongos entomopatogénicos. También se realizaron pruebas de cribado rápido en más de 80 variedades de *Musa* en el invernadero y en el campo. Las variedades de las pruebas, tanto dentro, como fuera de los grupos genómicos mostraron una amplia gama de respuestas a los ataques del picudo negro. Se observaron notables niveles de resistencia en casi todos los grupos, salvo el plátano.

Información y comunicaciones

Tejiendo la red de INIBAP

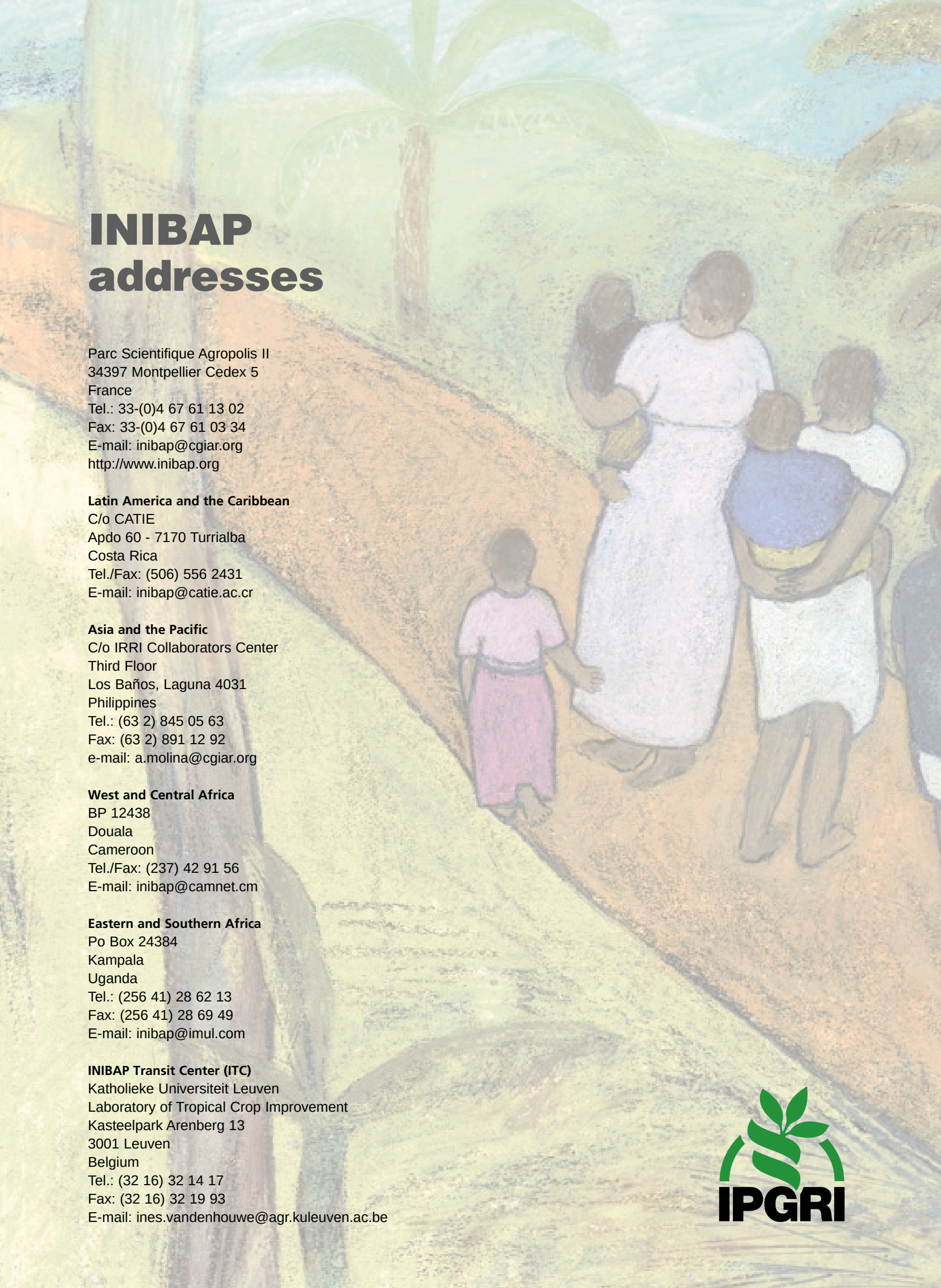
Aproximadamente 18 000 visitas fueron realizadas por usuarios externos al sitio Web de INIBAP (http://www.inibap.org) entre abril y diciembre de 2000. Las bases de datos y publicaciones han acumulado la mayoría de los puntos. La Internet permite a los usuarios bajar ediciones enteras de INFO*MUSA*, memorias de las reuniones, hojas divulgativas y otras publicaciones. El listado de las accesiones de germoplasma en el banco genético de INIBAP está disponible para referencia y pronto la base de datos MGIS también estará en línea.

Concienciación pública

INIBAP ha logrado una gran audiencia durante la Exposición Mundial, EXPO 2000, en Hanover, Alemania. El tema de conservación y distribución de germoplasma de *Musa* del banco genético de INIBAP fue seleccionado como uno de los 767 “Proyectos alrededor del Mundo “. Este hecho precipitó una oleada de interés en los bananos y en el trabajo del banco genético, así como la publicación de artículos en la prensa alemana y belga, incluyendo una publicación en la revista *Lufthansa*.

Los anfitriones de las reuniones de los comités asesores de PRO*MUSA* y ASPNET en Tailandia, el *Department of Agricultural Extension* y la Universidad de Naresuan, organizaron un despliegue espectacular en vivo de los bananos y sus productos provenientes de diferentes productores y comerciantes, abierto al público en el centro de conferencias Queen Sikirit en el centro de Bangkok. Su Alteza Real Maha Chakri Sirindhorn inauguró el evento.

Finalmente, en su sede en Montpellier, INIBAP disfrutó la celebración de su 15º aniversario. El personal se reunió con la comunidad de Agropolis, grupo de organizaciones de investigación agrícola basadas en Montpellier, para una tarde de presentaciones sobre “Bananos y seguridad alimentaria”. El evento fue agraciado por el Presidente del Comité asesor tecnológico del CGIAR (TAC), Emil Javier, quien presentó el discurso de fondo, brindando un apoyo caluroso a la filosofía de trabajo en la red de INIBAP.



INIBAP addresses

Parc Scientifique Agropolis II
34397 Montpellier Cedex 5
France
Tel.: 33-(0)4 67 61 13 02
Fax: 33-(0)4 67 61 03 34
E-mail: inibap@cgiar.org
http://www.inibap.org

Latin America and the Caribbean
C/o CATIE
Apdo 60 - 7170 Turrialba
Costa Rica
Tel./Fax: (506) 556 2431
E-mail: inibap@catie.ac.cr

Asia and the Pacific
C/o IRRI Collaborators Center
Third Floor
Los Baños, Laguna 4031
Philippines
Tel.: (63 2) 845 05 63
Fax: (63 2) 891 12 92
e-mail: a.molina@cgiar.org

West and Central Africa
BP 12438
Douala
Cameroon
Tel./Fax: (237) 42 91 56
E-mail: inibap@camnet.cm

Eastern and Southern Africa
Po Box 24384
Kampala
Uganda
Tel.: (256 41) 28 62 13
Fax: (256 41) 28 69 49
E-mail: inibap@imul.com

INIBAP Transit Center (ITC)
Katholieke Universiteit Leuven
Laboratory of Tropical Crop Improvement
Kasteelpark Arenberg 13
3001 Leuven
Belgium
Tel.: (32 16) 32 14 17
Fax: (32 16) 32 19 93
E-mail: ines.vandenhouwe@agr.kuleuven.ac.be

IPGRI