inibap

Networking Banana and Plantain

Annual Report 1995

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

INIBAP has four specific objectives:

- to organize and coordinate a global research effort on banana and plantain, aimed at the development, evaluation and dissemination of improved cultivars and at the conservation and use of *Musa* diversity;
- to promote and strengthen regional efforts to address region-specific problems and to assist national programmes within the regions to contribute towards, and benefit from, the global research effort;
- to strengthen the ability of NARS to conduct research on bananas and plantains;
- to coordinate, facilitate and support the production, collection and exchange of information and documentation related to banana and plantain.

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

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

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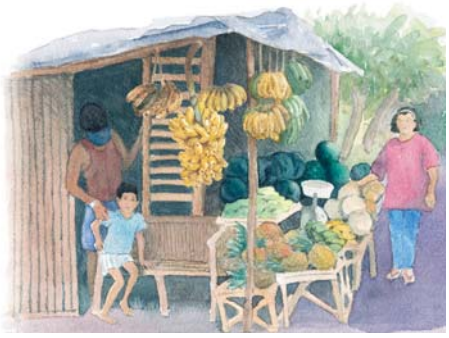


Foreword

In recent years, the international community has come to appreciate the vital importance of banana and plantain to the nutritional and economic well-being of millions of people throughout the developing world. A high-yielding source of dietary carbohydrates, rich in important vitamins and minerals, banana and plantain (often referred to collectively as Musa*, the name of the genus) are grown in some 120 countries, for the most part in gardens or on small farms. At the time of the establishment of INIBAP, which celebrated its tenth anniversary this year,* Musa *was under siege by a range of insects and diseases, in particular the destructive black Sigatoka disease.*

The spread of black Sigatoka through the Pacific and Latin America in the mid-1960s had devastating consequences for smallholder production throughout these regions. The introduction of the disease into West Africa—where plantain is a staple crop—and the need for international collaboration to improve the sustainable production of the world's fourth most economically important food commodity, were the main factors which led to the creation of INIBAP in 1985.

Collaboration is in fact the basis for all of INIBAP's operations. The INIBAP programme has drawn many of the world's Musa *research efforts together through its regional activities in Africa, Latin America and the Caribbean and Asia and the Pacific. It is this collaboration that has allowed the Network to make significant progress, in a relatively short time, towards its goal of sustainably increasing the productivity and stability of banana and plantain on smallholdings. INIBAP co-ordinates and supports research on* Musa*; works to strengthen national and regional programmes and to facilitate the exchange of materials; collects and disseminates information on* Musa*; and facilitates the training of developing country scientists and technicians.*

In many ways, 1995 was a turning point for INIBAP. This was the first full year of the Network's operation as a programme within the structure of the International Plant Genetic Resource Institutes (IPGRI). 1995 also saw the departure of Dr Nicolás Mateo who led INIBAP for three years and contributed significantly to building the Network as an important player in the global Musa *community. We would like to pay tribute to Dr Mateo for his dedication and commitment to the needs of banana and plantain smallholders world-wide.*

INIBAP prepares to enter its second decade with a renewed commitment to the goals of its founders. Future directions will emphasise a further strengthening of activities in Africa and contributing to the development of a broad-based Musa *Improvement Programme - a programme which would aim to bring together all key banana and plantain improvement efforts world-wide. In addition, recent developments in breeding and in biotechnology have opened up exciting new opportunities for* Musa *research. The INIBAP Support Group, at its October 1995 meeting, expressed its support for the Network's goals and new directions, and the Board of Trustees has expressed it strong commitment to maintaining INIBAP as a vibrant and visible programme within IPGRI.*

We are confident that INIBAP is well poised to meet the many and varied challenges that will confront small-scale banana and plantain producers over the next decade.

Geoffrey Hawtin
Director General, IPGRI

Emile Frison
Director, INIBAP

Banana and Plantain: the Earliest Fruit Crops?

Prof. Edmond De Langhe, Founding Director of INIBAP, Belgium

Historical references to banana and plantain are many and varied. The earliest written reference to banana is in Sanskrit and dates back to around 500 BC. Ancient Greek records of Alexander the Great's campaign in India of 327 BC describe bananas and the Arabs have long been familiar with the banana palm which they called by its Indian name, *pala.* The Romans also used this name and Pliny the Elder refers to *pala* in his *Natural History*. Later, in the Middle Ages, the banana was thought, by both Moslems and Christians, to be the forbidden fruit of paradise.

This led to the belief that the edible banana plant originated in continental South and Southeast Asia. However, botanical research and collecting missions carried out this century by E. Cheesman, N.W. Simmonds, Allen and others, discovered that the story was far more complex.

Domestication

The centre of origin of the wild banana stretches from India to Papua New Guinea and includes Malaysia and Indonesia. Within this area, some diploids, possibly hybrids, acquired the capacity to produce more pulp and became progressively seedless. Human intervention may have played a role in the generation of edible bananas, as reports on banana cultivation in settlements close to forests in Papua New Guinea describe seedless diploids growing in the gardens of the settlements, wild diploids growing at the edge of the forests and semi-wild variants growing in areas between the two.

Seedless edible bananas could only have reached other parts of the world via the transplantation of suckers by human beings. Therefore, the history of banana varieties is closely linked to that of human populations in the tropics. History, archaeology and anthropology can all help to interpret the history of banana cultivation.

Historical indications

The history of many popular banana cultivars is relatively simple. From about the 5th to the 15th century, and perhaps earlier, the Indian Ocean was navigated by traders from Arabia, Persia, India and Indonesia. Banana varieties from Southeast Asia, including Indonesia and India were, by this means, distributed over the coastal regions of the Indian Ocean. These varieties are a broad mixture of genomic combinations and include Red (AAA), Silk and Prata (AAB), Pisang Awak (ABB), and even AA's and AB's, and some plantains.

From the 16th to the 19th century the Portuguese and the Spaniards carried bananas all over tropical America. In fact, the name *pa-coba,* which is used in Brazil for (Horn) Plantain probably derives from the word *koba*, which is used in Sao Tomé and in the coastal zones of Southeast Africa, where that form of the name probably originated. The linking factor is clearly the Portuguese trading. Dutch, British, French and German traders also played a role in the distribution of the popular banana cultivars 'Gros Michel' and the Cavendish group to West Africa, Latin America and the Caribbean.

Beyond history

In the African continent a hundred or more different cultivars of Plantain grow deep in the rainforest. In the countries bordering the Great Lakes region in Africa, more than sixty different cultivars of the Highland Bananas - also called "Mutika/Lujugira" group, can be found (INIBAP, 1995). Cultural history and tradition point to the presence of the crop in these areas since time immemorial.

The history of the "Maia Maoli/Popoulu" group of banana in eastern Polynesia, and maybe also those on the west coast of South America and in Ecuador, is equally old.

Research has established few certainties and relies for the most part on indirect evidence which has come to light through the study of archaeology, linguistics and ethnology, plus speculation and common sense.

Maia Maoli/Popoulu

The history of the "Maia Maoli/Popoulu" group of bananas is closely tied to that of the Polynesian people. Archaeological, linguistic and genetic research on human populations in the Pacific has made much progress during the last two decades and the following general pattern of population movement has become apparent. The origin of the Austronesian-speaking people should be sought in Taiwan, many of whose inhabitants moved to the Philippines and then to eastern Indonesia, about 5500 years ago, taking their horticultural skills with them. A millennium later, one or several groups of these people navigated eastwards and established colonies along the northern coast of Papua New Guinea, in the Bismarck and Solomon islands. Approximately 2000 years ago, these people colonised the whole of Polynesia from Fiji, and may even have reached the Ecuadorian coast. These people became known as Polynesians.

During their odyssey, the Austronesians came into contact with the original inhabitants of the Philippines, Indonesia, Papua New Guinea and Melanesia, from whom they learned how to cultivate crops such as taro and banana. It is now known that Melanesians grew vegetatively propagated crops 30,000 years ago. The question of whether the Melanesians and not the proto-Polynesians were the first occupants of West Polynesia and the manufacturers of the famous Lapita pottery, is a matter of current debate.

As the 'Maia Maoli/Popoulu' cultivars, which are considered to be AAB hybrids, clearly belong to the *acuminata-balbisiana* complex, they must have been carried eastwards by the proto-Polynesians from somewhere in or near the Philippines more than 4000 years ago.

The African Highland bananas

Recent historic-linguistic studies show that banana cultivation became progressively very intensive in the Great Lakes area of Africa between the 5th and the 10th century. As Plantain does not easily grow at high altitudes the varieties that were developed must have been the AAA-Highlands bananas. The result is the existence of more than 60 cultivars which appear to be unique to this area as they have not been found anywhere else in the world. This area of secondary diversity of banana is clearly the work of East-Bantu speaking people.

Fascinating research still remains to be done to explain how these cultivars exactly came into being. Are they mutants of a basic cultivar that reached East Africa? Or did they develop within East Africa from edible diploïds, of which a few have been found eastward of the Great Lakes region, towards the Indian Ocean coast? Even a wild *acuminata* seems to exist on the island of Pemba.

The origin of the African Plantain

The existence of numerous Plantain cultivars in the middle of the African rainforest is intriguing. The plant was - and still is in some remote places - a key component of cultural life.

It has been explained elsewhere (De Langhe *et al*., 1996) that Plantain probably reached Africa more than 3000 years ago. However, the identity of the people responsible for growing Plantain during that remote age remains a mystery. They were certainly not relatives of the inhabitants of Madagascar, who reached and colonized that island at a much later date, about 1500 years ago. Neither are the ancestors of the Bantu- or Cushitic- speaking peoples likely to have been the growers.

Further research is needed on the oral traditions of the Chagga and other Highland people who tell of their ancestors finding on their arrival a forest-living "Bakinongo" people, who although hunter-gatherers also cultivated banana. It is evident, however, that once the Plantain spread to the more humid forest climates, it underwent an intensive diversification by the West-Bantu speaking people.

It is equally difficult to identify the people responsible for carrying Plantain from South and/or Southeast Asia to Africa. The earliest historical traces of a cultural contact between East Africa and India date from not more than 2000 years ago.

Is it possible that people with a limited technology could have crossed the Indian Ocean, carrying with them planting material such as plantain suckers in order to establish themselves in a new territory? Is there any evidence in South or Southeast Asia for the existence of such a people?

Such evidence does exist and can be derived partly from botanical considerations and partly from the recent progress made in understanding the prehistory of the Melanesians.

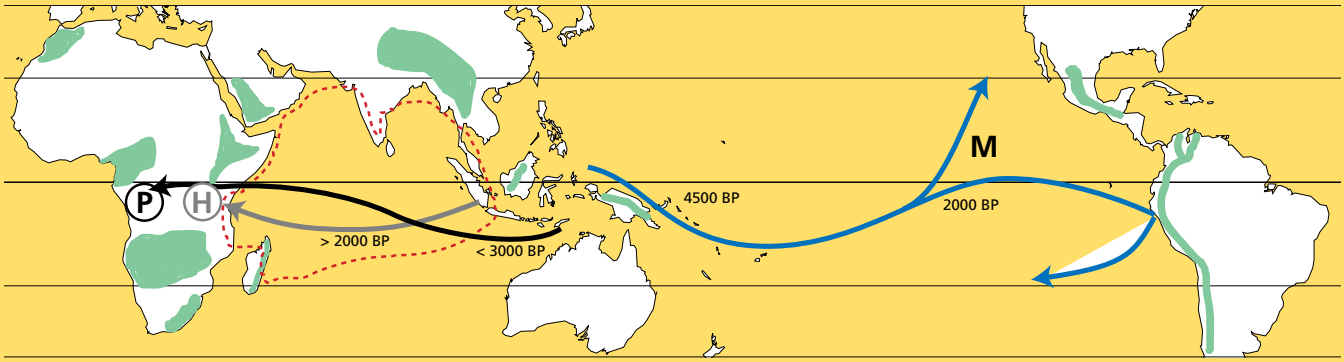
The very remote past of Plantains

Plantains are as rare in Asia as they are in East Africa. Diversity of Plantain varieties is found only in some parts of South India, and in remote areas in Luzon, in the Philippines. In the latter case, they are cultivated by the Aëta's who until recently practised itinerant agriculture.

The evidence suggests that Plantain must have been widespread at sometime in the whole of the humid tropics of South and Southeast Asia and that they have been replaced by various triploids which came into existence after Plantain but within the same huge area of origin. Many of these triploids are more robust and more resistant to drought and disease.

It is believed certain that a population of hunter-gatherers established themselves in Indonesia and Melanesia some 60,000 years ago; a people who were not afraid to navigate long distances to reach Papua New Guinea and Australia. This region is precisely the area of origin of the edible diploid banana and probably of Plantain and Maia Maoli/Popoulu as well. However, since the latter is not found in West Indonesia where Plantain was cultivated, it was probably generated at a later date than Plantain.

In all probability, this is the area where the Melanesians started itinerant agriculture by vegetatively propagating wild taro and banana, leading to the domestication of these plants. The present population of Papua New Guinea is well known for tropical agriculture which derived from the above type of agriculture.



Mountainous areas
Tentative boundaries of the Indian Ocean (banana) complex.
P Secondary Diversity Centre: Plantain
Plantain route to Africa
H Secondary Diversity Centre; African Highland Bananas
(proto-?) Highland Bananas route
M Secondary Diversity Centre: 'Maia Maoli/ Popoulu'
(proto-?) ' Maia Maoli/ Popoulu' route
< 3000 BP earlier than 3000 years before present time.

Movement of bananas through human migration

If proto-Polynesians were able to colonize islands thousands of miles to the east, then another group from the same region may have tried to use the currents of the Indian Ocean in search of new territory to the West. These people could have reached the East African coast, bringing with them and planting taro, edible diploid bananas and Plantain. As dry suckers of taro and banana plants can be preserved for several months and still keep their capacity to grow out into normal plants, the long duration of the voyage across the Indian Ocean is no objection *per se*.

Plantain, the oldest fruit crop?

Such a hypothesis fits with the finding that Plantain must have reached Africa more than 3000 years ago. However, it is unlikely that any archaeological evidence for this 'visit' by a group of navigators will ever be found.

This hypothesis also explains why the word *huti* is used to denote bananas in Melanesia, for example in the Solomon Islands, as well as by the Shamba'a and Bondei tribes, of Northeast Tanzania, for a group of bananas which includes French Plantain, found close to the coast in Northeast Tanzania, but nowhere else in Africa. The Madagascan word, *(h)ontsy* is of Austronesian origin, as is *futi* in Western Polynesia.

Even if the above hypothesis regarding the domestication of banana and plantain is accepted, and this may also apply to taro, the question still remain as to why people were interested in the vegetative propagation of the original wild relatives of banana, whose seedy fruit was inedible. Two practices may provide the key.

The corm, which is the underground part of all banana plants as well as taro, is starchy. In fact, taro is grown as a source of starch. It has been repeatedly recorded that in times of famine, the banana and plantain corms are eaten in Africa and in Asia. Moreover, the plants of the genus *Ensete*, which are morphologically very similar to those of the genus *Musa* - to which all wild and edible bananas and plantains belong - are cultivated in Ethiopia for the corm and for the starchy part of its leaves.

This would hint of a time when wild bananas were grown and propagated for their corms and not for the seedy, and therefore unattractive, fruits. Vegetative propagation may have started when the people responsible for cultivating bananas settled in areas where wild diploids were not grown nearby. They would soon have found out that suckers and buds of corms were good planting material just as with taro.

Another clue was provided forty years ago by the ethno-geographer C.O. Sauer who drew attention to the fact that some fishermen in Southeast Asia use dried banana pseudostems as fibres to weave around bamboo stems to form a type of raft, used for fishing along the coast. Vegetative propagation of bananas near the villages would have been a simple means of supplying a source for this material.

What is known is that after long millennia, vegetative propagation eventually led to fleshy and seedless fruits which became an attractive food source. This practice is also responsible for the seed sterility of many cultivars.

If the term 'crop' signifies a plant that can be grown for subsistence, then the plantain and the edible diploid bananas which originated many millennia ago may indeed have been the first fruit crop, at a time when hunting and gathering were still the main means of procuring food.

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Musa Germplasm Management

Musa germplasm collecting

Despite Viet Nam's location within the centre of genetic diversity for *Musa,* its wealth of *Musa* genetic resources has never been fully assessed or utilized. This situation is now being remedied by a project for the collecting, characterization, evaluation and conservation of *Musa* germplasm in Viet Nam. The *Institut national de sciences agronomiques* (INSA) Viet Nam submitted the proposal, which is being financed by UNDP, and is supported by INIBAP and IPGRI's Regional Office for Asia, the Pacific and Oceania.

During 1994 and 1995, five collecting missions gathered a total of 107 accessions which were deposited in two field genebanks in north and south Viet Nam. At the centres, characterization and evaluation of the material is being carried out using the standard INIBAP-IPGRI descriptor lists. Material stored at the centres will also be used to establish an *in vitro* collection at the Biotechnology Department of INSA, and duplicate material will be kept at the INIBAP genebank for safety.

In 1996, collecting activities are expected to take place in Indonesia, South China and the islands off the East African coast.

Musa germplasm conservation

The INIBAP Transit Centre (ITC), at the *Katholieke Universiteit Leuven* (KUL) in Belgium, holds the largest *in vitro* genebank of *Musa* in the world. Its role in conserving and making virus-tested tissue cultured plantlets available to users is a vital part of INIBAP's work. During 1995, the collection was supplemented with 18 new accessions originating from six sites in Latin America, Europe and Australia. These accessions consisted of 11 synthetic hybrids, two mutation breeding products, four natural *Musa* cultivars and one wild-type accession. By the end of 1995, the genebank contained 1056 *Musa* accessions and four *Ensete* clones. The germplasm is preserved under slow growth conditions.

Safety duplication

Currently, duplicates of 431 accessions, which represent 40% of the collection, are held *in vitro* at the Taiwan Banana Research Institute (TBRI) for safety reasons. The conservation of 20 replicates of each accession takes place under similar conditions to those used at ITC. COA-Executive Yuan of Taiwan is supporting the work carried out at TBRI.

The *Centro Agronómico Tropical de Investigación y Enseñanza* (CATIE) Costa Rica and the International Institute of Tropical Agriculture (IITA) Nigeria have also both agreed to INIBAP's request to store duplicate accessions. Draft agreements have been drawn up for each institute for the storage *in vitro* of approximately one third of the total collection. These agreements, which will further ensure the safety of the INIBAP collection, are expected to be finalized in 1996.

Long-term storage

Research is being carried out at KUL to develop cryopreservation protocols for the long-term storage of *Musa* germplasm; work which is supported by INIBAP. During 1994-1995, a new user-friendly cryopreservation technique for the *in vitro* conservation of *Musa* meristems was developed at KUL's Laboratory of Tropical Crop Improvement. In 1996, the duplication of the collection in long-term storage will be initiated using this technique. (See p. 12 for further details).

Research on bacterial contamination

Endogenous bacteria can cause serious problems in tissue cultures, especially those stored in *in vitro* genebanks, and can put valuable germplasm at risk. Although the decontamination method is 100% successful for fungal-contaminated cultures, it is less successful for bacterial contamination. Research continues at ITC to provide tools for early detection, control and elimination of endophytic contaminants.

Musa germplasm distribution

The *Musa* germplasm maintained in the INIBAP genebank at ITC has been assembled through donations from other genebanks, breeders and individuals, and collaborative collecting expeditions with national programmes. INIBAP holds this material "in trust" for conservation and distribution.

In October 1994, each of the CGIAR Centres signed an agreement with FAO, whereby the material held in their genebanks became part of an International Network of *Ex Situ* Collections under the auspices of FAO. As a result, the material held at ITC, which is referred to in the agreement as "designated germplasm" continues to be available to all on the understanding that it will remain in the public domain.

In line with the FAO/CGIAR Agreement, INIBAP developed a Material Transfer Agreement which became effective in November 1995. Under the terms of this agreement, shipment of material cannot take place until the institute, corporation or person ordering the material signs an agreement which contains the following three points.

- The recipient agrees not to claim ownership nor Intellectual Property Rights over germplasm or related information he/she receives.
- The recipient agrees to pass on this obligation to all future recipients of this germplasm.
- INIBAP requests the recipient to furnish data arising from research on the germplasm.

This agreement ensures that germplasm remains in the public domain and that any information acquired after the acquisition of the material is shared.

By the end of 1995, a total of 54 shipments had been made, providing 362 accessions to 42 different organizations in 36 countries worldwide. The most frequently requested accessions in 1995 were FHIA hybrids from the multilocation evaluation trials carried out during the first phase of the INIBAP International *Musa* Testing Programme (IMTP), i.e. two dessert banana types, FHIA-01 (Goldfinger) and FHIA-02, and a variety of cooking banana, FHIA-03.

In order to meet the demand for this material and to respond as quickly as possible to requests, the stock of proliferating cultures was increased. A set of 20-40 proliferating replicates of each accession is kept under normal growth conditions in addition to the 20 replicates maintained under slow growth conditions for storage.

Virus indexing

Samples of a total of 124 accessions from the *in vitro* collection were sent to the INIBAP Virus Indexing Centres (VICs), located at the *Centre de coopération internationale en recherche agronomique pour le*

INIBAP genebank review

Within the framework of the System-wide Programme on Genetic Resources of the Consultative Group on International Agricultural Research (CGIAR), the Inter-Centre Working Group on Genetic Resources recommended an external review of all the CGIAR genebanks in order to assess constraints and opportunities for the improvement of the technical, scientific and financial aspects of CGIAR genebank operations. An external panel of experts, chaired by Prof. N.L. Innes from the Scottish Crop Research Institute (SCRI), Edinburgh, UK carried out a review of INIBAP genebank operations in December.

This review offered a unique opportunity to identify areas where possible improvements could be made to the quality of services offered by the genebank. The main points assessed were:

1) General operations of the genebank
conservation facilities and regeneration/multiplication activities
germplasm viability testing
germplasm health aspects
germplasm distribution

2) General status of germplasm collections
number and quality of accessions
characterization, documentation, information
coverage of the species

3) Conservation research

4) Safety duplication

The review found the INIBAP Musa in vitro *collection to be not only an exemplary model of a genebank dealing with vegetatively propagated crops but also to be one of the most economical. The final report stated: "the panel was impressed by the close and productive links between Katholieke Universiteit Leuven (KUL), Belgium and INIBAP" and "commended INIBAP/KUL for their close collaboration with the three virus indexing centres located in France (CIRAD), Australia (QDPI) and Taiwan (TBRI)".*

développement (CIRAD), France and the Queensland Department of Primary Industries (QDPI), Australia. In 1995, the VICs released indexing results for 35 accessions. Worryingly, a large number of accessions tested (22) were found to contain virus-like particles.

By the end of 1995, 456 accessions representing 43% of the genebank, were virus tested. No virus pathogens were detected in 87% of the accessions but 13% were found to carry viruses. The virus-free accessions were made available for distribution. However, since a relatively large number of valuable accessions held in the genebank appear to be virus infected, the development of reliable therapeutic methods is a priority for INIBAP. Research will be carried out on this at the University of Gembloux, Belgium and at KUL.

To increase INIBAP's indexing capacity, a third virus indexing centre was established in 1995 at TBRI Taiwan.

Revision of the *Technical Guidelines for the Safe Movement of* Musa *Germplasm*

In June 1995, a meeting was held jointly by FAO and IPGRI to update the *Technical Guidelines for the Safe Movement of* Musa *Germplasm*. The meeting was attended by *Musa* virologists Dr Hughes of IITA; Dr Lockhart of the University of Minnesota, USA; Ms Magnaye of the Bureau of Plant Industry (BPI), Philippines; Dr Dale of the Queensland University of Technology (QUT), Australia; Dr Kummert of the University of Gembloux, Belgium; Dr Su of the National Taiwan University; Dr Thomas of QDPI Australia and by the Officer in Charge of ITC, Ir Van den Houwe. Drs Diekmann, Frison and Jones of IPGRI and Dr Putter of FAO hosted the meeting. The subjects of *Musa* viruses and indexing tests were discussed at the meeting and new recommendations were made. These closely follow current protocols used at INIBAP-VICs but some modification of present procedures were recommended and these are given below.

- The five plantlets sent from the ITC to the VICs for virus indexing should be selected from seven and not 20 cultures derived from the original shoot-tip, in order to lessen the risk of the plants being unrepresentative of the health status of the original accession. The remaining two cultures should be multiplied to obtain 20 cultures to be maintained under slow-growth conditions at the ITC.
- In view of the increased confidence in the reliability of tests to detect virus pathogens, the indexing period at VICs can be reduced from the present nine to 12 months to six months, with indexing taking place after three and six months growth.
- Accessions, even those coming from countries with banana bunchy top virus (BBTV), will be indexed at one VIC only and not two as previously recommended. This is because of increased confidence in the reliability of BBTV indexing tests.
- New antisera for banana bract mosaic virus (BBMV), developed by Dr Caruana of CIRAD and Dr Thomas of QDPI, will be routinely utilized at VICs in the near future, together with a wide spectrum antiserum for detecting banana streak virus (BSV) by immunosorbent electron microscopy, developed by Dr Lockhart. Partially purified leaf sap will still need to be examined by electron microscopy to detect particles of uncharacterized viruses.
- Germplasm will be tested for all viruses according to the protocols specified in the new guidelines. However, in some instances tests may be wavered if there is strong reliable evidence that particular viruses are not present in the country of origin of the germplasm.

The recommendations will be published early in 1996 in a new issue of the technical guidelines.

Inoculation of banana reference genotypes with banana bunchy top virus at the Laboratory of Plant Pathology, Gembloux, Belgium.

***Modifications in the* Technical guidelines for the Safe Movement of *Musa* Germplasm**

	Guidelines 1988	Guidelines 1995
Number of cultures from which material for indexing originates	20	7
Number of plantlets sent to VICs	5	5
Further multiplication	10 or 15 —> 20	2 —> 20
Indexing period	12 months	6 months
Indexing to be carried out at	1 or 2 VICs	1 VIC
BBTV	VO1	VO2 ELISA
CMV	VO1 Inoculation of indicator plants	VO2 EM ELISA
BSV	VO1	VO2 EM ISEM ELISA
BBMV	VO1	VO2 ISEM ELISA
Uncharacterized viruses		VO2 EM

Key: *VO1: visual observation weekly until eight-leaf stage; VO2: visual observation after three and six months' growth; EM: electron microscopy of partially purified preparation; ELISA: when antisera is available and protocol developed; ISEM: immunosorbent electron microscopy*

Research supported by INIBAP

Cryopreservation

R. Swennen, B. Panis and H. Schoofs, Katholieke Universiteit Leuven, Belgium

During the year, successful cryopreservation protocols were established for both embryogenic cell suspensions and meristem cultures.

The initiation of embryogenic cells, the material used for genetic engineering, is still difficult and time consuming. Once initiated it is of utmost importance to store this material under secure conditions, for example in liquid nitrogen. However, in view of the need to conserve the large number and diversity of accessions contained in a germplasm collection, this system is less practical.

In 1995, a simple cryopreservation technique for proliferating in vitro Musa *meristems was developed at the Laboratory of Tropical Crop Improvement, KUL. This improved technique can be used for a wide variety of* Musa *accessions.*

The optimal protocol involves the following procedures.

1) *Proliferating meristems are cultured on Murashige and Skoog medium containing 10^{-4} M BAP (N6-benzylaminopurine) and 10^{-6} M IAA (indole-3-acetic acid). This high BAP concentration is needed to suppress the outgrowth of meristems and thereby favours the formation of numerous white apical domes (See figure).*
2) *Clumps of 4 mm are excised and transferred to the normal proliferation medium (containing 10^{-5} M BAP and 10^{-6} M IAA) supplemented with 0.4 M sucrose.*
3) *After three weeks, surviving clumps containing three to six meristems are excised, transferred to a 2 ml cryotube and directly plunged into liquid nitrogen.*
4) *After storage, the material is thawed rapidly for 1.5 minutes in a stirred water bath of 40°C.*
5) *The thawed meristematic clumps are removed from the cryotube and transferred to a Petri dish containing the normal proliferation medium.*
6) *After one week of culture in the dark at 25°C, the Petri dishes are exposed to an illumination of 50 $\mu Em^{-2}s^{-1}$ at the same temperature.*
7) *Recovering clumps are transferred eight weeks after freezing to a regeneration medium containing 10^{-6} M BAP and 10^{-6} M IAA.*

To date, 12 cultivars belonging to different genomic groups have been screened for their reaction towards this freezing protocol. This has resulted in post-thaw viability rates ranging between 12.1 and 67.2%, depending on the cultivar. A limiting factor is the poor tolerance of many banana cultivars to high sucrose levels, resulting in a limited amount of healthy material for cryopreservation, after preculture. Efforts are being made to overcome this by using sugars other than sucrose. Several parameters are also under investigation in order to further increase post-thaw survival rates.

Identification and characterization of viruses associated with BBTV

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This research project investigated the hypothesis that more than one viral agent is present in BBTV-infected plants. Using polyvalent detection methods (dsRNA

Proliferation of Musa *meristems on Murashige and Skoog medium containing 10^{-4} M BAP and 10^{-6} M of IAA.*
a: Agbagba (AAB plantain); b: Kisubi (AB group); c and d : two different accessions of Williams (AAA group).

extraction, anti-dsRNA antibodies, PCR with degenerate primers and electronic microscopy) the project has been unable to find any evidence of the existence of another agent associated with the banana bunchy top DNA virus in BBTV-infected plants.

In 1995, activities focused on improving the sensitivity and reliability of BBTV diagnostic tests, on the characterization of BBTV isolates and on the evaluation of banana reference genotypes for resistance/tolerance to BBTV.

Detection of BBTV

Research at Gembloux confirmed the results by Hafner et al. *(1995) regarding the presence of BBTV in roots. High levels of BBTV were serologically detectable in roots of all tested genotypes, either in plants maintained in greenhouses or in micropropagated plantlets. Root tissues give rise to the largest differences between absorbency values obtained with BBTV-infected tissues and the healthy control, although differences varied according to the genotype.*

For routine tests of large numbers of samples, ELISA is more convenient and practical than PCR which is limited by the template preparation protocol. Several simple protocols which reduce interference from plant substances were compared for the preparation of large numbers of plant samples for PCR application. Immunocapture PCR (IC-PCR) was the most sensitive assay, allowing the detection of ≤ 0.003 mg partially purified virus particles per ml (Table 1). PCR was 100 times more sensitive than ELISA but was hampered by interference from plant components (especially the root extracts). PCR and IC-PCR techniques would be aided by rapid and simple methods for evaluating test results avoiding electrophoresis.

PCR-based detection techniques will benefit virus elimination programmes by facilitating the analysis of small amounts of tissue generated in meristem cultured plants and in large-scale testing of inventories from clean stock programmes. However, the small sample volume used for the PCR analysis limits the sensitivity of the technique in terms of the minimal concentration detectable; IC-PCR allows much higher sample volumes (100 µl) to be analyzed (Wetzel et al., *1992). It is therefore recommended to use the IC-PCR method to assess the elimination of BBTV in protocols for virus-free plant production. This assay is 100 times more sensitive than ELISA when performed on the crude extract of leaves and the sample preparation appears to be suitable for routine tests. In the case of serological variation of*

Table 1. Detection limits (mg particles/ml) of ELISA, PCR and IC/PCR assays performed on partially purified BBTV reparations diluted in extraction buffer, healthy leaf crude extract or healthy root crude extract.

	ELISA	PCR	IC-PCR
Extraction buffer	2	≤ 0.03	≤ 0.003
Leaves crude extract	2	0.6	0.03
Roots crude extract	1 .5	no detection	0.006

Table 2. Inoculation of banana reference genotypes with the Congolese isolate of BBTV. Inoculations were performed with 10 viruliferous aphids maintained for three days on plantlets. After treatment with nicotine, plantlets were maintained in a culture room at 26±2°C, 16 h light photoperiod and high humidity level for eight weeks.

Name	1st inoculation		2nd inoculation		3rd inoculation		4th inoculation		Overall % of diseased plants	mNLIS (plant leaves)
	I	D	I	D	I	D	I	D		
M. *acuminata* ssp. *zebrina*	20	9	10	Obs					45	4.6
M. *acuminata* ssp. *banksii*	16	16	10	Obs					100	3.5
Gros Michel	4	Obs								
Lacatan	14	4	6	5	7	3			44	3.8
Petite Naine	27	6	10	Obs					22	4.3
Igitsiri (Intutu)	23	2	10	Obs					9	
Figue Pomme	2	Obs								
Géante										
Foconah	11	2	7	0	10	Obs			11	
Popoulou (CMR)	15	14	10	Obs					93	2.4
Pisang Rajah Bulu	7	4	14	10	13	9			68	3.3
Rajapuri India	2	2								
Njombe N°2	12	9	8	3					60	3.1
N'jock Kon	3	2	6	4	6	3	7	2	50	3.1
3 Vert	8	5	13	Obs					62	3.8
Big Ebanga	8	7	3	0	14	Obs				4.3
3 Hands Planty	8	1	4	3	6	2			33	3.8
Dole	2	Obs								
Lep Chang Kut	2	0	1	Obs						
Grande Naine	8	6	10	4	14	Obs			56	3.7
Yangambi Km5	5	3	5	0	10	Obs			30	

I = Number of inoculated plantlets.
D = Number of plantlets exhibiting BBTV symptoms.
Obs = Plantlets in observation.
mNLIS = Mean number of emerged leaves from inoculation to first BBTV symptoms.

the BBTV isolates, PCR without immunocapture is useful but requires a nucleic acids extraction step.

Study of collected BBTV isolates

During the two first years of the project, BBTV infected plants were received from a number of different countries. PCR analysis performed with sequence-specific primers to amplify fragments from BBTV DNA component 1 and component 3, demonstrated the presence of these two components in all isolates of BBTV maintained in the laboratory. It was found that a PCR assay using primer combination B-GA is a convenient tool for assigning BBTV isolates to the Asian group of isolates defined by Karan et al. *(1994).*

The DNA component 1 derived fragments of a symptomless BBTV isolate on cv. Kamaramasenge 1 from Burundi presented a less than genome-length viral DNA. The genome deletion is located along the ORF sequence between primers B and A1. The occurrence of viral DNA forms of less than genome-length has been described in geminiviruses with laboratory-maintained isolates and also in natural conditions for Beet Curly Top Geminivirus (Stenger, 1995).

Inoculation of Banana Reference Genotypes with BBTV

In collaboration with ITC, the collection of banana reference genotypes, which includes both cultivated and wild bananas, is being assessed for resistance/tolerance to BBTV. In 1994, five proliferating tissue cultures of 29 reference accessions were provided by ITC.

The vector was infected by a Congolese isolate of BBTV. Banana plantlets with two to five leaves were inoculated giving infection rates of close to 100% when 20 or more infectious aphids were maintained for three days on the plantlets. To bring to the fore any possible differences between genotypes in terms of infection rate, inoculations were also carried out with 10 aphids per plantlet.

The following observations were made (Table 2):

- *A large variability in the infection rate.*
- *The latent period was evaluated by two linked parameters: the mean interval time to observe the symptoms (mTIS) or the mean number of emerged leaves before the observation of the first BBTV symptoms (mNLIS). As the mTIS parameter depends on the growing conditions, the mNLIS parameters were preferred.*
- *Infected plants of the genotypes Popoulou, N'jonck Kon, Lacatan, Grande Naine,* M. acuminata *ssp.* zebrina *and* M. acuminata *ssp.* banksii *were inoculated simultaneously and ELISA testing was carried out on the last leaf and on the roots, to detect possible differences in virus content. No significant differences were noted.*

The inoculation protocol needs to be further improved in order to decrease the variability of genotype response to infection. Genotypes seem to show some variability concerning two parameters (infection rate and mNLIS) which could potentially slow down the development of a BBTV epidemic.

The above approach will permit the definition of categories of genotypes exhibiting different behaviour. In order to validate the parameters defined, it will be necessary to relate their behaviour in controlled conditions of inoculation to their field behaviour in natural conditions, by setting up field experiments. This will allow the quantification of the impact of these parameters on a BBTV epidemic.

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Developing Methods to Detect Banana Streak Virus in *Musa*

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Both immunological and PCR-mediated amplification methods were developed for BSV detection. Polyclonal rabbit antisera, prepared against a mixture of serologically distinct BSV isolates, were able to detect all tested isolates of BSV by immunosorbent electron microscopy (ISEM) using partially purified extracts prepared from small leaf tissue samples. Although this method is sensitive and reliable, it is not suited to indexing large numbers of samples and should be reserved for corroborative testing of small numbers of critical samples. To overcome this limitation, additional polyclonal antisera were prepared in mice and chickens, and a triple-antibody sandwich (TAS) ELISA protocol was developed and is now being tested.

Reliable detection of BSV in Musa *has not been achieved using PCR protocols which use total extracted DNA as a template. It was found that BSV-related DNA was integrated into the* Musa *genome, giving a PCR product with BSV-specific primers whether or not virions were present, as determined by ISEM. Sequencing of Calcutta 4 genomic segments that hybridise with BSV-specific probes has so far identified two complete badnavirus ORF's and a portion of the third ORF.*

Musa Germplasm Improvement

Bunches of banana hybrids maturing before seed extraction

Breeders network

Breeding for nematode resistance has been identified as the third most important goal for global *Musa* improvement, after breeding for resistance to Sigatoka diseases and Fusarium wilt.

A workshop organised by the Malaysian Agricultural Research and Development Institute (MARDI) and INIBAP, entitled "New Frontiers in Resistance Breeding for Nematodes, Fusarium and Sigatoka", was a milestone in the development of the breeders' network. The meeting, which was held in October at the Human Resource Development and Technology Centre, MARDI, brought together nematode specialists and *Musa* breeders from 14 countries as well as several Malaysian *Musa* researchers.

At this meeting, wide ranging discussions took place on future requirements for effective breeding for nematode resistance. There was clear consensus on the need to identify new sources of resistance to the major nematodes affecting bananas, for incorporation into breeding programmes.

The screening of fertile diploid types was considered particularly important in this regard. Screening protocols were proposed and resistant and susceptible reference varieties were suggested in order to establish a common evaluation procedure for breeding lines and improved varieties. The need to develop reliable screening protocols for use in glasshouses was also highlighted. Finally, the participants agreed that both conventional (hybridization) and non-conventional (biotechnology) *Musa* improvement methods were complementary. All improvement strategies are worth pursuing and genes engineered into breeding diploids would benefit conventional breeding programmes.

Table 1: Distribution of FHIA Hybrids in 1995

Food and Agricultural Research Council, Réduit, Mauritius
Ministry of Agriculture, Forests, Fisheries and Meteorology, Apia, Western Samoa
National Agriculture Research Centre, Islamabad, Pakistan
Ministry of Agriculture and Cooperation, Bangkok, Thailand
INIFAP-CIRGOC, Teapa, Tabasco, Mexico
Ministère de l'agriculture et de l'élevage, Papeete, French Polynesia
MHRS, Nambour, Queensland, Australia
INSA, Hanoi, Viet Nam
CIRAD-FHLOR, La Foa, New Caledonia
South China Agricultural University, Guangzhou, China
Ministry of Agriculture and Forests, Vaini, Tonga
ARI-Maruku, Bukoba, Tanzania
Universidad Autónoma "Gabriel René Moreno", Santa Cruz de la Sierra, Bolivia
CRBP, Douala, Cameroon
BARI, Joydebpur, Bangladesh
Bengnet State University, Bengnet, Philippines
South Pacific Commission, Suva, Fiji
CIRAD-FHLOR, Montpellier, France
Centre de recherche et de documentation agricole, Port-au-Prince, Haiti
Ministère du dévelopement rural, de la pêche et de l'environment, Anjouan, the Comoros
ACT-Tanzania, Arusha, Tanzania
Horticultural Research and Development Institute, Peradeniya, Sri Lanka
Central Research Institute for Horticulture, Jakarta, Indonesia

International *Musa* Testing Programme (IMTP)

In 1989, UNDP agreed to fund the IMTP in order to promote the testing of new banana and plantain hybrids for resistance to black Sigatoka (*Mycosphaerella fijiensis*) and to stimulate the breeding and identification of black Sigatoka resistant germplasm.

Following IMTP Phase I (1990-1993), three FHIA hybrids FHIA-01, FHIA-02 and FHIA-03, were recommended for further distribution and evaluation through National Evaluation Programmes (NEPs). The selected hybrids have been distributed free of charge by the ITC to National Agricultural Research Systems (NARS), Universities and Institutes in more than 40 countries (Figure 1). In 1995, these hybrids were distributed to 23 countries (Table 1) and INIBAP signed formal contracts to support their evaluation in five of these: Cameroon, Gabon, India, Venezuela and Western Samoa.

It is anticipated that germplasm already multiplied and disseminated to NARS will be widely adopted and utilized in national

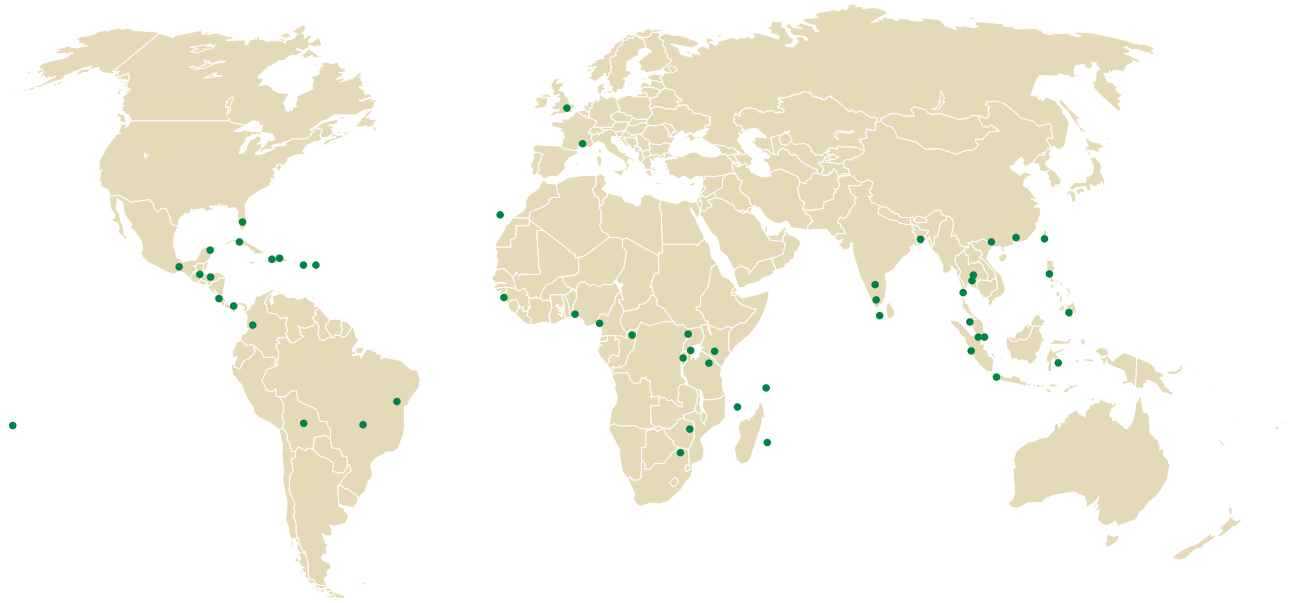


Figure 1. Distribution of IMTP Phase I hybrids by ITC since 1993

programmes and will thereby be made available to smallholders.

The target diseases of IMTP Phase II (1993-1996) are black Sigatoka, yellow Sigatoka (*Mycosphaerella musicola*) and Fusarium wilt (*Fusarium oxysporum* var. *cubense*). All hybrids, selections and landraces for IMTP Phase II have been virus indexed at the VICs. After multiplication, more than 10,000 *in vitro* plantlets (proliferating tissue cultures or rooted plantlets according to the partner's requirements) were distributed by ITC, in 1995, to collaborators from 19 countries for use in IMTP Phase II. Some plants were planted in 1995, but most were hardened out in 1995 for planting in 1996.

During 1996, 18 of the 37 test sites will evaluate 11 accessions for Sigatoka disease and 19 will test 21 accessions for Fusarium wilt resistance/tolerance. Following discussions with disease experts, technical guidelines outlining data to be collected and field plans for evaluation sites were developed and published in the proceedings of the first Global Conference of IMTP, held in Honduras in April 1994, on the "The Improvement and testing of *Musa*: a Global Partnership" and these will be used at the test sites.

At the end of IMTP Phase II, the selected disease-resistant germplasm will be distributed. The adoption of resistant varieties should lead to increased yields and reduced production costs for smallholders, while a reduction in pesticide use will have beneficial effects not only for the environment, but also for the health of the banana producers. It should also result in the availability of a wider range of improved varieties from which smallholders will be able to select those varieties most suited to their needs. This is the beginning of an on-going system for screening and releasing improved germplasm worldwide.

An increasing number of breeding programmes are already contributing new and promising pest/disease-resistant germplasm for further evaluation in 1997. Germplasm for IMTP Phase III, which will be extended to cover nematode resistance, is currently undergoing virus indexation.

Research supported by INIBAP

INIBAP has been supporting strategic research undertaken by several of its partners since 1992. In Belgium, INIBAP promotes research at KUL on the improvement of in vitro *techniques to produce embryogenic cell suspension in order to provide suitable material for genetic transformation, and the development of an early screening programme for nematode resistance. In Honduras, INIBAP supports breeding activities at the Fundación Hondureña de Investigación Agrícola (FHIA) through Phase II of the IMTP.*

Embryogenic cell suspension

The production of embryogenic cell suspensions (ECS) is limited by the ability to produce high quality scalps from in vitro *proliferating shoot meristems and the induction of ECS via embryogenic material on such scalps. From a survey of twenty varieties belonging to different genome groups, it was observed that:*

- *most varieties need to pass several cycles on a proliferation medium with 10 times higher cytokinin content (100 μM) than the routinely used proliferation medium; and*
- *ECS can be established from all the tested varieties.*

However, the response to liquid and semi-solid media to produce ECS, depended on the variety.

Genetic transformation

The genetic transformation protocol, developed at KUL, is based on the introduction of foreign genes into ECS via particle bombardment. Several marker genes have been tested for their efficiency to select transgenic banana cultures. The bar *gene coding for phosphinothricin acetyltransferase proved to be unsuitable whereas neomycin phosphotransferase* (neo) *and hygromycin phosphotransferase* (hph) *genes have been found to be useful. Using the* gusA *reporter gene as a marker for transformation efficiency, several heterologous promoters have been compared and it appears that the maize polyubiquitin promoter is the most efficient at producing high gene expression in banana cells. Several stable transformed banana plants are growing in the greenhouse at KUL.*

Screening for nematode resistance

A preliminary experiment has been conducted on a first selection of eight diploid Musa *accessions, originating from Papua New Guinea, for resistance to* Radopholus similis *and* Meloidogyne javanica. *Although no resistance was observed, differences were noted between the banana varieties. However no strong correlation was noted between the response to the different nematode species.*

In order to widen this study, populations of Radopholus similis, Pratylenchus coffeae *and* Meloidogyne *spp. were established and a number of genotypes representing a larger array of* Musa *diversity were selected.*

Breeding at FHIA

INIBAP is financially supporting Musa *breeding at FHIA under IMTP Phase II.*

The hybrids FHIA-03, FHIA-18 and FHIA-21 are milestones in the FHIA breeding programme. Apart from FHIA-01 which was released this year to Australian banana farmers, they are the first bred hybrids to be planted commercially because of their superiority to traditional natural varieties, both in terms of productivity and disease resistance.

The FHIA-03 tetraploid was derived from crossing the black Sigatoka-resistant improved diploid SH-3320 onto the short triploid hybrid SH-3386. This is the first bred cooking banana; it has several qualities superior to those of natural ABB cultivars and has been readily accepted by consumers in Grenada and Cuba. By the end of 1995, the first FHIA-03 planted in Grenada had produced five crop cycles and had remained free of Moko infection. In Cuba, FHIA-03 has been adopted as a replacement for the standard ABB-'Burro CEMSA' cultivar and 700 hectares of this hybrid have now been planted. Many countries have requested this hybrid, which was selected as a result of INIBAP-IMTP Phase I, for evaluation.

The FHIA-18 sweet-acid dessert banana has also received ready acceptance in Cuba. This hybrid, which has the same pedigree as FHIA-01 (AAB Dwarf Prata x SH-3142 improved diploid) is fast to flower and has a high level of resistance to black Sigatoka. Bunch weights of up to 40 kg have been reported for the second fruiting cycle.

The FHIA-21 plantain-like hybrid resistant to black Sigatoka was evaluated in Honduras. Production was twice that obtained with the traditional AAB-'Horn' plantain and many farmers wanted to convert immediately to FHIA-21. However this promising material is not yet available from INIBAP due to the detection of bacilliform virus particles in the first sample received at ITC. Research is ongoing at INIBAP to obtain clean material.

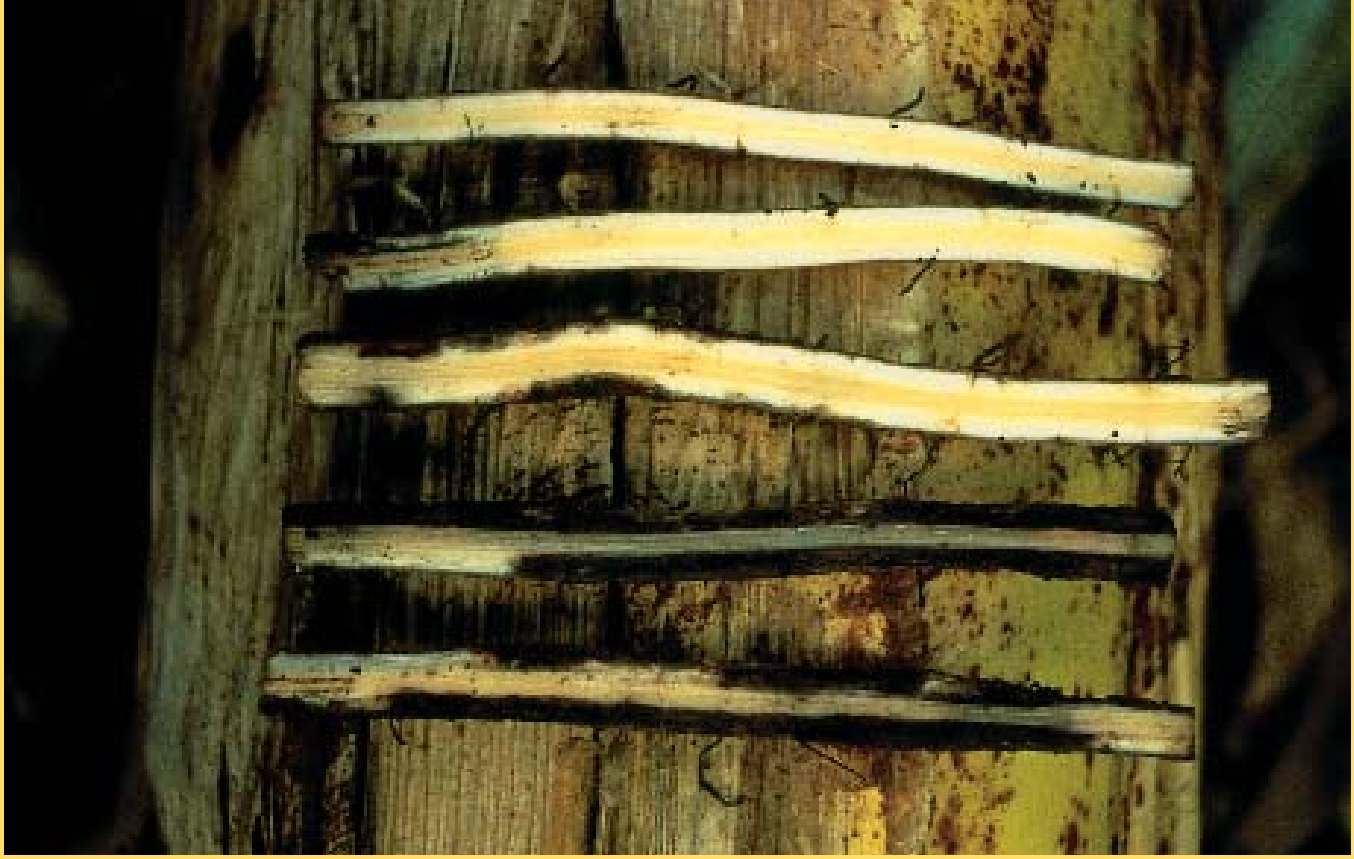
Embryogenic cell clumps in an embryogenic cell suspension of 'Williams' (200x)

In addition to their immediate value to farmers and consumers, these hybrids, which represent three different types of edible Musa *- plantains, cooking bananas and dessert bananas - prove that breeding by cross-pollination has been successful in genetically improving the crop, and that the traditional approach to* Musa *breeding, which emphasises the development of agronomically superior, disease-resistant pollen-fertile diploids for subsequent crossing onto seed-fertile triploids for the synthesis of tetraploids, is giving useful results.*

It is expected that hybrids superior to FHIA-03, FHIA-18 and FHIA-21 will be produced in the future as further progress is made in improving the parental lines utilized in these crossing schemes. In 1995, approximately 13,000 pollinated bunches were processed for seed extraction and 2050 segregating hybrids, produced from germinating these seeds, were transplanted in the field.

A primary objective in banana breeding is to develop disease-resistant hybrids with shorter stature. Dwarf and semi-dwarf AAB-'French' plantain cultivars have been selected for subsequent use as female parent lines in the programme. Emphasis has also been placed on developing tetraploid hybrids for specific country uses, for example: dwarf, vigorous black Sigatoka-resistant cooking bananas for East Africa (one hybrid already selected, SH-3755); ABB-type cooking bananas for Asia and East Africa for beer making (crosses on-going); and dessert bananas for domestic consumption, 600 plants of the AAA-Gros Michel dwarf mutant 'Lowgate' were planted this year and cross pollination has already begun.

FHIA-18, SH-3755 and SH-3746 black Sigatoka-resistant cooking bananas were sent to INIBAP for virus indexing this year.



Damage caused by root-lesion nematodes

Musa Nematologists' Consortium: A Step Towards Global Collaboration

Dr Dirk de Waele, Nematologist, KUL, Belgium

Until recently, research efforts to obtain higher yielding *Musa* cultivars were lacking in two very important areas: nematological evaluation of *Musa* breeding material (parents, progeny) and identification of new nematode-resistance sources. A *Musa* Nematologists' Consortium has now been formed, thanks to funding from the Banana Improvement Project (BIP), which is sponsored by the Common Fund for Commodities (CFC), the Food and Agriculture Organization (FAO) and the World Bank; and to funding from the Flemish Association for Development Cooperation and Technical Assistance (VVOB), the Belgian Administration for Development Cooperation (BADC), the *Fundación Hondureña de Investigación Agricola,* Honduras (FHIA), IITA and INIBAP. The formation of this consortium could be the first step in global efforts to evaluate the susceptibility and sensitivity of *Musa* genotypes to nematodes under different agro-ecological conditions, in order to assist *Musa* breeding programmes and provide small-scale farmers with either nematode resistant or tolerant cultivars.

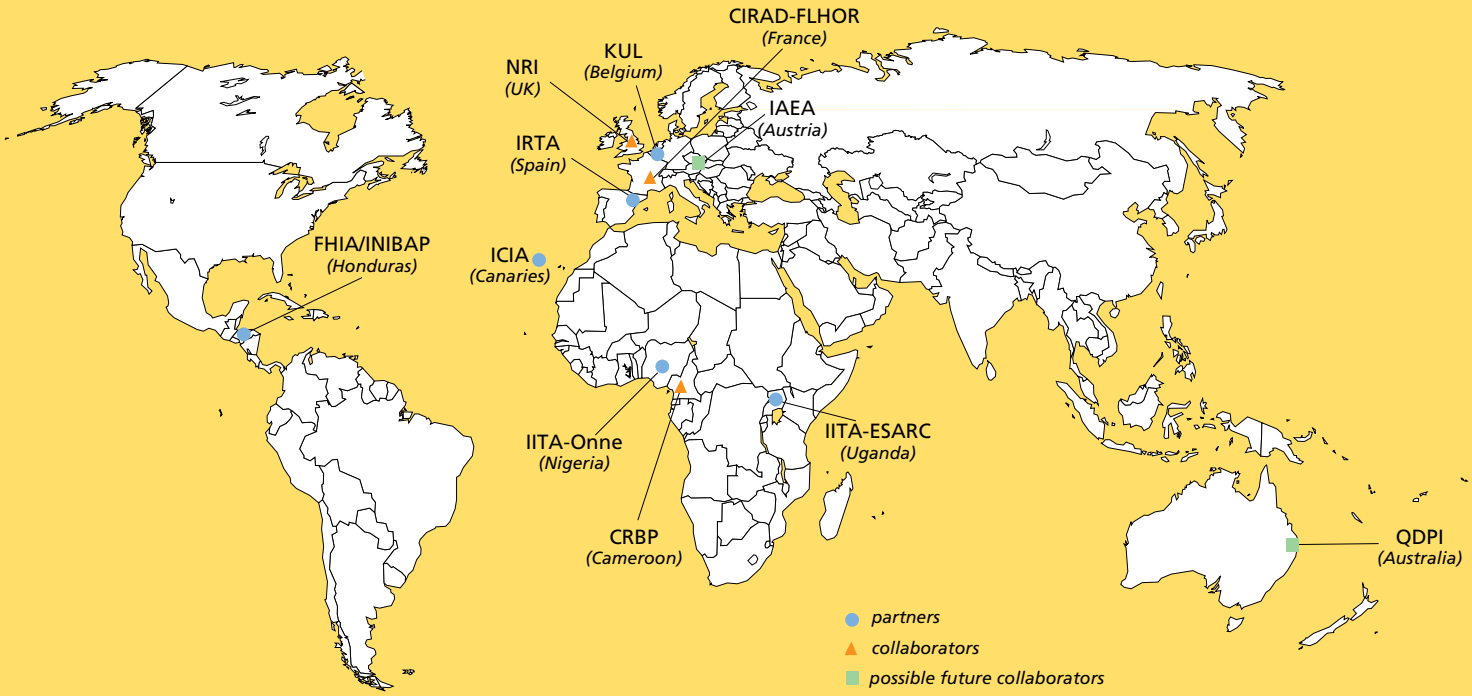
Musa Nematologists' Consortium

The *Musa* Nematologists' Consortium currently has six partners carrying out activities in Europe, East and West Africa and Central America. Of these, the *Instituto de Recerca y Tecnología Agroalimentaria / Instituto Canario de Investigación Agrícola* (IRTA/ICIA), KUL and FHIA are sponsored by BIP. The remaining partners are IITA-Onne, the East and Southern Africa Regional Centre of IITA (ESARC) and INIBAP-Honduras.

VVOB provides funding for three Flemish research associates: one based with INIBAP at FHIA; and two with IITA, one in Nigeria and one in Uganda. BADC provides funding for the nematological research activities at IITA-Onne and IITA-Uganda. In order to extend activities to Asia, negotiations are underway with VVOB to obtain an additional Flemish research associate to carry out work in Viet Nam.

Through INIBAP, the *Musa* Nematologists' Consortium is able to establish links with all major *Musa* improvement programmes in the world. In particular, links have been established with the *Centre de recherches régionales sur bananiers et plantains* (CRBP), where another BIP project on the tolerance and resistance of *Musa* genotypes to nematodes is based. CRBP, in turn, is linked to CIRAD's *Département des productions fruitières et horticoles* (FLHOR) and the Natural Resources Institute (NRI), UK.

In future, it is also hoped to establish links with nematology research in Australia and



Partners/collaborators of the Musa *Nematologists' Consortium*

with the programme being run in Austria by FAO, the International Atomic Energy Agency (IAEA) and KUL, on identifying nematode-resistance sources in *Musa* using induced mutations.

Activities in the Consortium started in spring 1995 with nematode culturing and early screening activities. The screenhouse and field screening activities will commence in April, 1996 with the arrival of the INIBAP and IITA research associates at FHIA, IITA-Onne and IITA Uganda.

Objectives

In the initial phase, the three major objectives of the *Musa* Nematologists' Consortium are:

- to adapt or develop early, rapid and reliable methods for nematode resistance/tolerance screening,
- to provide the existing classical *Musa* breeding programmes at FHIA, IITA-Onne and IITA-Uganda with a nematological component, and
- to screen *Musa* genotypes for nematode resistance/tolerance.

Nematode Culturing

To support the screening activities, two types of nematode cultures are being established and maintained: "dormant" stock cultures of all nematode populations used for screening (at IRTA) and active screening cultures which serve as sources of inoculum (at IRTA, KUL, FHIA and IITA).

As multiple resistance/tolerance to the major *Musa* nematodes is envisaged and in view of the reports of intraspecific differences in pathogenicity, especially between *Radopholus similis* populations, a representative number of populations of nematode species associated with *Musa* in the major banana-producing regions is being preserved at IRTA and used for screening.

A collection of nematode populations will be maintained at KUL as a source of inoculum for early screening; as bananas are not cultivated in Belgium, nematode populations from all over the world can be maintained. However, at FHIA, IITA-Onne and IITA-Uganda, only a small number of local nematode populations will be maintained as a source of inoculum.

Early Screening

The early screening undertaken at KUL and IRTA focuses mainly on the nematode reproductive potential and, therefore, only data on the resistance of *Musa* genotypes are generated; *in vitro* propagated plants are used for this. The genotypes are screened against *Radopholus similis*, *Pratylenchus coffeae*, *Pratylenchus goodeyi* and *Meloidogyne* spp. In addition to genotypes selected from the *Musa* germplasm collection at ITC, material from the breeding centres will also be included in the early screening at KUL.

Screenhouse and Field Screening

Screenhouse and field screening will be undertaken in the Canary Islands at ICIA in collaboration with IRTA, at FHIA, IITA-Onne and IITA-Uganda. This type of screening, which will focus on nematode reproductive and damage potential, will generate data on resistance and tolerance of *Musa* genotypes.

In the Canary Islands, the genotypes will be screened under subtropical conditions against *P. goodeyi* and *Meloidogyne* spp.; at FHIA and IITA-Onne against *R. similis* and *P. coffeae;* and at IITA-Uganda against *R. similis* and *P. goodeyi.* Genotypes identified at KUL or IRTA as showing nematode resistance, other interesting material from the breeding centres as well as local breeding material, will also be

included in the screenhouse and field screening.

The eventual establishment of a nematological evaluation programme in Viet Nam will allow the screening of *Musa* genotypes against nematode populations which are more representative of *Musa* production in Southeast Asia, such as *Meloidogyne* spp. and *Pratylenchus* spp. other than *P. coffeae* and *P. goodeyi*.

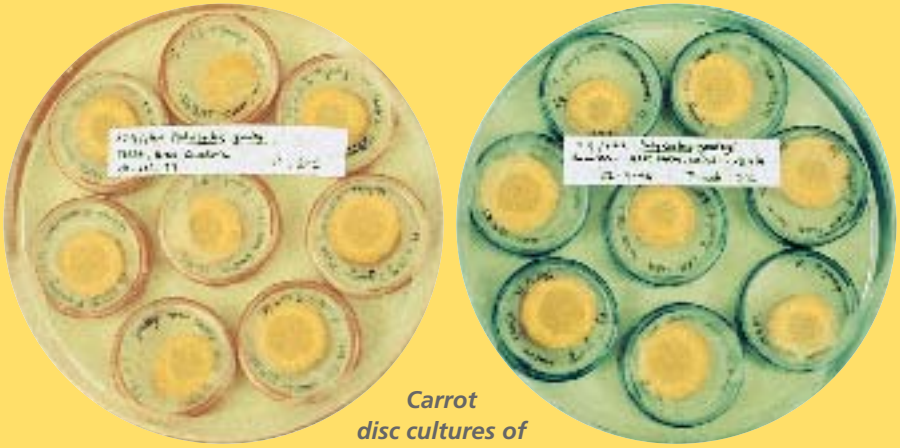
Technical Guidelines for Nematode Resistance/Tolerance Screening

Several protocols, describing procedures to be used at various stages of nematode screening of *Musa* genotypes under laboratory, screenhouse or field conditions, have been published. However, none contain a complete set of guidelines for nematode-resistance screening under all conditions and the methods advocated by different nematologists sometimes vary.

INIBAP, the Asia and Pacific Regional Network (ASPNET) and MARDI organized an international workshop on 'New Frontiers in Resistance Breeding for Nematode, Fusarium Wilt and Sigatoka' in October in Malaysia. This occasion was taken to arrange a meeting of nematologists in order to exchange experiences and agree on a basic outline for a complete set of technical guidelines for *Musa* nematode screening. Dr Jorge Pinochet from IRTA, Dr Jean-Louis Sarah from CIRAD-FLHOR, Dr Nigel Price from the International Institute of Parasitology, Dr Simon Gowen from the University of Reading, Dr Dirk De Waele from KUL, Dr Paul Speijer from IITA and Dr Roger Fogain from CRBP participated in the meeting.

As a result of the meeting, detailed technical guidelines, to be published by INIBAP, are now being prepared on all aspects of *Musa* nematode screening in the laboratory, screenhouse or field, including nematode culturing, preparation of *in vitro* propagated plants, evaluation of nematode reproductive and damage potential as well as extraction methods and effect on plant growth and yield. The meeting also agreed on a list of *Musa* genotypes to be used as a reference in experiments.

These guidelines will serve as a reference for all members of the *Musa* Nematologists' Consortium and will also be made available to all interested *Musa* researchers.



Carrot disc cultures of Pratylenchus goodeyi *populations*

Tomato hairy root cultures of a Meloidogyne incognita *population*

Conclusion

The *Musa* Nematologists' Consortium already brings together many nematologists engaged in *Musa* nematode resistance screening. It will contribute to the nematological characterization of the *Musa* genotypes preserved at ITC and the nematological evaluation of *Musa* genotypes under different pathogen pressures and under the ecological conditions prevailing in the major banana producing regions of the world. The consortium represents an important step towards global collaboration in the nematological evaluation of *Musa* breeding material and the identification of nematode resistance sources. This initiative should be further broadened to include all important research efforts in this field.

Latin America and the Caribbean

In several countries in the region, new multi-institutional organizations, such as corporations and foundations which group public-sector institutions, private enterprises, non-governmental organizations, regional institutes and growers' associations have been developed. Optimizing the way of working with such organizations, which have very different structures and modes of operation, will be a major challenge for the Network in the coming years.

A further challenge, identified by Network members at the Fourth Regional Advisory Committee (RAC) meeting of the Regional Network for Latin America and the Caribbean (LACNET) held in Santo Domingo, Dominican Republic, in December 1994, is the need to consider the socioeconomic impact of new technologies. This could include providing information on the environmental benefits of using new disease-resistant varieties, as well as on the need for adapting and developing new banana and plantain production systems to meet the increasing and changing demands of both domestic and export markets.

Regional Advisory Committee

The Fifth LACNET RAC meeting took place from 23 to 26 September 1995 in Caracas, Venezuela and was hosted by the *Servicio Autónomo de Sanidad Vegetal* (SAS), Venezuela and the *Facultad de Agronomía, Universidad Central de Venezuela.* The meeting was preceded by a day of very useful informal discussions on breeding, *Musa* improvement, biotechnology, plant health, production systems and training issues.

As a result, two initiatives were launched: the establishment of the Regional *Musa* Breeding Programmes and Breeders' Working Group; and the setting-up of an information system on the effects of potential pests in the region. Both initiatives will be coordinated by Dr Franklin Rosales (Honduras) and Dr Sylvio Belalcázar (Colombia).

The LACNET Regional Coordinator took this occasion to review INIBAP's history during the last ten years, reminding members that the network is the co-responsibility of RAC

Visit of the LACNET Regional Advisory Committee to a NEP planted with FHIA hybrids at the CENIAP experiment station in Maracay, Venezuela.

members and INIBAP, and, as such, combines regional priorities with the INIBAP Global Plan of Action.

Several RAC members presented special topics on research and development. These included the progress of the Regional Network on *Musa* Biotechnology managed by CATIE; the evaluation of several FHIA hybrids in Cuba; the importance of banana and plantain in the Windward Islands; a collaborative *Musa* Research Programme carried out in Brazil; the methodology used by FHIA to set up a NEP and to introduce several hybrids from the breeding programme into production systems in Honduras; the dynamics and management of *Mycosphaerella fijiensis* populations resistant to fungicides in Costa Rica, and the latest advances in the plantain research programme in Colombia.

CIRAD-FLHOR representatives outlined the regional French cooperation and breeding programmes while INIBAP headquarters staff outlined the status of INIBAP's main programmes and the progress made in developing a global INIBAP information system.

The meeting concluded with a general discussion on regional priorities and strategies and agreement was reached on a set of recommendations to be implemented by the Network partners. Dr Nicolás Mateo closed the meeting by presenting his vision of INIBAP's future, in which he believed LACNET has a major role to play. Pointing out that 10 years ago a meeting like this would not have been feasible, he noted that the RAC has now reached the level of maturity which would allow agreements on strategies and objectives to be reached.

Musa Germplasm Management

Germplasm conservation

Progress was made in the negotiations between CATIE and INIBAP on the duplication of one fourth of the *in vitro* collection kept at ITC. A first draft of the agreement was circulated in both institutions at the end of 1995.

Countries in the region have continued to invest in the maintenance of *Musa ex situ* field collections. Plans for 1996 include replanting collections at EMBRAPA-CNPMF (Cruz das Almas, Brazil), CORPOICA ("El Agrado" Experiment Station, Armenia, Colombia) and INIVIT (Cascajal, Santa Clara, Cuba).

Dr Jean Pierre Horry reclassified the INIVIT collection in Cuba in early September.

Germplasm exchange

The list of germplasm available at ITC was circulated in June to RAC members and to breeding programmes; this should lead to increased germplasm movement to the region.

In 1995, ITC provided germplasm to the following countries: Argentina (INTA and the *Instituto de Botanica del Noreste*), Bolivia (*Universidad Autónoma Gabriel Rene Moreno*), Costa Rica (CATIE), Cuba (INIVIT), Honduras (FHIA), Mexico (INIFAP, Tabasco), St. Lucia (WINBAN), Venezuela (*Fondo Nacional de Investigaciones Agropecuarias-Centro Nacional de Investigaciones Agropecuarias* - FONIAP-CENIAP and *Universidad Central*). At the end of the year, preparations were underway at ITC to send germplasm to Brazil (EMCAPA), the Dominican Republic (*Fundación de Desarrollo Agropecuario Inc* - FDA). , Guadeloupe (CIRAD-FLHOR) and Mexico (CICY).

Improved germplasm was sent to the ITC by FHIA, Honduras (FHIA-16, FHIA-18, FHIA-20 and FHIA-21).

Musa Improvement

FHIA made substantial progress during 1995 in breeding disease-resistant bananas and plantains for domestic consumption. (See main section on *Musa* Germplasm Improvement for further details.)

INIBAP's Director and the LACNET Coordinator visited INIVIT, Cuba in early June to discuss the project "Mutation

induction by irradiation in banana", managed by Dr José Pino with support from IAEA. To date, dwarf mutants from the Zanzibar cultivar (AAB 'Plantain') have been obtained.

A visit was also paid to the Brazilian Banana Breeding Programme at EMBRAPA-CNPMF to discuss the evaluation and selection of new varieties, tetraploid production, hybrid evaluation in different ecosystems and different fertility conditions, evaluation of resistance to Fusarium wilt, nematodes and weevil borers and participation in INIBAP's programme. A demonstration plot was established at the Centre in Cruz das Almas, Bahia, in order to compare traditional varieties planted by farmers, with hybrids produced by the CNPMF and FHIA's Improvement Programmes.

The CIRAD-FLHOR, Guadeloupe *Musa* Improvement Programme received financial support from the BIP to conduct research to determine the mechanisms which govern the inheritance of resistance to black Sigatoka.

IMTP

The institutions in the region participating in IMTP Phase II are: EMBRAPA-CNPMF, INIVIT and FHIA for Fusarium wilt; CORPOICA, INIVIT and WINBAN-WIDBECO for yellow Sigatoka; and *Corporación Bananera Nacional* (CORBANA) Costa Rica, INIVIT and FHIA for black Sigatoka. During 1995, these institutions received germplasm for evaluation chosen by the participating improvement programmes and INIBAP.

NEPs

The recommended black Sigatoka resistant hybrids, FHIA-01, FHIA-02 and FHIA-03, distributed to 15 countries in 1994, were multiplied during the year.

The Director of the Banana and Plantain Programme in Cuba reported that 50 demonstration plots were planted in May with 5000 plants each of FHIA-01 and FHIA-03 hybrids, and that 700 hectares of FHIA-03 had been planted in place of the local variety, Burro CEMSA. New FHIA hybrids are also under evaluation. The goal is to have 3000 hectares planted with hybrids by the end of 1996.

Colombia's plantain programme is distributing material to different experimental stations around the country.

In Costa Rica, CORBANA is analysing the results of the first evaluation trials, held in 1994/95, on FHIA-01 and FHIA-02. A local company has been established to export FHIA hybrids as organic bananas and plantains; the first shipments to Holland and the USA were well received by consumers.

In Honduras, the demand for FHIA-21 grows continuously as its high yield and resistance to black Sigatoka makes it very attractive to producers.

In Venezuela, the *Facultad de Agronomía, Universidad Central* has carried out evaluation on FHIA-01, FHIA-02 and FHIA-03 and recently commenced distributing them to other experimental stations.

The Banana and Plantain Programme at the *Instituto de Investigaciones Agropecuarias de Panama* (IDIAP) signed a Memorandum of Understanding (MoU) with INIBAP to conduct multilocation trials with FHIA's hybrids, particularly in Chiriqui Province.

Information / Documentation / Communications

MGIS

Characterization manual in Spanish

During 1995, a first draft in Spanish of the users' characterization manual was developed as part of a collaborative project between INIBAP and CIRAD. Prof. Oscar Haddad from the *Universidad Central de Venezuela*, Dr Franklin Rosales from FHIA and Dr Sylvio Belalcázar of CORPOICA reviewed the Spanish version of the manual.

Morphotaxonomic study

Three institutions in the region were identified (FHIA, CORPOICA and CIRAD-FLHOR, Guadeloupe) to collaborate on a morphotaxonomic study of the reference cultivars, in order to detect environmental effects on the plant characteristics, and thus update the MUSAID. The participating institutions have received 13 of the 30 reference cultivars from ITC with which to start the study.

Information/Documentation

UPEB, which hosts the LAC Regional Information Network, is undergoing major restructuring and faces a severe reduction in personnel numbers. Unless member countries (Colombia, Costa Rica, Guatemala, Honduras, Nicaragua, Panama and Venezuela) reach an agreement on the future of the organization, the largest banana and plantain information and documentation centre in the region could be

Dr Sylvio Belalcázar and Mr Jorge Valencia (CORPOICA Plantain programme) stand before a FHIA-03 hybrid in its fourth cycle at El Agrado Experiment Station (1320m altitude) near Armenia, Colombia.

lost. At the end of the year, UPEB's Council approached the *Instituto Interamericano de Cooperación para la Agricultura* (IICA), Costa Rica, in an attempt to reach an agreement regarding the operation of at least two departments: information/documentation and economic analysis. It is hoped that an agreement will be reached in 1996.

In the meantime, INFOMUSA and *Musarama* will continue to be published in Spanish using the translator formerly contracted by UPEB.

Regional Research and Training

Crop Protection

Following a request from the Crop Protection Service of the Venezuelan Ministry of Agriculture, INIBAP supported the visit of a black Sigatoka expert to the southern part of Lake Maracaibo, the main plantain producing region of the country and the area most affected by the disease. The specialist elaborated a plan to control the pathogen and also gave two lectures to agronomists, technicians and growers interested in the disease.

After the discovery of black Sigatoka in Jamaica, LACNET provided the Banana Board with information on this pathogen. Dr Xavier Mourichon and Dr Jean Carlier collaborated with Jamaican authorities and INIBAP in analyzing diseased leaf tissue to identify the pathogen throughout the country. It is now planned to train a plant pathologist/agronomist in epidemiology and control strategies.

Information on BSV was sent to interested institutions such as UNIBAN in Colombia, PNB in Ecuador, FUSAGRI in Venezuela and the IPM-CATIE project in Nicaragua.

Post harvest research

Dr Benjamin Dadzie of the NRI, completed his assignment evaluating the postharvest characteristics of the fruit of some FHIA hybrids at FHIA in Honduras. The project, which was sponsored by INIBAP with a grant from the Overseas Development Administration (ODA), UK, aimed to develop postharvest screening methods and procedures that are reliable, easy to use and which require limited equipment. Various screening methods and procedures were used on black Sigatoka-resistant cooking banana and plantain hybrids developed at FHIA, as well as on standard susceptible

Drs Jean-Vincent Escalant from CATIE-CIRAD/FLHOR and Thierry Legrave from CIRAD-BIOTROP during a laboratory demonstration at the occasion of the hands-on workshop in Musa genetic transformation held at CATIE in June, 1995.

cultivars. Dr Dadzie determined that one of the fundamental postharvest quality differences between types of triploid and tetraploid cooking bananas and plantain cultivars was that both the unripe and ripe fruits of the triploid cultivars were firmer than those of the tetraploid hybrids. The results of Dr Dadzie's work will be published by INIBAP, as will a manual compiled by Dr Dadzie on postharvest evaluation methods.

Training

Short courses and workshops

The Regional Working Group on Biotechnology applied to *Musa* organized a hands-on workshop in genetic transformation at CATIE in May. This involved CATIE's Unit of Biotechnology, CIRAD-FLHOR, the *Biotechnologies appliquées à l'amélioration des plantes tropicales* of CIRAD (BIOTROP) and LACNET, and was sponsored by the International Development Research Centre (IDRC), Canada. The workshop was attended by scientists from seven institutes in the region. Their report analyzes the advantages and disadvantages of the use of such technologies in the region.

CORPOICA's Plantain Programme organized a short course in Armenia, Colombia, on 'Technological Updates on Plantain Production'. INIBAP and IDRC supported the attendance of four participants to the course which was attended by 40 agronomists.

Following a recommendation of the RAC meeting, FHIA organized a regional course on plantain production in La Lima in March. Dr Sylvio Belalcázar, Coordinator of CORPOICA's Plantain Programme, was invited to give a lecture at this event which was attended by 60 scientists from Central America and the Dominican Republic.

Special courses

INIBAP has been instrumental in forming close links between *Musa* research institutions in the LAC region, and universities and institutes in developed countries, especially those concerned with biotechnology and cell-molecular biology.

Within the framework of the CORPOICA/KUL project on 'Production of Varieties Resistant to Sigatoka in Colombia', which receives support from the European Union (EU), and at the request of the LACNET Regional Coordinator, two Colombian specialists, Ms Martha L. Orozco and Mr Jorge Alberto Valencia from CORPOICA's biotechnology and plantain programme, received three-months training in *Musa* embryogenic cellular suspension at the KUL Laboratory of Tropical Crops Improvement, under the guidance of Prof. Rony Swennen and Dr Hilde Schoofs. Likewise, Dr Gilberto Surga, on sabbatical leave from CENIAP, also undertook training with Prof. Swennen on cryopreservation.

The LACNET Coordinator assisted Dr Ronald Vargas, Deputy Research Director of CORBANA, to participate in the First International Tropical Fruticulture Course, organized by the Canary Institute of Agricultural Research and held in the Canary Islands, Spain in June.

Dr Pilar Ramírez, from the Research Centre in Molecular and Cell Biology, University of Costa Rica, visited Dr Ben Lockhart's laboratory at the University of Minnesota, USA to discuss the latest findings and scientific advances in BSV diagnostics, and to transfer the methodology developed by Dr Lockhart to the Research Centre, as part of an informal cooperation agreement. The visit was supported by IDRC and INIBAP.

Horizontal cooperation

Following LACNET's initiative to increase horizontal cooperation amongst its members and to make use of regional institutes, centres or universities with comparative advantages in specific fields, LACNET has been identifying candidates to attend short courses or in-service training sessions. CATIE, FHIA and INIBAP joined together to support the participation of Mr Roger Medina, FHIA's assistant librarian, in a training course organized by CATIE on 'Information Services in the Agricultural Sector', held in Costa Rica from August 21 to September 1.

Likewise, CORBANA trained an agronomist from the Crop Protection Service of the *Servicio Autónomo de Sanidad Agropecuaria* (SASA), Venezuela in epidemiology and control strategies of *Mycosphaerella fijiensis*. The trainee, Mr Oswaldo Caceres, will work with plantain producers in southern Lake Maracaibo, the area of Venezuela most affected by the pathogen.

Postgraduate studies

During 1995, RAC members have acted as advisors to postgraduate students. Dr Jean-Vincent Escalant, CATIE's RAC representative, was principal advisor to two MSc students: Ms Carmen Bieberach of Panama studying somatic embryogenesis in *Musa,* and Mr Ramon Hernandez of the Dominican Republic studying *in vitro* and greenhouse selection of *Musa* materials to evaluate resistance to black Sigatoka. Similarly, Dr Sebastiao de Oliveira e Silva, Brazil's RAC representative, was principal advisor to Ms Fernanda Vidigal Duarte, during her studies at the Federal University of Bahia, Brazil, on *in vitro* multiplication and mitotic instability of Caipira.

Other Achievements

Proposals

In 1995, INIBAP-LACNET together with Network members, put into operation the second phase of the small grants project supported by IDRC through INIBAP. The specific objectives of this phase were:

- to support small key thematic research activities on the production and evaluation of genotypes resistant to several pathogens;
- to establish an informal regional network on biotechnology applied to *Musa;* and
- to train *Musa* researchers in germplasm management and evaluation, and the use of biotechnological tools.

Research institutes throughout the region have benefited from this important project.

A proposal submitted by INIBAP as part of the Regional Agricultural Technology Programme for the development of disease-resistant banana and plantain varieties, and the promotion of collaborative *Musa* research in the region was approved by the Inter American Development Bank in October. At the national level, training will be given to enhance the capability of national research systems to evaluate natural and improved germplasm for resistance to disease. The project will be executed in collaboration with IPGRI's Regional Office for the Americas, based in Cali, Colombia.

Dr Victor Galán Sauco from ICIA met with INIBAP officials in Montpellier, France in March, to prepare ideas on possible areas for cooperation between the institutes. Plant physiology, Fusarium wilt research, breeding, studies on nematodes and soil microbiology (mychorrizae) were identified as major areas for cooperation. The programme will commence with the reciprocal visits of scientists to key institutes in the Canary Islands and LACNET.

Four institutes submitted proposals through LACNET to the BIP to carry out the following studies:

- banana breeding in Brazil (CNPMF);
- the origin and distribution of fungicide-resistant strains of *M. fijiensis* in banana plantations in Costa Rica (CORBANA);
- field and laboratory evaluation of diploid bananas for use in breeding schemes and field crossing experiments to examine the mechanisms governing the inheritance of black Sigatoka-resistant characters in banana (CIRAD-FLHOR); and,

Mr José Manual Alvarez, RAC Member from Cuba, at a packing station of Manzano (Musa *AAB Silk) for local consumption near Maracay, Venezuela.*

Mr Oscar Cruz, President of the Ecos del Agro Company, next to FHIA-02 bunches produced organically on his farm near Guápiles, Costa Rica. Mr Cruz named FHIA-02 as Monalisa.

- research on nematodes in Honduras (FHIA).

Other initiatives

CORPOICA and INIBAP signed an MoU to govern collaboration in the characterization of germplasm of the main food crops in Colombia, including both natural and improved *Musa*. This project is now underway.

INIBAP also provided support to EMBRAPA to replace irrigation equipment needed for the Germplasm Active Bank and for key experiments of the Banana Breeding Programme at CNPMF, in Bahia, Brazil.

The LACNET Coordinator supported the participation of Dr Franklin Rosales of FHIA as the NARS representative at the INIBAP Genebank Review which was completed in December.

Meetings

In 1995, the Regional Coordinator participated in the following events.

Cooperation in research and training between Spain and Latin America for the conservation and utilization of plant genetic resources - CATIE, Turrialba, Costa Rica, June 27-30.

Sub-regional Meeting on Plant Genetic Resources for Central America, Mexico and the Caribbean - IICA, San José, Costa Rica, August 21-24.

- The International Banana Breeding Workshop on 'New Frontiers in Resistance Breeding for Nematodes, *Fusarium* and Sigatoka' - Serdang, Malaysia, October 2-5.
- Fifth Regional ASPNET Regional Advisory Committee - Langkawi, Malaysia, October 6-9.
- CIRAD-CATIE Symposium on Genetic Improvement and Development of Tropical Crops - CATIE, Costa Rica, November 20-29.
- CATIE's Scientific Week - Turrialba, Costa Rica, December 4-8.

Network News

During their mission to Cuba in May, the INIBAP Director and the LACNET Coordinator visited the *Instituto de Biotecnología de Plantas* (IBP) which is located in the *Universidad Central de las Villas*. The main objective of IBP is crop improvement, particularly disease resistance in sugar cane, bananas, plantains, potato, papaya, garlic and coffee. IBP is unique in the region as it combines basic and strategic research with applied research and production. For the micropropagation of bananas and plantains, IBP has developed, under the directorship of Dr Juan Nivaldo Perez Ponce, the concept of biofactories which are designed for tropical conditions. Each biofactory has the capacity to produce between four to five million plantlets per year. To date, 14 biofactories have been built and these are strategically distributed in all provinces.

As part of the INIBAP-LACNET programme of reciprocal visits between scientists involved in advanced *Musa* programmes, Dr Escalant from CATIE/CIRAD-FLHOR, visited IBP in 1993. Since then this Institute has become part of the Regional Working Group in Biotechnology Applied to *Musa*, coordinated by Dr Escalant, who transferred to IBP techniques developed at CATIE in somatic embryogenesis and cell suspension.

During INIBAP's mission to Brazil in June, a visit was paid to Dr Kazumitsu Matsumoto, a specialist in plant protoplast, cell and tissue culture applied to *Musa* at the *Centro Nacional de Pesquisa de Recursos Geneticos e Biotecnologia*. Dr Matsumoto, who has been working with several biotechnological tools applied to *Musa*, mostly for the AAB banana varieties Prata and Maça which are susceptible to Fusarium wilt, is of the opinion that *in vitro* selection of mutants tolerant to fusaric acid may be a viable method of obtaining *Fusarium oxysporum* var. *cubense* (*Foc*) tolerant plants. The first results will be published in *Euphytica* in the coming months. Together with his colleagues, Dr Matsumoto has also obtained plants tolerant to *Foc* race 1 through the *in vitro* selection of banana bud clumps by fusaric acid.

EMBRAPA-CNPMF, which is one of INIBAP's main partners in the region, was also visited by the INIBAP mission. During a visit to the Banana Breeding Programme at Cruz das Almas, Bahia, special attention was paid to the research on evaluating Fusarium wilt in infected areas previously planted with Maça.

In Colombia, ICA-CORPOICA has a strong scientific team which has generated innovative plantain-production systems during the last decade as well as training more than 3000 agronomists, growers and students in techniques of plantain production. LACNET supported the attendance of agronomists from Costa Rica, the Dominican Republic, Ecuador, Nicaragua, Panama and Venezuela at training courses in new techniques at the El Agrado Experimental Station, the Headquarters of the Colombian Plantain Programme near Armenia. In 1995, the Institute published *Mejoramiento de la producción del cultivo del plátano.*

Demand for black Sigatoka-resistant hybrids in Latin America is expected to increase as North American consumers switch to organically grown fruit and the high costs of disease-control increase. Current black Sigatoka control costs are estimated to be approximately US$1,400 per hectare per year.

Dr Phil Rowe of FHIA reports that FHIA-18, a black Sigatoka resistant sibling of FHIA-01, has proved very popular in Brazil and Cuba. Its bunch is smaller and more compact than FHIA-01 but the fruit does not go soft when ripe. FHIA-18 has also been reported as being resistant to nematodes in Cuba. INIBAP has received FHIA-18 for virus indexing and inclusion in the next round of IMTP.

During 1995, Ms Rose Koening, of the Department of Plant Pathology, the University of Florida, Gainsville, visited FHIA to carry out research as part of her PhD programme.

Black Sigatoka has now been reported in Jamaica. Dr Andrea Johanson identified *Mycosphaerella fijiensis* in specimens sent to NRI by the Jamaican Banana Board. This was confirmed when further specimens were sent to INIBAP for examination. Haiti and the Dominican Republic are seen as the next countries in the Caribbean where this serious disease will appear. Its effect on plantain, which is an important crop in Hispaniola, would be significant. FHIA-21 and the plantain hybrids bred by IITA should play an important role in this area in the future.

Asia and the Pacific

During 1995, INIBAP expanded its activities in China, Indonesia, Malaysia, the Philippines, Thailand, Viet Nam and the South Pacific.

Regional training activities were strengthened considerably during the year through the support of the Horticultural Research Institute (HRI), Thailand and cooperation with IITA-ESARC and the Australian Centre for International Agricultural Research (ACIAR). The first formal training course organized in the region by the Asia and Pacific Regional Network (ASPNET) of INIBAP was on 'Damage Assessment Methods and Integrated Pest Management Approaches for Banana Weevil and Nematodes' and it was attended by 20 scientists from ASPNET.

TBRI gave 'visiting scientist awards' to two senior banana researchers from the ASPNET region. An 'on-the-job training award' was also given to the curator of the Viet Nam banana germplasm collection to undertake training at the University of the Philippines at Los Baños (UPLB) and the Bureau of Plant Industry (BPI), Davao in the Philippines.

Musa Germplasm Management

INIBAP is engaged in *Musa* germplasm management activities in several countries in the ASPNET region, in addition to the collection, characterization and conservation of indigenous banana germplasm in Viet Nam and the safety duplication of germplasm from ITC at TBRI. (See the main section on *Musa* Germplasm Management). A description of some of the projects in the region in which INIBAP/ASPNET is involved is given below.

The Philippines—rescue and conservation of the Southeast Asian banana germplasm collection

This is the second year of a two year project which was prepared by INIBAP-ASPNET and is funded by ODA. The project is implemented by BPI and consists of three major activities: determining the health status of the regional field germplasm collection and the *in vitro* duplicate collection; carrying out a national survey on the extent and severity of virus diseases affecting bananas and identifying an alternative site for the regional field collection; and the transfer of all remaining healthy germplasm material in the field collection to the *in vitro* collection and the sending of duplicates to ITC for safekeeping.

Virus indexing revealed that all germplasm material transferred to the *in vitro* collection between 1989-1991 is free from BBTV. However, the field collection is now heavily infected by BBTV and BBMV. Field surveys during the first year of operation covered all the important banana growing regions in the country and brought to light the alarming spread of BBMV. BBTV is also serious in specific areas although several isolated islands and locations are still free. Unfortunately, these sites cannot be considered as alternative locations for the regional germplasm bank because of their distance from the research institutions.

The field survey yielded 28 new accessions, comprising 18 cultivars, which showed no visible diagnostic symptoms of any systemic disease. These were re-introduced to the screenhouse at Davao, where explants of all virus-free materials were taken for duplication *in vitro*.

In 1996, all the remaining tissue culture materials will be indexed and the

Dr Ramon Valmayor, INIBAP-ASPNET Regional Coordinator at a roadside stall near Los Baños, Philippines

unexplored regions of the country will be covered by the survey team.

Indonesia—cooperation in banana germplasm conservation and improvement

This innovative programme is designed to integrate the on-going banana germplasm conservation project of Indonesia, which covers the islands of Sumatra, Java, Sulawesi and Kalimantan, with an INIBAP initiative which will finance exploration missions to Maluku and Irian Jaya, as well as training in germplasm documentation and characterization. The proposed cooperative programme will adopt standard INIBAP/IPGRI *Musa* germplasm information and documentation formats, and a duplicate collection of Indonesian banana germplasm will be maintained at ITC. An MoU is expected to be signed between INIBAP and the Central Research Institute for Horticulture (CRIH) in early 1996.

China—banana and plantain collection, characterization and maintenance

An original project proposal, which covered five banana-growing provinces in south China, was revised in 1995 to match the funding made available by ODA. The South China Agricultural University (SCAU) identified Yunnan and Guangxi as the provinces where activities should start; the remaining three provinces, Guangdong, Fujian and Hainan, will be explored as soon as more funds become available. The revised proposal was endorsed by INIBAP in late 1995 and collecting will be initiated in 1996.

INIBAP Virus Indexing Centre at TBRI

TBRI has satisfied the strict requirements needed to become a VIC and became operational in 1995. This new VIC will strengthen the capacity of INIBAP for indexation. There are now two VICs based in the region, both funded by ASPNET members.

ITC meets strong demand for banana germplasm in ASPNET

In 1995, ITC sent more banana germplasm to the region, which is the centre of origin of bananas, than was received. Only one accession from the region was sent to the Transit Centre whereas 102 accessions were shipped to the region for general study and 81 for safety duplication at TBRI. In addition, 7,140 *in vitro* plantlets were sent to supply IMTP sites in the region and 13 reference varieties for morpho-taxonomic evaluation within the scope of MGIS were sent to BPI in the Philippines and to CIRAD-FLHOR in New Caledonia.

Musa Improvement

Banana breeders and nematologists conference/workshop

INIBAP/ASPNET hosted a conference/workshop for banana breeders and nematologists in Malaysia from 2 to 5 October, co-sponsored by MARDI. One of the aims of the conference, which brought the world's leading banana breeders and nematologists to the region, was to stimulate interest in banana improvement programmes in Asia and the Pacific. Banana breeders and nematologists from Taiwan, India, Australia, Malaysia and the Philippines participated in the conference which was also attended by scientists from Thailand and Indonesia.

IMTP

ASPNET members are actively participating in IMTP Phase II and all testing sites, with the exception of those in Tonga and Queensland which are supported by ACIAR, are funded by NARS. Australia, India, Indonesia, Malaysia, Philippines, Taiwan, Thailand and Tonga have already received test material.

NEPs

India, Western Samoa and Fiji received INIBAP assistance to undertake NEP trials using FHIA-01, FHIA-02 and FHIA-03 hybrids. China (SCAU), Viet Nam (INSA), Philippines (Benguet State University), Malaysia (MARDI), Indonesia (RIF) and Thailand (HRI) are also evaluating the FHIA hybrids with support from national funding.

Information / Communications

MGIS

Several ASPNET banana taxonomists are engaged in activities linked to the MGIS project. Dr Nasution of Indonesia, Dr Lavigne of New Caledonia, Mr Daniells of Australia and Mr Pascua of the Philippines are participating in the revision of the descriptor lists for bananas. Mr Pascua and Dr Lavigne received 13 reference varieties from ITC for evaluation of morphological character stability under different environmental conditions. Mr Daniells has completed the evaluation of 240 Papua New Guinea accessions at South Johnstone Research Station in Queensland, Australia; the results of this study should be published in 1996 in a special issue of *Musa*logue.

RISBAP

The ASPNET secretariat renewed contact with NARS members interested in the Regional Information System for Banana and Plantain in Asia and the Pacific (RISBAP). A regional consultation is scheduled for April 1996 at ASPNET's headquarters in Los Baños, Philippines.

Communications

The ASPNET secretariat published the minutes of the 4th RAC meeting hosted by TBRI in Chiuju, Pingtung, Taiwan. Copies were distributed to RAC members, ASPNET member institutions, INIBAP/IPGRI Trustees, Regional Coordinators, cooperating agencies and INIBAP officials. There is a continuing demand for INIBAP/ASPNET publications and 660 were disseminated by ASPNET in 1995.

Regional Research and Training

Damage assessment of banana nematodes and weevil borers

INIBAP/ASPNET conducted a training course on 'Damage Assessment Methods and Integrated Pest Management Approaches for Banana Weevil and Nematodes' at Phichit Horticulture Research Centre, Phitsanuloke, Thailand in September, 1995. The course was attended by 20 participants from China, Indonesia, Malaysia, the Philippines, Tonga, Viet Nam and the host country, Thailand. The training personnel came from IITA-ESARC Uganda, QDPI and the Australian Department of Agriculture. This highly successful and low budget activity was co-funded by HRI, ACIAR and INIBAP; IITA contributed to the expenses of their training personnel.

Banana tissue culture and virus indexing

INIBAP/ASPNET sponsored the attendance of Mr Agus Sutanto from CRIH, Indonesia and Mr Zamzuri bin Hj Ishak of the Malaysian Department of Agriculture at a three-week training course on banana tissue culture and virus indexing held at TBRI from February 21 to March 10, 1995. Ms Lydia Magnaye, a Virologist from BPI, was supported by INIBAP to spend a week as a visiting scientist at TBRI and at Dr Su's virology laboratory at National Taiwan University (NTU).

At the invitation of Dr S.C. Hwang, Dr Ho Huu Nhi, Officer-in-Charge of the banana tissue culture laboratory of INSA, spent two

weeks as a visiting scientist at TBRI to study the technology of banana germplasm conservation *in vitro.* Funding support was provided by INIBAP.

Banana taxonomy

Mr Le Dinh Danh, Officer-in-Charge of Phu Ho Fruit Research Centre and curator of the Viet Nam banana field collection, was given the opportunity to study banana classification in Taiwan. Mr Danh and Dr J.P. Horry, INIBAP's Germplasm Officer and Taxonomy Expert, visited banana taxonomists at the germplasm collection at Los Baños and Davao to discuss the classification scheme adopted in the Philippines.

Network coordination

Epidemiology of banana virus diseases

ASPNET is coordinating collaboration between BPI and NRI on the epidemiology of banana viruses in Davao, Philippines.

Collection of *Fusarium*

ASPNET also coordinated the collection of *Fusarium* specimens from Thailand by Dr Randy Ploetz of the University of Florida with the cooperation of Mr Det Wattanachaiyingcharoen, the Coordinator of the Thai banana research network.

NARS support for INIBAP

The Philippines has decided to include INIBAP-IPGRI among the CGIAR beneficiary agencies receiving annual support from the Republic of the Philippines. At the International Centres Week, held in November in Washington, D.C., the Philippines representative to CGIAR announced an annual contribution of US$20,000 to INIBAP.

Strategic Research

Diversity in Fusarium wilt pathogen

The QDPI research laboratory at Indooroopilly is conducting research on the diversity of *Fusarium oxysporum* f. sp. *cubense*, the Fusarium wilt pathogen. Scientists from the region cooperate by collecting Fusarium fungus from various sources for identification by the QDPI laboratory.

Diagnostic tests for BBMV

QDPI has been given an INIBAP grant to develop diagnostic tests for BBMV to permit the screening of germplasm and planting material. CIRAD-FLHOR and BPI also cooperate on this project.

Network News

During a visit to QDPI's Centre of Wet Tropics Agriculture at South Johnstone in Queensland, Australia, INIBAP's Scientific Research Coordinator observed a disease on Kluai Namwa Khom (ABB dwarf 'Pisang Awak') that closely resembled Acrodontium leaf speckle. This is reportedly caused by *Acrodontium simplex* and is manifested by lesions which first appear as brown to dark brown specks and later elongate to form fine streaks parallel to the veins; the necrotic streaks then coalesce and the surrounding leaf tissue turns yellow. However, specimens from South Johnstone were identified by QDPI, Indooroopilly, as leaf speckle caused by *Periconiella musae* (*Ramichlorodium musae*). This was unexpected as *R. musae* had previously been described as producing circular blotches on the lower surfaces of banana leaves in humid locations and not streaks. A microscopic examination of more specimens from Asia is needed to resolve the identity of the fungi producing the various speckle symptoms.

QDPI reports that FHIA-01 (Goldfinger) continues to perform well under subtropical conditions in Australia. Compared to the leaves of Cavendish-type varieties, the leaves of FHIA-01 remain green in the winter and there is no underpeel discoloration on winter fruit.

With regard to susceptibility to yellow Sigatoka, FHIA-01 is said to have 10 healthy leaves at harvest compared to one or two with untreated Cavendish. QDPI also reports that FHIA-01 is both resistant and tolerant to *Radopholus similis*. This burrowing nematode does not multiply significantly on FHIA-01 and little growth reduction has been observed when plants are artificially inoculated. Resistance is manifested four to eight months after tissue cultured plantlets are deflasked.

INIBAP's Scientific Research Coordinator visited the Horticultural Research and Development Institute (HORDI) of the Sri Lanka Department of Agriculture at Gannoruwa in July 1995, to investigate suspected outbreaks of Moko disease, and to identify key disease and pest constraints to production. No evidence could be found that Moko disease was present in Sri Lanka. However, a bacterium isolated by Dr I. De Zoysa, from a banana with wilt symptoms, has been identified by IMI as *Pseudomonas solanacearum* race 1, biovar 3. This solanaceous strain usually excludes *Musa*. However, it has been reported on *Musa* species in Honduras and could be the cause of the minor bacterial problem on banana which has been reported in Sri Lanka since 1930.

Embul (AAB 'Mysore'), the most popular and widespread banana in Sri Lanka, was seen with virus symptoms in many locations. An analysis of leaf specimens from three plants sent to Dr John Thomas at QDPI revealed that one was infected with BBMV, one with BBMV and BBTV, and one with BBMV and BSV. These are the first reports of BBMV and BSV in Sri Lanka. Yield losses due to double virus infections have been considerable.

Symptoms of freckle (*Guignardia musae*), Cordana leaf spot (*Cordana musae*) Cladosporium speckle (*Cladosporium musae*) and tropical speckle (*Ramichlorodium musae*) were also observed on Embul. Damage caused by pseudostem borer (*Odiporus longicollis*) was evident in Embul, Seeni (ABB 'Pisang Awak') and also I.C.2 growing in trial plots; symptoms of Fusarium wilt were also seen on Seeni. Leaf spot was severe on Cavendish types and Anamala (AAA 'Gros Michel'), but fungi isolated from specimens sent to CIRAD-FLHOR could not be identified as either *Mycosphaerella musicola* or *M. fijiensis*.

The Scientific Research Coordinator also visited Kerala State in India where discussions were held with Dr Harishchandra Singh, the Officer-in-Charge of the National Research Centre on Banana (NRCB) and Dr Krishnan Nair of the Department of Agricultural Botany at KAU. While in Kerala, the opportunity was taken to investigate Kokkan, a disease of Nendran (AAB 'French Plantain') and other local cultivars. Kokkan is seen frequently in farmers' plots and can be controlled in the same way as BBTV, i.e. by roguing and selection of suckers from unaffected plants. However, the incidence of Kokkan is much higher than that of BBTV.

The characteristic bract streaks were an indication that Kokkan is caused by BBMV. This was confirmed by QDPI's examination of leaf specimens of Nendran with typical Kokkan symptoms. Symptoms of BBMV were also recognized on many accessions in the germplasm collection at the KAU Banana Research Station at Kannara, including Monthan (ABB) types, Basrai (AAA 'Dwarf Cavendish') and *Musa ornata*.

Dr Nair has recently been awarded a research grant from the BIP to establish a centre at Kannara to develop banana and plantain cultivars with pest and disease resistance and export potential. A Nendran with resistance

Sources of Resistance to Yellow Sigatoka Present in Banana Germplasm from Papua New Guinea

Jeff Daniells, Ron Peterson and Neil Bryde

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*In many countries, yellow Sigatoka has been completely replaced by the more virulent leaf disease black Sigatoka (*Mycosphaerella fijiensis *Morelet). However, yellow Sigatoka remains the most important leaf disease in Brazil, several countries in South and Southeast Asia as well as in high altitude tropical areas such as Colombia and Cameroon. In north Queensland, Australia, the major banana disease is still yellow Sigatoka (*Mycosphaerella musicola *Leach) which, if not treated, causes major leaf damage and results in reduced yield and fruit quality.*

Because yellow Sigatoka remains important, especially in Queensland, the opportunity was taken to assess the reaction to yellow Sigatoka of the many Papua New Guinea banana varieties which were being taxonomically and agronomically assessed by QDPI at South Johnstone Research Station. These 200 or so varieties had been collected in Papua New Guinea by IBPGR (now IPGRI), in association with INIBAP and QDPI, during 1988-89.

The varieties were rated for disease on three occasions at monthly intervals prior to bunch emergence. Varieties were categorized as highly resistant, resistant, susceptible or very susceptible, using the criteria shown in Table I. The results indicate that over one half of the germplasm was resistant or highly resistant to yellow Sigatoka. These resistant varieties came from a range of genomes but the positive effect of the B genome on resistance was notable as had been found previously (Cheesman and Wardlaw, 1937; Simmonds, 1966; Meredith and Lawrence, 1970). Our characterization is only preliminary and the allocation to categories may change. Additional studies are required over a range of environments and where the accessions are assessed alongside a number of varieties with known reactions to yellow Sigatoka.

None of the Papua New Guinea accessions would be useful as direct replacements for north Queensland's main cultivar, 'Williams' (AAA Group, Cavendish Subgroup) because of their much lower yields and because most are better suited for cooking than for dessert purposes. However, they may be useful as a source of yellow Sigatoka resistance for breeding programmes.

Those varieties which may be of particular interest to conventional breeding programmes because of their high resistance to yellow Sigatoka would include Musa acuminata *ssp.* banksii *accessions PNG 151 and PNG 181. Of interest as female parents would be 'Kofi' (AAB, PNG 310), 'Kandrian' (ABB, PNG 148) and 'Dwarf Kalapua' (ABB, PNG 171) which possess some good agronomic features as well as high resistance to yellow Sigatoka.*

Yellow Sigatoka resistance tends to receive much less attention than black Sigatoka from international breeding programmes, some of which are unable to screen for yellow Sigatoka resistance unless their breeding material is evaluated elsewhere.

This is of particular concern to Australia as both SH-3362 and FHIA-01 ('Goldfinger') from FHIA have some susceptibility to yellow Sigatoka despite their high resistance to black Sigatoka (Daniells and Bryde, 1993; Daniells et al.*, 1995). For breeding programmes to have a broader impact, greater consideration needs to be given to yellow Sigatoka resistance. This is especially relevant for banana production in the subtropics and high-altitude tropics where yellow Sigatoka is likely to remain the dominant leaf disease organism.*

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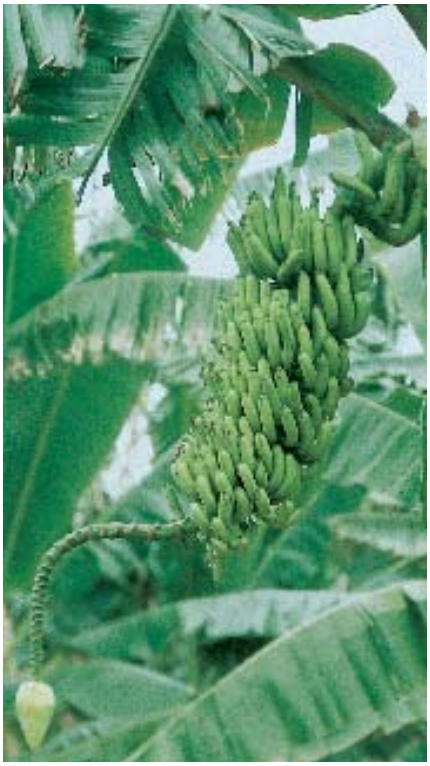
to BBMV would benefit local growers, but genetic engineering may prove to be the only way such a variety can be developed.

Another disease seriously affecting Nendran in Kerala is a leaf spot attributed to yellow Sigatoka. Plantain cultivars are generally resistant to yellow Sigatoka at sea level so the occurrence of Sigatoka on Nendran in coastal areas was of particular concern. Specimens collected and sent to CIRAD-FLHOR were found to be neither *M. musicola* nor *M. fijiensis*. As in Sri Lanka, the leaf spot, which closely resembles a Sigatoka disease, was shown to be caused by a *Mycosphaerella* sp. with *Septoria* as the imperfect state. Whether yellow Sigatoka is present in southern India is now open to question. Leaf spot specimens sent from Tamil Nadu State to CIRAD-FLHOR have also been found to be caused by the *Mycosphaerella /Septoria* pathogen and it is highly likely that the fungus is the same as that reported on banana in Kerala State in 1963. A similar fungus has also been recovered from leaf spots which predominate in Malaysia and Thailand, and which were attributed in the past to yellow Sigatoka. The leaf spot situation in West Malaysia has become more complex with the discovery of black Sigatoka in Johore in the south and Langkawi Island in the north.



(from left to right)

Musa acuminata *ssp.* banksii *(PNG 181) is highly resistant to yellow Sigatoka.*

'Dwarf Kalapua' (PNG 171) is highly resistant to yellow Sigatoka.

'Kofi' (PNG 310) combines high bunch weight, dwarf characteristics and high resistance to yellow Sigatoka.

Table 1 The reaction of the genomic groups to yellow Sigatoka

		No. of accessions	Disease Reaction[1]			
			HR	R	S	VS
WILD SPECIES						
Eumusa						
	M. a. sbsp. *banskii*	17	4	5	8	0
	M. a. sbsp. *banksii* x *M. schizocarpa*	5	1	2	2	0
	M. schizocarpa	1	1	0	0	0
Australimusa						
	M. peekelii and *M. maclayi*	4	4	0	0	0
EDIBLE VARIETIES						
Fe'i	1	1	0	0	0	
AAT	3	3	0	0	0	
AS	5	2	1	2	0	
AA	81	6	26	47	2	
AAA	13	0	3	9	1	
AAB	24	12	8	4	0	
ABB	9	9	0	0	0	
ABBB	1	1	0	0	0	
BB[2]	3	3	0	0	0	
TOTAL	167	47	45	72	3	

[1] *HR = Highly Resistant - Youngest Leaf Spotted (YLS) ≥ 10.0*
R = Resistant - YLS 8.5-9.9
S = Susceptible - YLS 6.0-8.5
VS = Very Susceptible - YLS < 6.0

[2] *Chromosome counts indicate diploids. Morphological features are predominantly B. However, INIBAP 1993 Annual Report indicates AB for 2 of these accessions (PNG034 and 125).*

Sites in India and Thailand, where recently developed hybrids and selected cultivars are to be evaluated for reaction to leaf spot under the IMTP, may be well suited for assessing germplasm for resistance to the *Mycosphaerella/Septoria* pathogen. Studies are underway at CIRAD-FLHOR in Montpellier to obtain more information on the pathogenicity of isolates from India, Sri Lanka and other countries, and to determine the geographic distribution of the pathogen.

Most *Musa* accessions from Indian regional field genebanks have been established at the NRCB at Podavur, in Tamil Nadu State, in a consolidated field collection for future taxonomic work to resolve synonymy. Diploids are also being evaluated at NRCB for breeding potential. The most important cultivar grown locally is Poovan (AAB 'Mysore'), but many plants are infected with BSV. Severe leaf symptoms are common, and stunted plants and plants with bunches 'choking' on emergence, or emerging through the pseudostem, are observed frequently. Yield reductions are believed to be high and will be quantified at NRCB. INIBAP will supply NRCB with Pisang Ceylan (AAB 'Mysore'), a clone free of BSV from ITC to act as mother stock for a possible restocking programme for the local industry.

Sub-Saharan Africa

Children selling bananas at Port Harcourt, Nigeria

INIBAP continues to play an active role in sub-Saharan Africa despite the lack of permanent INIBAP staff in the region.

The future direction of research on banana and plantain in the region was discussed at a meeting held at IITA's High Rainfall Station at Onne, Nigeria, in September 1995. INIBAP actively participated in this meeting which brought together 26 *Musa* scientists from West and Central Africa, IITA and INIBAP.

Musa Germplasm Management

Virus indexed germplasm was sent to the region either directly from ITC or through CRBP, which has agreed to act as an intermediate centre, under the auspices of INIBAP, for the multiplication and dissemination of selected germplasm. In 1995, ITC sent 61 accessions to eight different organisations in seven countries in the region for general studies. In addition, CRBP supplied 2 214 vitroplantlets, of 26 different varieties, to four extension agencies in Guinea, Chad and Gabon.

Six improved hybrids, developed at IITA, have successfully passed INIBAP's phytosanitary testing and are now available for distribution from ITC.

The first batch of 13 reference varieties was also sent by ITC to the three MGIS partners.

Musa Improvement

IMTP

IITA Nigeria, the Kawanda Agricultural Research Institute of the National Agricultural Research Organization (NARO-KARI), Uganda and CRBP all participate actively in IMTP and MGIS activities. In 1995, 32 *Musa* varieties were sent to NARO-KARI for IMTP trials to evaluate resistance to black Sigatoka and Fusarium wilt.

Network News

INIBAP Participates in IITA workshop

A meeting was held by IITA in September to discuss the future scope of research on banana and plantain in the region. Dr Margaret Quinn, Director of IITA's Crop Improvement Division, opened the workshop by posing the questions "What are the priority areas for research?", "Which programmes or institutions are best able to

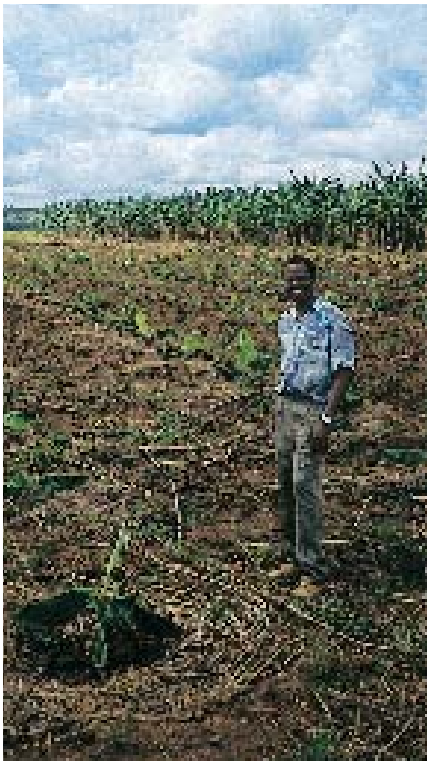
carry out this research?" and "With scarce resources, how best can duplication be minimized and complementarities optimized in the implementation of the regional research agenda?".

INIBAP's Scientific Research Coordinator, Dr David Jones, outlined INIBAP's global and regional programmes, highlighting the benefits for *Musa* researchers in Africa.

Dr Rodomiro Ortiz gave a talk on IITA's banana and plantain improvement programme at Onne and Mr Dirk Vuylsteke spoke on IITA's progress in building a partnership with NARS in East Africa. Dr Cornelia Pasberg-Gauhl and Dr Friedhelm Gauhl described IITA's *Musa* health programme and the diagnostic surveys undertaken in the region. Surveys carried out in 60 villages in Nigeria found low levels of BSV on plantains; this indicates that the disease has been present in Nigeria for a long time and may also be widespread in West Africa. They produced a publication describing symptoms of BSV in Nigeria, these include leaf streaks, stunted plants, inverted bunches protruding through the pseudostem, distorted bunches showing incomplete emergence and necrotic tissue within the pseudostem.

Talks were also given by Dr Jonathan Crouch on prospects of biotechnology in

IMTP Trial site at the Kawanda Agricultural Research Institute, Uganda



A taxonomic-linguistic study of plantain cultivars in Africa : fieldwork in Eastern Africa[1]

Gerda Rossel

For an understanding of the history of plantain in Africa, of its origin, introduction, diffusion and diversification, knowledge about the cultivars grown in East Africa is indispensable. Plantain was introduced from Asia to Africa's east coast from where it spread to the interior of the continent. The origin, date and agent of introduction are unknown, as is the identity of the original cultivar(s) or cultivar-type(s) and the routes by which the crop spread to the interior of the continent.

Fieldwork was undertaken to obtain an overall impression of the cultivars and cultivar groups present in East Africa and to test the conclusions from fieldwork carried out in West and Central Africa. One of the conclusions was that the French Giant and Medium Green Pendulous cultivars must have been the first plantains to arrive in the Congo-Gabon area from an easterly direction, via northern Zaire, and along the Zaire and Ubangui rivers and their affluents. The False Horn type of plantain was believed to have been a relatively recent introduction to the area, but data were inconclusive.

Plantain history in Africa cannot be studied by looking at botanical data alone, because there are too many unknown factors. Linguistic and other information will, therefore, be used here to look at the problem from different angles and to help construct a composite picture of the crop's past in the continent. However, this cannot be done adequately without considering the history of the other bananas in the area. Therefore, they have been included in the study, wherever possible or necessary.

Africa

The French Medium Green Pendulous plantain must have been the first cultivar to be introduced to the northern Swahili coast, probably by Arab traders, at the beginning of the period of Islamic expansion, from India. The Horn plantain (and some other bananas) came later. The False Horn plantain was the last to arrive, from a westerly direction, and was possibly introduced by the Portuguese to the coast of West and Central Africa. The question of whether the East African highland banana spread to the interior of Africa before or after the plantain will be dealt with below.

One of the reasons why plantain cultivars are so numerous in the central African forest zone and banana in the highlands of East Africa, is the advantage of Musa *over other crops. This is in part a result of agro-ecological conditions but may have been enforced by culture. In most of eastern Africa, grain crops were, and still are, the main staple but they are not well suited to humid rain-forest conditions with low light-intensity, where hunting and gathering continued to form an important part of subsistence. Moreover, yam* (Dioscorea) *was practically the only root crop available before the introduction of taro* (Colocasia) *from Asia, and cassava* (Manihot) *and sweet potato* (Ipomoea) *from the New World. What is more, root crops are better suited to intermittent forest-savannah areas (Rossel, 1987). Only in a few high-rainfall areas in East Africa is* Musa *as important as in the west of Central Africa. This situation may be due to diseases (blights, rusts, blasts, smuts, rots, etc.) and to the cold weather-susceptibility of the traditional grain crops. Another factor is bird damage. In the Kagera area in Northwest Tanzania, where the highland banana is a staple, more bird species occur than in the whole of Europe. It is a real birdwatcher's paradise, but grain cultivators may not see it this way. The success of* Musa *in these areas has been further enhanced by mixed-farming methods, making permanent banana plantations possible. Interestingly, the different ways in which plantains in Central Africa and the East African highland bananas in East Africa are cultivated are very similar to the different systems of* Ensete *cultivation in Ethiopia (Rossel, in press). Another reason for high-density banana cultivation in East Africa is that when grown close together bananas create their own favourable microclimate. Kreuer (1979) reports that for this reason farmers in Southwest Uganda like to plant their bananas near those of their neighbours.*

India

The (French) plantain is believed to have originated in Malabar in Southwest India and the Horn cultivar 'moongil' in South India (Jacob, 1952, Nayar, 1957 cited in Singh and Chadha, 1993). In Kerala, Southwest India, dishes made

Musa improvement at IITA and on virus indexing/elimination and the safe movement of *Musa* germplasm in West and Central Africa. Following a report on postharvest research in *Musa* at IITA, representatives of NARS and research institutes from Cameroon, Côte d'Ivoire, Ghana, Guinea Conakry, Nigeria, Togo and Zaire summarized the constraints and needs of *Musa* research in their respective countries.

During discussions on research priorities and limitations to *Musa* production, it became clear that participants believed that the main issues were, in order of importance: pests and diseases, crop management, nutritional problems, postharvest problems and insufficient germplasm resources. In many countries, the effect of black Sigatoka and weevil borer has been significant. The representative of Ghana mentioned that weeds and the short supply of planting material was of importance in Ghana.

BSV symptoms

Dr Jackie Hughes of IITA reported that the appearance of BSV symptoms in infected plants is related to temperature changes and that she had been able to stimulate symptom expression in new leaves by heat shock. The transfer from 34°C, the outside temperatures in Nigeria, to 26-28°C, and *vice versa*, could initiate the development of streak symptoms. Other findings showed that the longer an infected plant is held at the same temperature, the less intense symptoms become.

of French plantain are considered delicacies and the fruits are in very high demand during festive seasons (Singh, 1990), as is also the case in coastal Kenya and Tanzania, where Arabic influence is strong. The False Horn type was presumably found further south in Asia by the Portuguese and brought to Africa's western coast. The different locations of the three types in Asia is thus mirrored in the differences in the presumed antiquity and distribution of plantain in Africa.

As for the group of East African highland bananas, which are said to be unknown outside East Africa, Simmonds (1966) believes that they may be represented in South India by cultivars like 'Kari vazhai', 'manoranjitham' and 'nalla chakkarakeli' (keli means 'banana' and the resemblance of 'chakkara' with the Ganda cultivar name 'nshakara' must be a coincidence). The cultivar suspected as being the oldest in Africa, on the grounds of its name and its spread, is called 'ndishi' in the Taita-Killimanjaro area and belongs to the 'Lulugira' group of cultivars. The above-mentioned group of Indian cultivars is found, like the Horn plantain, in South India. The highland banana, like the Horn plantain may, therefore, have come to Africa later than French plantain. Further botanical, historical and linguistic study is needed on Musa *in Asia to confirm these conclusions.*

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[1] *Excerpt from "Taxonomic-linguistic study of plantain cultivars in Africa". Phase III. Fieldwork Eastern Africa. 20/06/94-20/01/95. DGIS: RF91/867" by G. Rossel (June 1995). This report is the result of field work in eastern Africa in the third phase of a study on plantain cultivars in Africa, executed on behalf of INIBAP and financed by the Dutch Ministry of Development and Cooperation. Reports of Phase I (East Cameroon) and Phase II (Gabon, Congo) have been submitted in June 1992 and May 1994.*

Editor's Note: The author uses the word "plantain" to refer to the formal Musa *AAB group Plantain subgroup, whereas "banana" is used in a wider sense. East African highlands banana belong to the* Musa *AAA group Mutika-Lujugira subgroup.*

Dr Friedhelm Gauhl, IITA* Musa *pathologist, inspecting banana plants at Onne, Nigeria

Information & Communication

The INIBAP Information/Documentation Unit supports INIBAP's partners and other members of the *Musa* community by maintaining and regularly updating the global *Musa* information and documentation network; by providing a wide range of tools, products and services; and by assisting in the development and maintenance of regional information and documentation networks.

Information Tools and Services

MGIS

Development of the MGIS database

A meeting of the Steering Committee of the MGIS/IDRC project took place in May 1995. Participants discussed the technical report prepared by CIRAD biometry and computer experts, in consultation with INIBAP staff, which gives the architecture of the whole information system and a flowchart for the software design. Terms of Reference for the development of the database software were prepared and sent for tender. INIBAP received the bids in October and CIRAD's offer was selected.

Morpho-taxonomic study of reference varieties

Reference varieties will be characterized in various locations under a range of environmental conditions in order to determine the effect of the environment on morpho-taxonomic characters. This information will be used to improve the variety identification software known as MUSAID. Reference varieties have already been dispatched to nine *Musa* genebank curators around the world together with technical guidelines. Details are provided in regional sections.

Revision of the "Descriptors for Banana (Musa)"

The draft English version of the revised Descriptors for Banana was sent to IPGRI's - Documentation, Information and Training Group (DIT) and to other experts for appraisal in July. Some modifications will be made by DIT to make it compatible with the existing series of descriptor lists. Comments received from experts will also be taken into account and incorporated as appropriate.. The final version of the characterization chapter will be trilingual (English, French and Spanish) to cover the range of prospective users in banana-producing countries.

MGIS and SINGER

The main objective of the System Wide Information Network on Genetic Resources (SINGER) is to make the data on genetic resources, held in the CGIAR Centres, available worldwide in an electronic format. A SINGER planning meeting was organized at CIMMYT, Mexico in October, to which genetic resources experts and database specialists within the CGIAR were invited, to ensure that the CGIAR Centres have a clear understanding of SINGER and to reach consensus on its objectives and planning.

The MGIS Project Coordinator attended the meeting and presented the MGIS initiative, highlighting the fact that most of the information concerning accessions held by INIBAP has been provided by the network's partners and should be made widely and freely available. The SINGER meeting participants decided that each database on genetic resources maintained by the Centres would be made available on Internet through a server base at Palo Alto in California, USA. All data related to the accessions held at the ITC will be available on Internet in 1997.

*MUSA*LIT

In 1995, 602 records were added to *MUSA*LIT, the INIBAP trilingual bibliographic database of abstracts, which now contains 3824 trilingual bibliographic records on *Musa*. These records were provided by CIRAD-FLHOR (274 records), UPEB (76 records) and INIBAP (252 records) and were published in *Musarama*, the international bibliographic abstract journal on bananas and plantains, which is printed in three languages. Three issues of *Musarama* and one Index were produced during the year.

Banana Research Information System

The updating of the project section of the Banana Research Information System (BRIS) commenced in 1995. The output will be the first edition of a directory of research in progress. The section on researchers is also in the process of updating and the third edition of the Directory of Researchers Working on Banana and Plantain will be available at the end of 1996.

Regional testing of the databases package

The "INIBAP Trilingual Databases Package", including the two INIBAP databases *MUSA*LIT and BRIS, is now available for testing in 10 sites around the world namely: CRBP; IITA-Nigeria; IRAZ; NARO-KARI; NRCB; the Philippines Council for Agriculture, Forestry and Resources Research and Development (PCARRD); the *Centro de Información y Documentación Agropecuaria* (CIDA), Cuba; EMBRAPA-CNPMF; UPEB; and WINBAN. The comments received were positive and the package will be distributed to other information centres in 1996.

Question-and-answer service

The Information/Documentation Unit at INIBAP handled 370 requests for information during 1995, which entailed the distribution of 850 INIBAP publications, the provision of 420 articles published in *Musarama*, and 13 bibliographic searches, including 900 bibliographic records on specific topics. The number of requests received has continued to grow since the service was inaugurated, the main clients being researchers from Africa, followed by Latin America and the Caribbean, and Asia and the Pacific.

Visits in the regions

Panama

The Head of INIBAP's Information/ Documentation Unit visited the UPEB premises in Panama in early September to discuss future information and documentation activities in the region. In 1990, in view of its experience in *Musa* information gathering and exchange, UPEB was chosen to be the Regional Information/Documentation Coordinating Centre at an INIBAP-LAC Regional Information/Documentation Workshop. The UPEB Information/ Documentation Centre, with the support of INIBAP, IDRC and the UPEB member countries, established the basic structure of the Regional Information/ Documentation Network.

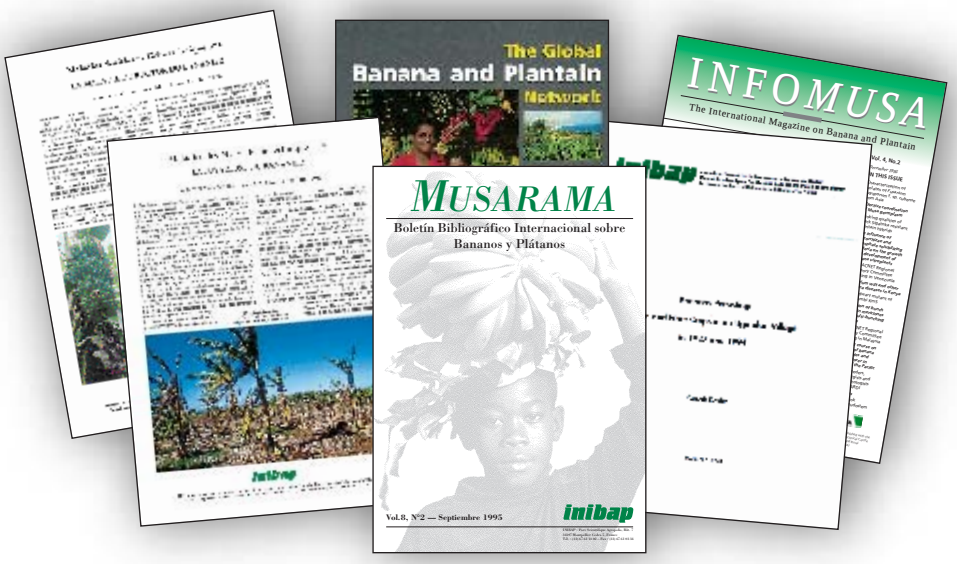
The Regional Information/Documentation Network now includes 24 institutions in 12 LAC countries. The library contains 10,000 documents dedicated exclusively to banana and plantain. Unfortunately, UPEB is presently facing a very difficult financial situation and is undergoing drastic restructuring. Most of those linked with UPEB and the Regional Information/Documentation Network are in agreement that the Centre is of inestimable value and should not be allowed to close. Several options on how to save the Centre and its services have been studied and the most likely solution is that IICA will integrate the information/documentation activities of UPEB into its operations.

In the meantime, arrangements have been made to ensure the continuity of the Spanish version of *Musarama* and INFO*MUSA*. The translator formerly contracted by UPEB continues to translate *Musarama* and INFO*MUSA,* and the Spanish version of *Musarama* is compiled, printed and distributed in Montpellier. INFO*MUSA* continues to be produced entirely in Panama.

Cuba

In September, the Head of the INIBAP Information/Documentation Unit visited CIDA in Cuba to discuss future collaboration and participation in the pre-INFO'95 Conference on *Información, Comunicación Científica Tecnológica y Extensión en el Sector Agro-Alimentario.*

CIDA actively participates in the LAC Regional Information/Documentation Network and is also an FAO depository library and an input centre for AGRIS and CARIS. The library includes more than 16,000 serials and 50,000 books. The CIDA database, which includes more than 31,000 records, uses CDS/ISIS software.



During the visit, a meeting with 15 *Musa* researchers was organized. A presentation on the INIBAP information system was made and the researchers were shown how to use the INIBAP databases. The usefulness of the databases and INIBAP's publications was praised by those present at the meeting.

At the Conference/Workshop pre-INFO'95, 18 papers were presented on topics linked with information, scientific and technical communication, and extension in the agricultural sector. A round table on *Musa* information included three presentations: research on bananas and plantain in Cuba; the status of banana cultivation in Holguín Province; and the INIBAP information network, with emphasis on LAC regional activities. A demonstration of INIBAP's databases was also given.

A meeting was organized with CIDA and INIVIT to discuss further collaboration and funding possibilities for *Musa* information/documentation activities in Cuba. INIVIT is the main research centre working on *Musa* in Cuba and has a collection of 350 *Musa* accessions. Of the total research staff of 53, 12 carry out full-time research on banana and plantain. The possibilities of preparing a joint CIDA/INIVIT two-year project proposal were discussed and a draft was prepared which will be finalized in early 1996. The proposal contains the following components: improvement of technology to ensure good communications at national, regional and international level as well as access to information on *Musa;* the training of national users in the INIBAP information/ documentation system; and, an impact study.

Venezuela

The Head of Information/Documentation participated in the LACNET-RAC meeting, held in Venezuela in September, where a presentation was made on INIBAP. The difficulties facing UPEB were discussed and members of the LAC Information/ Documentation Regional Network, and the representatives of UPEB countries, were urged to reach a decision as soon as possible on its future so as not to lose the information/ documentation dynamic that had been created in the region.

Communications/ Publications

In 1995, 16,000 copies of ten new publications and serials were distributed worldwide. Other publications which are in progress include: the Proceedings of the International Workshop 'New frontiers in resistance breeding for nematode, Fusarium and Sigatoka,' held in Serdang, Selangor, Malaysia, from 2-5 October, 1995; a *Musa*logue on Papua New Guinea varieties, and a manual on postharvest criteria and methods for routine screening of banana and plantain hybrids.

Musarama, the International Bibliographic Abstracts Journal on Banana and Plantain, has changed its look but not its spirit; its cover has changed from green to beige but it remains "green" as it is now printed on recycled paper. The cover shows a boy carrying a bunch of bananas on his head.

Global publications

- *Annual Report 1994*. 56p.
- *Bananas persisting: Food and Fibre Crops in a Ugandan Village in 1937 and 1994.* 63p.

Trilingual serials

- *Musa* Disease Fact Sheet No.5 *Fusarium Wilt of Banana*
- *Musa* Disease Fact Sheet No.6. *Bugtok Disease of Banana*
- *Musarama* Vol. 8, No. 1, 2 & 3 and indexes
- INFO*MUSA* Vol. 4, No. 1 & 2

Staff Publications and Presentations

Publications

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Engels, J.M.M. and *E.A. Frison*. A multilateral system for plant genetic resources. A paper presented at the Adaptation in Plant Breeding XIV EUCARPIA Congress, 31 July-4 August, 1995. Jyväskylä, Finland.

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Mateo, N. The future of INIBAP. Paper presented at the fifth INIBAP-LACNET Regional Advisory Committee meeting held in Caracas, Venezuela, 23-26 September 1995.

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1995

Financial Highlights

Revenue

	Core			
	Unrestricted	Restricted	Complementary	Total
Australia	232		35	267
Belgium	254	167	414	835
Canada	231			231
France	220	51		271
India	25			25
Netherlands	94		7	101
Spain	50			50
USAID	50			50
IBRD	171			171
IDRC		5	45	50
UNDP		280	330	610
CTA			38	38
EEC-STD3			14	14
CIRAD			67	67
TBRI			3	3
United Kingdom			112	112
Other Incomes	129			129
Total Revenues	**1456**	**503**	**1065**	**3024**

As of December 31, 1995 - (US$000)

Expenditures

	Core			
	Unrestricted	Restricted	Complementary	Total
Research Programmes				
Germplasm and Breeding	430	392	723	1545
Conferences and Training	151	48	151	350
Information Services	306	5	142	453
General Administration	515			515
Total Expenditures	**1402**	**445**	**1016**	**2863**
Recovery of Indirect Costs	(107)	58	49	0
	1295	**503**	**1065**	**2863**

As of December 31, 1995 - (US$000)

Staff List 1995

Name	*Position*	*Nationality*	*Joined*	*Stationed*
Emile Frison*	Director	Belgium	01-10-95	Montpellier
Nicolás Mateo**	Director	Costa Rica	01-09-92	Montpellier
Elisabeth Arnaud	Documentalist	France	01-10-89	Montpellier
Ronald Bogaerts	Technician	Belgium	12-02-88	ITC, Belgium
Philippe Deschamps	Documentalist	France	01-09-92	Montpellier
Susan Faure	Senior Programme Assistant	U.K.	01-06-88	Montpellier
Jean-Pierre Horry	Germplasm Coordinator	France	15-08-94	Montpellier
Ramiro Jaramillo	Regional Coordinator LAC	Costa Rica	01-07-87	Costa Rica
David Jones**	Scientific Research Coordinator/ IMTP Leader	Australia	01-02-92	Montpellier
Els Kempenaers	Research Technician	Belgium	15-10-90	ITC, Belgium
Florence Malafosse	Programme Assistant	France	01-02-91	Montpellier
Claudine Picq	Head, Information/Documentation	France	01-04-87	Montpellier
Versalynn Roa	Regional Programme Assistant ASPNET	Philippines	01-01-91	Philippines
Régine Roux	Programme Assistant	France	02-06-87	Montpellier
Rony Swennen*	Honorary Research Fellow	Belgium	01-12-95	KUL, Belgium
Tom Thornton	Financial Manager	U.K.	01-08-90	Montpellier
Ramon Valmayor	Regional Coordinator ASP	Philippines	01-01-91	Philippines
Ines van den Houwe	Officer in Charge ITC	Belgium	01-02-92	ITC, Belgium
Lissette Vega	Regional Programme Assistant LACNET	Costa Rica	01-02-92	Costa Rica

** Joined during the year*
*** Left during the year*

Acronyms and Abbreviations

ACIAR	Australian Centre for International Agricultural Research
ARI	Agricultural Research Institute, Tanzania
ASPNET	Asia and Pacific Regional Network, INIBAP, Philippines
BADC	Belgian Agency for Development Cooperation
BBMV	Banana bract mosaic virus
BBTV	Banana bunchy top virus
BIOTROP	Biotechnologies appliquées à l'amélioration des plantes tropicales, CIRAD-FLHOR, France
BIP	Banana Improvement Programme
BPI	Bureau of Plant Industry, Philippines
BRIS	Banana Research Information System, INIBAP, France
BSU	Benguet State University, Philippines
BSV	Banana streak virus
CATIE	Centro Agronómico Tropical de Investigación y Enseñanza, Costa Rica
CENIAP	Centro Nacional de Investigaciones Agropecuarias, Venezuela
CFC	Common Fund for Commodities, the Netherlands
CGIAR	Consultative Group on International Agricultural Research
CICY	Centro de Investigaciones Científicas de Yucatán, Mexico
CIDA	Centro de Información y Documentación Agropecuaria, Cuba
CIMMYT	Centro Internacional de Mejoramiento de Maiz y Trigo, Mexico
CIRAD	Centre de coopération internationale en recherche agronomique pour le développement, France
CNPMF	Centro Nacional de Pesquisa de Mandioca e Fruticultura, EMBRAPA, Brazil
CORBANA	Corporación Bananera Nacional, Costa Rica
CORPOICA	Corporación Colombiana de Investigación Agropecuaria, Colombia
CRBP	Centre de recherches régionales sur bananiers et plantains, Cameroon
CRI	Crop Research Institute, Ghana
CRIH	Central Research Institute for Horticulture, Indonesia
DIT	Documentation, Information and Training Group, IPGRI
ECS	Embryogenic cell suspension
EMBRAPA	Empresa Brasiliera de Pesquisa Agropecuaria
ESARC	East and Southern Africa Regional Centre, IITA, Uganda
EU	European Union
FAO	Food and Agriculture Organization of the United Nations
FDA	Fundación de Desarrollo Agropecuario Inc., Dominican Republic
FHIA	Fundación Hondureña de Investigación Agrícola, Honduras
FLHOR	Département des productions fruitières et horticoles, CIRAD, France
FONIAP	Fondo Nacional de Investigaciones Agropecuarias, Venezuela
FUSAGRI	Fundación Servicio para el Agricultor, Venezuela
HORDI	Horticultural Research and Development Institute, Sri Lanka
HRI	Horticultural Research Institute, Thailand
IAEA	International Atomic Energy Agency, Austria
IBP	Instituto de Biotecnología de las Plantas, Cuba
ICA	Instituto Colombiano Agropecuario, Colombia (now CORPOICA)
ICIA	Instituto Canario de Investigación Agrícola, Spain
IDEFOR	Institut des Forêts, Côte d'Ivoire
IDIAP	Instituto de Investigaciones Agropecuarias de Panama
IDRC	International Development Research Centre, Canada
IICA	Instituto Interamericano de Cooperación para la Agricultura, Costa Rica
IITA	International Institute of Tropical Agriculture, Nigeria
IMI	International Mycological Institute, UK
IMTP	International *Musa* Testing Programme, INIBAP, France
INCV	Institut national des cultures vivrières, Togo
INERA	Institut national pour l'étude et la recherche agronomiques, Zaire.
INIFAP	Instituto Nacional de Investigaciones Forestales y Agropecuarias, Mexico
INIVIT	Instituto de Investigaciones en Viandes Tropicales, Cuba
INSA	Institut national des sciences agronomiques, Viet Nam
INTA	Instituto Nacional de Tecnología Agropecuaria, Argentina
IPGRI	International Plant Genetic Resources Institute, Italy
IPM	Integrated pest management
IRA	Institut de la recherche agronomique, Cameroon
IRAG	Institut de la recherche agronomique de Guinée
IRAZ	Institut de recherches agronomique et zootechnique de la Communauté économique des pays des grands lacs, Burundi
IRTA	Instituto de Recerca y Tecnología Agroalimentaria, Spain
ISEM	Immunosorbent electron microscopy
ITC	INIBAP Transit Centre, Belgium
KARI	Kawanda Agricultural Research Institute, NARO, Uganda
KAU	Kerala Agricultural University, India
KUL	Katholieke Universiteit Leuven, Belgium
LACNET	INIBAP Regional Network for Latin America and the Caribbean, Costa Rica
MARDI	Malaysian Agricultural Research and Development Institute
MGCN	*Musa* Germplasm Conservation Network
MGES	*Musa* Germplasm Exchange System
MGIS	*Musa* Germplasm Information System
MHRS	Maroochy Horticultural Research Station, Australia
MoU	Memorandum of Understanding
NARO	National Agricultural Research Organization, Uganda
NARS	National Agricultural Research Systems
NEPs	National Evaluation Programmes
NRCB	National Research Centre on Banana, India
NRI	Natural Resources Institute, UK
NTU	National Taiwan University
ODA	Overseas Development Administration, UK
ORF	open reading frame
PCARRD	Philippines Council for Agriculture, Forestry and Resources Research and Development
PCR	polymerase chain reaction
PNB	Programa Nacional de Banano, Ecuador
QDPI	Queensland Department of Primary Industries, Australia
QUT	Queensland University of Technology, Australia
RAC	Regional Advisory Committee
RC	Regional Coordinator
RFLP	restriction fragment length polymorphism
RIF	Research Institute of Fruits, Indonesia
RISBAP	Regional Information System for Banana and Plantain in Asia and the Pacific, INIBAP, Philippines
SAS	Servicio Autónomo de Sanidad Vegetal, Ministerio de Agricultura y Cria, Venezuela
SASA	Servicio Autónomo de Sanidad Agropecuaria, Venezuela
SCAU	South China Agricultural University
SCRI	Scottish Crop Research Institute, UK
SINGER	System Wide Information Network on Genetic Resources
SSA	Sub-Saharan Africa
TAS	Triple-antibody sandwich
TBRI	Taiwan Banana Research Institute
UNIBAN	Unión de Bananeros de Urabá, Colombia
UPEB	Union of Banana Exporting Countries, Panama
UPLB	University of the Philippines at Los Baños
VCG	vegetative compatibility group
VIC	Virus Indexing Centre
VVOB	Flemish Association for Development, Cooperation and Technical Assistance, Belgium
WIBDECO	Windward Island Banana Development and Exporting Company
WINBAN	Windward Islands Banana Growers' Association

L'INIBAP en 1995

Les activités concernant la conservation du matériel génétique de *Musa* ont été examinées par les membres d'une revue externe qui ont souligné dans leurs conclusions le bon rapport coût-efficacité et l'importance de l'utilisation de la collection de *Musa* maintenue au Centre de transit (ITC) de l'INIBAP à l'Université catholique de Leuven (KUL) en Belgique. De nouvelles directives pour l'échange en toute sécurité du matériel génétique de *Musa* ont été élaborées pendant l'année ; elles permettront d'augmenter la capacité des centres d'indexation des virus (VICs) de l'INIBAP. Des progrès significatifs ont été faits au cours de la Phase II du Programme international d'évaluation des *Musa* (IMTP) dans le cadre de laquelle l'ITC a distribué 27 accessions à évaluer sur 37 sites localisés dans 19 pays. L'évaluation du matériel végétal débutera début 1996. Les collaborations entre améliorateurs et nématologistes se sont renforcées à l'occasion d'une réunion organisée à Kuala Lumpur en Malaisie au cours de laquelle l'état actuel des connaissances sur l'amélioration des *Musa* pour la résistance aux nématodes a été passé en revue ; des directives techniques concernant l'évaluation de résistance aux nématodes ont également été élaborées. Les recherches réalisées au cours de l'année à la KUL sur la transformation génétique des bananiers ont permis de produire différents plants stables de bananiers transformés. L'amélioration conventionnelle réalisée à la *Fundación Hondureña de Investigación Agrícola* (FHIA) a eu pour résultat la création de plusieurs hybrides de type plantain résistant à la cercosporiose noire, la maladie la plus menaçante pour les *Musa ;* ces hybrides seront mis à disposition pour une évaluation internationale. Le projet de Système d'information sur le matériel végétal de *Musa* (MGIS), financé principalement par le Centre de recherches pour le développement international (CRDI), a progressé à grands pas en 1995 avec la mise en place de l'étude morpho-taxonomique de variétés standards dans 9 collections, la finalisation de la nouvelle liste de descripteurs pour les *Musa* et le développement de l'architecture du système d'information. Le logiciel du MGIS sera développé en 1996. L'INIBAP encourage les efforts régionaux en matière de recherche concernant les problèmes spécifiques des régions et renforce les collaborations entre partenaires des réseaux régionaux. Dans le cadre de ces réseaux, une évaluation, au niveau national, d'hybrides améliorés sélectionnés au cours de la Phase I de l'IMTP a eu lieu dans plus de 45 pays.

L'INIBAP : un programme au sein de l'IPGRI

Pour l'INIBAP, 1995 a été une année de transition. Après son fusionnement avec l'Institut international des ressources phytogénétiques (IPGRI) en 1994, des dispositions ont été prises afin que l'INIBAP puisse opérer comme un Programme au sein de la structure de l'IPGRI, ce qui permet de garder l'identité et la visibilité de l'INIBAP tout en augmentant le niveau de synergie du Programme résultant de la fusion.

Lors de sa réunion en septembre 1995, le Conseil d'administration a décidé d'entamer la construction d'un bâtiment destiné à abriter le siège de l'INIBAP au Parc Scientifique Agropolis à Montpellier en France. Le bâtiment de l'INIBAP, financé pour sa plus grande partie par des fonds spéciaux du Gouvernement français et du District de Montpellier, devrait être fini en septembre 1996.

Activités thématiques

Gestion des ressources génétiques de *Musa*

Collecte de matériel génétique

Bien que le Viêt-nam soit localisé dans le berceau de la diversité génétique des *Musa*, la richesse de ses ressources génétiques n'a jamais été complètement évaluée ni exploitée. L'INIBAP et le Bureau régional de l'IPGRI pour l'Asie, le Pacifique et l'Océanie (APO) ont financé un projet soumis par l'Institut national des sciences agronomiques (INSA) concernant la collecte, la caractérisation, l'évaluation et la conservation des ressources génétiques de *Musa* du Viêt-nam. Ce financement provient partiellement d'une subvention du PNUD. Un total de 107 accessions a été collecté et deux collections au champ ont été constituées, l'une dans le nord et l'autre dans le sud du Viêt-nam. Ces collections sont utilisées comme centres pour la caractérisation et l'évaluation du matériel collecté et représentent un réservoir pour l'établissement d'une collection *in vitro* au département biotechnologies de l'INSA ; pour des raisons de sécurité, le matériel génétique du Viêt-nam sera également dupliqué au Centre de transit de l'INIBAP.

Conservation du matériel génétique

Le Centre de transit de l'INIBAP, localisé à l'Université catholique de Leuven, assure la conservation *in vitro* de la plus grande collection de matériel génétique de *Musa* dans le monde et la mise à disposition des utilisateurs de cultures de tissus testés pour les virus. En 1995, 18 nouvelles accessions ont été introduites à l'ITC en provenance de six origines différentes en Amérique latine, Europe et Australie. A la fin de 1995, la banque de gènes comprenait 1056 accessions de *Musa* et 4 clones d'*Ensete*. Pour des raisons de sécurité, 40 % des accessions *in vitro* ont été dupliquées au *Taïwan Banana Research Institute* (TBRI). D'autres accords du même type sont en préparation avec le *Centro Agronómico Tropical de Investigación y Enseñanza* (CATIE) au Costa Rica et l'Institut international d'agriculture tropicale (IITA) au Nigeria afin d'assurer la duplication en toute sécurité de la partie restante de la banque de gènes.

L'INIBAP appuie le développement de protocoles de cryoconservation à la KUL pour le stockage à long terme du matériel génétique de *Musa*. En 1995, une nouvelle technique de cryoconservation pour les méristèmes de *Musa* proliférants *in vitro* a été appliquée avec succès sur plus de 15 génotypes.

Mise à jour des directives techniques pour la sécurité des mouvements de matériel génétique de *Musa*

Une réunion FAO-IPGRI-INIBAP s'est déroulée au siège de l'IPGRI afin de discuter les nouvelles directives techniques concernant la sécurité des mouvements de matériel génétique de Musa. *Les nouvelles recommandations qui ont été faites seront appliquées par les centres d'indexation des virus de l'INIBAP.*

- *Les cinq plants expédiés par le centre de transit aux centres d'indexation des virus seront sélectionnés parmi 7 et non plus 20 cultures dérivées de l'apex d'origine, afin de réduire le risque que les plantes-tests ne soient pas représentatives de l'état sanitaire de l'accession. Les deux cultures restantes seront multipliées de manière à obtenir 20 cultures de chaque accession qui seront conservées en condition de croissance lente.*
- *La période d'indexation sera réduite de 9-12 mois à 6 mois et l'indexation des virus se fera désormais après 3 et 6 mois de croissance du fait de la confiance accrue dans la fiabilité des tests pour détecter les pathogènes viraux.*
- *Les accessions, y compris celles en provenance de pays affectés par le bunchy top, seront indexées dans un seul centre d'indexation et non dans deux comme il était recommandé précédemment étant donnée que les tests d'indexation pour détecter le virus du bunchy top bananier sont aujourd'hui très fiables.*
- *De nouveaux antiserums concernant le virus de la mosaïque des bractées seront, dans un proche avenir, utilisés systématiquement dans le centre conjointement à un antiserum à large spectre pour détecter le virus de la mosaïque en tirets par microscopie électronique immuno-spécifique (ISEM). Il sera toujours nécessaire d'examiner par microscopie électronique le jus de feuilles partiellement purifié afin de détecter les particules de virus non caractérisés.*
- *Le matériel génétique sera testé pour tous les virus selon les protocoles spécifiés dans les nouvelles directives techniques. Malgré tout, les directives prévoient que, dans certains cas, les tests puissent être allégés s'il y a une quasi certitude que certains virus particuliers ne sont pas présents dans le pays d'origine du matériel végétal.*

Distribution du matériel génétique

A la fin de 1995, 465 accessions avait été testées pour les virus dans les Centres d'indexation des virus de l'INIBAP situés au Centre de coopération internationale en recherche agronomique pour le développement (CIRAD) à Montpellier et au *Queensland Department of Primary Industries* (QDPI) à Indooroopilly en Australie. Aucun pathogène viral n'a été détecté sur 87 % des accessions testées. En 1995, 362 accessions ont été envoyées à 54 organisations différentes dans 36 pays dans le monde.

Audit de la banque de gènes

En décembre 1995, le fonctionnement de la banque de gènes de l'INIBAP a été passé en revue par un panel d'experts choisis par l'*Inter-Center Working Group on Genetic Resources* (ICWG-GR). Le panel a considéré que la gestion de la collection pouvait servir d'exemple pour n'importe quelle banque de gènes traitant de plantes à reproduction végétative et que son fonctionnement était d'un très bon rapport coût/efficacité. Comme indiqué dans le rapport final, le panel a été impressionné par les liens étroits et très productifs existant entre la KUL et l'INIBAP et a félicité les deux intitutions pour leurs collaborations soutenues avec les trois centres d'indexation de virus situés en France, en Australie et à Taïwan.

Recherche stratégique

Méthodes de détection du virus de la mosaïque en tirets chez les *Musa*

Des méthodes de détection du virus de la mosaïque en tirets (BSV) par immunologie et amplification par PCR ont été développées au Département de phytopathologie de l'Université du Minnesota à Saint-Paul. Des antiserums polyclonaux de lapin dirigés contre un mélange d'isolats de BSV sérologiquement distincts ont permis de détecter par ISEM tous les isolats testés du virus. Bien que cette méthode soit sensible et fiable, elle n'est pas adaptée à l'indexation d'un grand nombre d'échantillons et devra être réservée pour des tests de confirmation. Afin d'outrepasser cette limitation, des antiserums polyclonaux additionnels ont été préparés sur des souris et des poulets et un protocole ELISA de type sandwich à triple anticorps (TAS-ELISA) a été développé.

Les protocoles utilisant la PCR à partir de sondes d'ADN total n'ont pas permis une détection fiable du BSV. Il a été montré que de l'ADN du type de l'ADN viral est intégré au génome de *Musa* donnant lieu à des produits PCR lorsque des sondes spécifiques du BSV sont utilisées, qu'il y ait présence ou non de particules virales détectées par ISEM.

La banque de gènes de l'INIBAP sous les auspices de la FAO

Le matériel génétique maintenu à la banque de gènes de l'INIBAP à l'ITC a été rassemblé par le biais de donations d'autres banques de gènes, de missions de collecte avec les programmes nationaux, de dons d'améliorateurs et d'individus. Ce matériel a été donné à l'INIBAP dans le but de sa conservation et au bénéfice des partenaires du réseau. L'INIBAP agit donc comme garant de ce matériel génétique. En octobre 1994, par un accord signé entre la FAO et l'IPGRI, la banque de gènes est passée sous les auspices intergouvernementaux de la FAO. Le matériel génétique couvert par cet accord est listé comme "matériel génétique désigné". Ce dernier continue à être à la disposition de toute personne qui en fera la demande sous la condition qu'il reste dans le domaine public. L'INIBAP a instauré de nouvelles procédures pour la distribution de matériel génétique qui tiennent compte de cette condition, appliquée depuis novembre 1995. Chaque expédition de matériel est soumise à la signature d'un formulaire de demande par l'institut, la corporation ou l'individu demandeur qui acceptent ainsi une liste de conditions qui permettent de garantir la maintenance du matériel génétique dans le domaine public et le partage de l'information obtenue après l'acquisition du matériel.

Identification et caractérisation des virus associés au virus du bunchy top du bananier

Les activités développées en 1995 au Laboratoire de pathologie végétale de la Faculté universitaire des sciences agronomiques de Gembloux en Belgique ont principalement porté sur l'amélioration de la sensibilité et de la fiabilité des tests diagnostiques pour la détection du virus du bunchy top bananier (BBTV), la caractérisation des isolats de BBTV et l'évaluation de génotypes bananiers de référence pour la résistance/tolérance au BBTV.

La technique qui associe l'immunocapture au PCR (IC-PCR) s'est avérée la plus sensible pour déceler les particules de BBTV ; elle est recommandée pour l'évaluation de

l'élimination du BBTV dans le cadre de protocoles concernant la production de plantes exemptes de virus. L'analyse par PCR réalisée sur les plantes infectées par le BBTV en provenance de différents pays du monde a montré la présence des composants 1 et 3 d'ADN du BBTV sur tous les isolats de BBTV du Laboratoire. La technique PCR utilisant des sondes B-GA s'avère être un outil adéquate pour détecter les isolats de BBTV appartenant au groupe asiatique d'isolats tel que défini par Karan *et al.* (1994).

La collection de génotypes de bananiers de références, incluant des bananiers sauvages et cultivés, est actuellement évaluée pour la résistance/tolérance au BBTV, en collaboration avec l'ITC. Les résultats préliminaires montrent une certaine variabilité entre les génotypes portant sur deux paramètres : le taux d'infection et le nombre de feuilles devant émerger avant l'observation des premiers symptômes sur des plantes infectées. Bien que ces paramètres aient besoin d'être validés par des expériences au champ, cette approche permet la définition de catégories de génotypes bananiers exhibant différents niveaux de tolérance au BBTV.

Amélioration des *Musa*

Depuis 1992, l'INIBAP appuie des projets de recherche développés par plusieurs partenaires dans des laboratoires de pointe et des programmes d'amélioration.

Quelques exemples sont présentés ci-dessous.

Suspensions cellulaires embryogènes

L'obtention de suspensions cellulaires embryogènes rencontre plusieurs obstacles. Une étude sur 20 variétés appartenant à différents groupes génomiques a démontré que la plupart ont besoin de plusieurs cycles de culture sur un milieu de prolifération 10 fois enrichi en cytokinine (100µM alors que le milieu de prolifération généralement utilisé n'est qu'à 10µM). Des suspensions ont pu être obtenues pour toutes les variétés testées mais la réponse au milieu liquide ou semi-solide était dépendante des variétés.

Manipulation génétique

Le protocole de manipulation génétique développé à la KUL est basé sur l'introduction de gènes étrangers dans une suspension cellulaire embryogène à l'aide d'un canon à particules. L'efficacité de plusieurs gènes marqueurs a été comparée en vue de sélectionner des cultures de bananiers transgéniques. Plusieurs promoteurs hétérologues ont été comparés par l'expression du gène *gusA*, marqueur de l'efficacité de la transformation. Le promoteur poly-ubiquinine de maïs s'est révélé le plus efficace pour entraîner une expression élevée des gènes dans les cellules de bananier. Des bananiers transformés de façon stable sont maintenant dans la serre de la KUL.

Appui au programme d'amélioration de la FHIA

Les hybrides FHIA-03, FHIA-18 et FHIA-21 sont des éléments déterminants dans le programme d'amélioration de la FHIA. Ce sont les premiers hybrides (avec FHIA-01 qui a été mis à disposition des producteurs de bananes australien cette année sous le nom de "Goldfinger") à être plantés commercialement du fait de leur supériorité, à la fois au niveau de la productivité et de la résistance aux maladies si on les compare avec les variétés traditionnelles. FHIA-03 est le premier bananier de type à cuire amélioré qui possède plusieurs qualités supérieures à celles que l'on trouve chez les cultivars naturels ABB. A Cuba, par exemple, 700 ha de cet hybride ont été plantés. FHIA-18, un bananier de type dessert à saveur douce-acide est également très bien accepté. Ce bananier a une floraison plus rapide et possède une grande résistance à la cercosporiose noire. FHIA-21, un hybride de type plantain résistant à la cercosporiose noire, a été évalué au Honduras. La production obtenue a représenté le double de ce que produit le traditionnel plantain 'Horn'(AAB) et beaucoup de producteurs ont souhaité se convertir immédiatement au FHIA-21. Malgré tout, l'INIBAP n'a pas rendu ce matériel prometteur disponible car des particules virales bacilliformes ont été détectées dans les premiers échantillons reçus à l'ITC. L'INIBAP continue la recherche afin d'obtenir un matériel sain.

Réseau d'améliorateurs

L'amélioration pour la résistance aux nématodes a été identifiée comme le troisième objectif dans le cadre de l'amélioration globale des *Musa*, après les cercosporioses et la fusariose. Un atelier, organisé par le *Malaysian Agricultural Research and Development Institute* (MARDI) et INIBAP a rassemblé des nématologistes et des améliorateurs de *Musa* de 14 pays ainsi que plusieurs chercheurs bananiers Malais. Un consensus s'est dégagé sur le besoin d'identifier de nouvelles sources de résistance aux principaux nématodes s'attaquant aux bananiers, en particulier aux types diploïdes fertiles, afin de les intégrer dans les programmes d'amélioration. Des protocoles de criblage des cultivars de référence résistants et sensibles ont été proposés afin d'établir une procédure d'évaluation commune pour des lignées d'amélioration et des variétés améliorées. Le besoin de mettre en place des protocoles de criblage fiables à utiliser en serre a également été souligné. Pour finir, les participants se sont mis d'accord sur la complémentarité entre les méthodes d'amélioration génétique conventionnelles (hybridation) et non-conventionnelles (biotechnologies).

Programme international d'évaluation des *Musa*

La phase I (1990-1993) du Programme international d'évaluation des *Musa* (IMTP), qui s'est concentrée avec succès sur la cercosporiose noire, a finalement recommandé trois hybrides de la FHIA pour distribution et évaluation au niveau national. Ces variétés sont actuellement évaluées dans 49 pays différents. Les maladies cibles de la phase II sont les cercosporioses jaune et noire et la fusariose. Après multiplication, l'ITC a distribué plus de 10 000 vitroplants à des collaborateurs dans 19 pays pour une évaluation sur un ensemble de 37 sites. Plusieurs programmes d'amélioration ont fourni de nouveaux hybrides prometteurs au niveau de leur résistance aux maladies et ravageurs pour une évaluation en 1997. Le matériel végétal résistant aux maladies devrait diminuer l'utilisation des pesticides, et donc favoriser le respect de l'environnement ; leur meilleure productivité sera également une source de profit pour les petits producteurs.

L'INIBAP dans le monde

Amérique latine et Caraïbes

En 1995, la *Corporación Colombiana de Investigación Agropecuaria* (CORPOICA) et l'INIBAP ont signé un accord visant à renforcer les efforts nationaux dans le domaine de la caractérisation du matériel génétique des principales plantes

alimentaires, y compris le matériel génétique naturel et amélioré de *Musa.*

L'INIBAP a financé la visite au Venezuela d'un expert en cercosporiose noire. Il s'est rendu dans la région la plus affectée par cette maladie afin de développer un plan de lutte contre le pathogène. Le Dr Dadzie du *Natural Ressources Institute* (NRI) a finalisé avec succès son projet en collaboration avec la FHIA, l'*Overseas Development Administration* (ODA) et l'INIBAP sur la caractérisation des bananiers à cuire et des bananiers plantain au stade post-récolte. Outre les conclusions scientifiques, le Dr Dadzie a préparé des manuels de références sur les caractéristiques post-récolte des hybrides de la FHIA. Ces manuels seront publiés par l'INIBAP.

Le réseau régional LACNET a co-organisé, au Costa Rica, avec le CATIE et le CIRAD, un atelier pratique sur la transformation génétique. LACNET et le CRDI ont financé la participation de 4 personnes à un cours de mise à jour sur les techniques de production des bananiers plantain, organisé par CORPOICA.

Asie et Pacifique

Le matériel génétique collecté au cours de missions antérieures au Viêt-nam a été planté en 1995 dans deux collections au Viêt-nam afin de le caractériser. Un projet financé par l'ODA sur le sauvetage et la conservation de la collection de matériel génétique de *Musa* d'Asie du sud-est à Davao aux Philippines a révélé que tout le matériel génétique transféré *in vitro* en 1989-1991 n'était pas atteint par le virus du bunchy top. La duplication de la collection de matériel génétique d'Asie/Pacifique localisée au TBRI s'est achevée en 1995. Le TBRI a également commencé ses activités d'indexation pendant le second trimestre 1995, devenant ainsi le troisième centre d'indexation pour les virus de l'INIBAP. L'ASPNET a reçu un financement de Taïwan pour mettre en place le Système d'information régionale sur les bananiers et bananiers plantain en Asie/Pacifique. Une session de formation sur "les méthodes d'évaluation des dommages et la lutte intégrée contre les ravageurs pour les charançons et les nématodes des bananiers", co-organisée par l'ASPNET, s'est déroulée en Thaïlande en septembre. Elle a rassemblé 20 participants venus de Chine, d'Indonésie, de Malaisie, des Philippines, de Tonga, du Viêt-nam et du pays hôte, la Thaïlande. L'ASPNET a également financé des formations individuelles sur la culture de tissus, l'indexation de virus et les technologies de conservation du matériel génétique de *Musa* au TBRI et sur la classification des bananiers à Davao et Los Baños aux Philippines.

Le représentant des Philippines auprès du CGRAI a annoncé, lors de la semaine des centres internationaux en novembre 1995, l'octroi d'une subvention de 20 000 dollars par an à l'INIBAP.

Afrique

Du matériel génétique testé pour les virus a été envoyé dans la région, directement de l'ITC ou au travers du Centre de recherches régionales sur bananiers et plantains (CRBP) qui agit comme centre intermédiaire pour la multiplication et la distribution du matériel génétique sélectionné sous les auspices de l'INIBAP. En 1995, l'ITC a envoyé 61 accessions à 8 organisations dans 7 pays. Le CRBP a fourni 2 214 vitroplants issus de 26 variétés différentes à 4 agences de développement situées en Guinée, au Tchad et au Gabon.

L'IITA au Nigeria, la Station de recherche agronomique de Kawanda de la *National Agricultural Research Organization* (NARO-KARI) en Ouganda et le CRBP au Cameroun participent de façon très active à l'IMTP et au Système d'information sur les ressources génétiques de *Musa* (MGIS). Les expéditions de matériel sur les sites d'évaluation de l'IMTP se sont achevées en 1995 avec l'envoi au NARO-KARI des 32 variétés nécessaires à l'évaluation pour la résistance à la cercosporiose noire et le premier lot de 13 variétés de référence a été envoyé aux 3 partenaires du MGIS.

Information et communication

Outils et services d'information

MGIS

Dans le cadre du MGIS, une étude morphotaxonomique de cultivars standards a débuté en 1995. Dans ce but, un lot de cultivars de référence a été envoyé aux collaborateurs de l'étude accompagné de directives techniques concernant les descripteurs morphotaxonomiques. Un *Musa*logue (catalogue descriptif des accessions) est en préparation sur des accessions collectées en 1988-89 en Papouasie-Nouvelle Guinée par l'IBPGR et le QDPI. A la suite de la collecte, ces accessions ont été évaluées à la Station de recherches du QDPI de South Johnstone en Australie. La structure de la base de données du système d'information sur le matériel génétique de *Musa* a beaucoup progressé en 1995.

Bases de données

*MUSA*LIT, la base de données bibliographique trilingue de l'INIBAP, a été régulièrement enrichie pour atteindre un total de 3824 enregistrements à la fin de 1995. Les enregistrements de 1995 ont été publiés dans *Musarama*, le bulletin bibliographique sur les bananiers et bananiers plantain publié en trois langues. Trois numéros de *Musarama* et les index afférents ont été produits et distribués pendant l'année, générant 370 demandes de publications et d'articles.

BRIS, le système d'information sur les recherches bananières est en cours d'actualisation. Les données mises à jour seront publiées sous forme de répertoires.

Les bases de données *MUSA*LIT et BRIS sont actuellement testées sur 10 sites dans le monde et seront distribuées plus amplement en 1996.

Visites dans les régions

En septembre, la Responsable du Service information/documentation de l'INIBAP s'est rendue au siège de l'Union des pays exportateurs de banane (UPEB) à Panama où elle a rencontré la responsable régionale du réseau d'information afin d'envisager l'avenir des activités en matière d'information et de documentation dans la région Amérique latine/Caraïbes. Elle s'est ensuite rendue à Cuba où elle a présenté le système d'information de l'INIBAP en différentes occasions puis au Venezuela pour participer à la réunion du Comité consultatif régional Amérique latine/Caraïbes.

Publications

L'INIBAP a publié en 1995 le Rapport annuel 1994, une publication régionale et plusieurs produits trilingues incluant deux fiches techniques sur les maladies des *Musa*, deux numéros d'INFO*MUSA* et trois numéros de *Musarama.* Au total, 16 000 copies de l'ensemble de ces publications ont été distribuées dans le monde pendant l'année.

INIBAP en 1995

Las actividades de conservación de germoplasma de INIBAP fueron analizadas en 1995 por una junta de revisión externa que remarcó la efectividad en costos y el alto grado de uso de la colección de *Musa* mantenida por el Centro de Tránsito de INIBAP (ITC) en la Universidad Católica de Lovaina (KUL), Bélgica. Durante el año fueron desarrolladas las nuevas guías técnicas para el movimiento seguro del germoplasma de *Musa* las cuales permitirán incrementar la capacidad de los centros de indización de virus de INIBAP. Se progresó significativamente en la fase II del Programa Internacional de Evaluación de *Musa* (PIEM) para la cual el ITC distribuyó 27 accesiones a 19 países para su evaluación en 37 sitios diferentes. La evaluación de germoplasma comenzará a inicios de 1996. Se reforzó la colaboración entre mejoradores y nematólogos con una reunión en Kuala Lumpur que revisó el estado del mejoramiento para la resistencia en contra de nemátodes y desarrolló guías técnicas para la evaluación de la resistencia de nemátodes. Investigaciones en KUL en transformación genética de banana produjeron varias plantas transformadas estables en el invernadero. El mejoramiento tradicional en FHIA, Honduras produjo varios híbridos de tipo plátano con resistencia a la Sigatoka negra, la enfermedad principal de *Musa*, los que estarán disponibles para evaluación internacional. El proyecto financiado por IDRC para desarrollar un sistema de información de germoplasma de *Musa* (MGIS) progresó considerablemente en 1995 con la implementación del estudio morfo-taxonómico de las variedades estándar de 9 colecciones, se terminó con la nueva lista de descriptores para *Musa* y el diseño de la arquitectura del sistema de información. El desarrollo del software de MGIS se realizará en 1996. INIBAP promueve los esfuerzos de investigación regionales que traten con problemas específicos de cada región y acoge la colaboración entre colegas en redes regionales. Dentro del marco de estas redes, la evaluación de híbridos mejorados seleccionados en la fase I de IMTP se estaba llevando a cabo en más de 45 países a fines de 1995.

INIBAP, un programa dentro de IPGRI

1995 ha sido un año de transición para INIBAP. Después de la unión con el Instituto Internacional de Recursos Fitogenéticos (IPGRI) en 1994, se ha acordado que INIBAP operará como un programa dentro de la estructura de IPGRI. Esto le permitirá a INIBAP mantener su identidad y visibilidad al mismo tiempo que maximizar la sinergía resultante de la unión al nivel de los programas. 1995 también ha visto un cambio en la administración de INIBAP con un compromiso firme de reforzar aun más el programa de INIBAP dentro del marco de IPGRI.

En su reunión en Septiembre, la junta directiva decidió proceder con la construcción del edificio para la sede de INIBAP en el Parque Científico Agropolis en Montpellier, Francia. Se espera que el edificio de INIBAP, que está financiado en gran parte por fondos especiales del gobierno de Francia y el Distrito de Montpellier, esté terminado en Septiembre.

Actividades tematicas

Manejo de germoplasma de *Musa*

Colectando germoplasma de *Musa*

A pesar de su ubicación dentro del centro de diversidad de *Musa*, la riqueza de recursos genéticos de *Musa* de Viet Nam nunca ha sido evaluada y utilizada. INIBAP y la oficina regional de IPGRI para Asia y el Pacífico (APO) apoyaron un proyecto presentado por el Instituto Nacional de Ciencias Agronómicas (INSA) con financiamiento parcial de PNUD para colectar, caracterizar, evaluar y conservar germoplasma de *Musa* de Viet Nam. Un total de 107 accesiones fueron colectadas y establecidas en dos bancos de germoplasma en el norte y el sur de Viet Nam. Estas colecciones sirven como centro de caracterización y evaluación de material colectado y actúan como un depósito para establecer una colección *in vitro* en el departamento de biotecnología del INSA ; para razones de seguridad, este germoplasma será también duplicado en el banco de germoplasma de INIBAP.

Conservación de germoplasma de *Musa*

El centro de tránsito de INIBAP ubicado en la Universidad Católica de Lovaina, Bélgica, intenta asegurar la conservación *in vitro* del banco de germoplasma de *Musa* mas grande del mundo y la disponibilidad continua de explantes indizados para presencia de virus. En 1995 se suplementó la colección ITC con 18 nuevas introducciones de 6 orígenes diferentes de América Latina, Europa y Australia. A fines de 1995, el banco de germoplasma comprendía 1056 accesiones de *Musa* y 4 clones de *Ensete*. Cuarenta por ciento del banco está duplicado en Taiwan como resguardo en el *Taiwan Banana Research Institute* (TBRI). Se preparó un borrador para un acuerdo con el Centro Agronómico Tropical de Investigación y Enseñanza (CATIE), Costa Rica y el *International Institute of Tropical Agriculture* (IITA), Nigeria para la duplicación de resguardo del remanente del banco de germoplasma.

INIBAP apoya el desarrollo de protocolos de crioconservación en KUL para el almacenamiento a largo plazo del germoplasma de *Musa*. En 1995 una nueva técnica de crioconservación para meristemas proliferantes de *Musa* mas fácil para el usuario fue aplicada exitosamente a más de 15 genotipos.

Distribución del germoplasma de *Musa*

A fines de 1995, 456 accesiones fueron evaluadas para detectar presencia de virus en los Centros de indización de INIBAP ubicados en el *Centre de coopération*

Revisión de las guías técnicas para el movimiento seguro del germoplasma de *Musa*

Se llevó a cabo una reunión FAO-IPGRI-INIBAP en la sede central de IPGRI en Roma para discutir la nuevas guías técnicas para el movimiento seguro de germoplasma de Musa. *Las nuevas recomendaciones que se hicieron se aplicarán en los centros de indización de virus de INIBAP (VICs):*

Las cinco plantas despachadas del Centro de tránsito a los Centros de indización de virus serán seleccionadas de 7 y no de 20 explantes derivados del ápice original debido a que esto disminuirá el riesgo de que las plantas evaluadas no sean representativas del estadío de salubridad de la accesión original. Los dos explantes remanentes serán multiplicados para obtener 20 explantes de cada accesión que serán mantenidos bajo condiciones de crecimiento lento.

- *El período de indización en los VICs será reducido de 9-12 meses a 6 meses y la indización se llevará a cabo después de 3 y 6 meses de crecimiento debido al incremento de la confianza en la fiabilidad de las pruebas para detectar virus patógenos.*
- *Las accesiones, incluso las que vienen de países en los que existe la enfermedad del cogollo racemoso (BBTD) serán indizadas solamente en un VIC y no en dos como previamente, dado que, hoy en día, las pruebas de indización para detectar el virus del cogollo racemoso son fiables.*
- *En el futuro cercano, nuevos antisueros para el virus de mosaico de la bráctea del banano serán utilizados rutinariamente en los VICs, junto con un antisuero de amplio espectro para detectar el virus de la raya de la hoja usando microscopía electrónica inmunosorbente (ISEM). Aún se necesitará evaluar con microscopía electrónica savia de las hojas parcialmente purificada para detectar partículas virales aun no caracterizadas.*
- *El germoplama será evaluado para todos los viruses de acuerdo a protocolos especificados en las nuevas guías. Sin embargo las guías prevén que bajo algunas circunstancias las pruebas puedan ser eliminadas si existen evidencias fuertes y confiables que ciertos virus no están presentes en el país de origen del germoplasma.*

internationale en recherche agronomique pour le développement (CIRAD), Montpellier, Francia y el *Queensland Department of Primary Industries* (QDPI), Indooroopilly, Australia. No se detectó virus patógenos en 87% de las accesiones evaluadas. Durante 1995, se realizaron 54 envíos representando 362 accesiones a 42 organizaciones diferentes en 36 países del mundo.

Revisión del Banco de Genes

La operación del banco de genes de INIBAP fue revisada por una junta comisionada por el *Inter-Center Working Group on Genetic Resources* (ICWG-GR) en Diciembre de 1995. Los miembros de la junta consideraron la operación de la colección como ejemplar para cualquier banco de genes de cultivos propagados vegetativamente y una de las más efectivas en cuanto a costos de operación. Como se señaló en el informe final, la junta estuvo impresionada por las relaciones tan cercanas y productivas entre KUL e INIBAP y felicitó a ambos organismos por su colaboracion con los tres centros de indización de virus localizados en Francia, Australia y Taiwan.

Investigación estratégica

Métodos para detectar el virus de la raya de la hoja en *Musa*

En el Departamento de fitopatología de la Universidad de Minnesota, St Paul, se han desarrollado métodos de detección del virus de la raya de la hoja (BSV) tanto inmunológicos como de amplificación mediada con PCR. Antisueros policlonales de conejo preparados con una mezcla de aislamientos de BSV serológicamente distintos fue capaz de detectar todos los aislamientos del virus evaluados con microscopía electrónica inmunosorbente. A pesar que este método es sensible y confiable, no es adecuado para indizar un gran número de muestras, y podría estar reservado para pruebas confirmatorias de un pequeño número de muestras críticas. Para evitar esta limitación, sueros policlonales adicionales fueron preparados en ratones y pollos y se desarrolló un protocolo de ELISA de tipo sandwich de anticuerpo triple (TAS-ELISA).

No se pudo lograr la detección confiable del BSV usando protocolos de PCR y extracción de ADN total como molde. Se ha encontrado que el ADN relacionado al virus estaba integrado al genoma de *Musa*, dando un producto de PCR con *primers* específicos para el BSV ya sea las partículas del virus estén presentes o no como se determinó con microscopía electrónica de inmunosorbencia.

El banco de genes de INIBAP bajo los auspicios de la FAO

El germoplasma de Musa *mantenido en el banco de INIBAP en ITC-KUL fue formado con donaciones de otros bancos de germoplasma, a través de expediciones de colección en colaboración con programas nacionales y de donaciones de mejoradores e individuos. Este material fue donado a INIBAP con el propósito de que sea conservado y para el beneficio de los participantes de la red. Como tal, INIBAP actúa como garante de este germoplasma. En octubre de 1994, a través de un acuerdo firmado entre FAO e IPGRI, el banco de genes fue puesto bajo el auspicio intergubernamental de la FAO. Los materiales incluidos en el acuerdo están listados como 'germoplasma designado'. Este material continúa disponible para todos con el conocimiento de que permanecerá en el dominio público. INIBAP desarrolló nuevos procedimientos para la distribución de germoplasma los cuales rigen desde Noviembre de 1995. Cada envío de material está supeditado a la firma de un formulario de pedido por el instituto, corporación o persona solicitante quien debe aceptar una lista de condiciones que garantizan que el germoplasma será mantenido en el dominio público y que debe compartirse la información adquirida después de la adquisición del material.*

Identificación y caracterización de virus asociados con BBTV

Las actividades de investigación llevadas a cabo durante 1995 en el Laboratorio de Patología Vegetal de la Universidad de Ciencias Agronómicas, Gembloux, Bélgica, estuvieron enfocadas en mejorar la sensibilidad de y la fiabilidad de las pruebas de diagnóstico del virus del cogollo racemoso del banano (BBTV), en la caracterización de aislamientos de BBTV y en la evaluación de genotipos que puedan ser usados como referencia para resistencia/tolerancia a BBTV.

Se encontró que el método que asocia la inmunocaptura al PCR (IC-PCR) fue el más sensible para detectar partículas de BBTV; se recomienda esta técnica para confirmar la eliminación de BBTV en los protocolos de

producción de plantas libres de virus. Los análisis de PCR realizados usando plantas infectadas con BBTV recibidas de diferentes países del mundo demostraron la presencia de los componentes 1 y 3 de ADN del BBTV en todos los aislamientos de BBTV mantenidos en el laboratorio. Se encontró que la PCR usando el *primer* B-GA es una herramienta conveniente para asignar los aislamientos de BBTV al grupo asiático de aislamientos definido por Karan *et al*. (1994).

La colección de genotipos referenciales de banano que incluye tanto a los bananos cultivados como a los silvestres está siendo evaluada para su resistencia/tolerancia a BBTV en colaboración con el Centro de Transito de INIBAP. Los resultados preliminares han mostrado alguna variabilidad entre los genotipos en lo concerniente a dos parámetros: la tasa de infección y el número de hojas que emergen antes de la observación de los primeros síntomas en plantas infectadas. A pesar que estos parámetros necesitan ser reconfirmados en experimentos en el campo, este método permitirá la clasificación de los genotipos de banana que tienen diferentes niveles de tolerancia a BBTV.

Mejoramiento de *Musa*

El INIBAP ha estado apoyando la investigación de diversos colaboradores en laboratorios desarrollados y en programas de mejoramiento desde 1992. A continuación señalamos trabajos realizados en 1995.

Suspensión de células embriogénicas

Existen diversos obstáculos para obtener suspensiones de células embriogénicas. Un estudio usando 20 variedades que pertenecen a distintos grupos genómicos mostró que la mayoría necesitaba varios ciclos de medio de proliferación con un contenido de citoquinina 10 veces mayor (100µM) que el medio usado rutinariamente (10µM). Se pudieron hacer suspensiones con todas las variedades probadas, pero la respuesta a los medios líquidos y semi-sólidos dependió de la variedad.

Transformación genética

El protocolo de transformación genética desarrollado en KUL se basa en la introducción de genes foráneos en una suspensión celular usando bombardeo de partículas. Se ha probado la eficiencia de varios genes marcadores para seleccionar explantes transgénicos de banana. Se compararon varios promotores heterólogos usando el gen reportero *gusA* como marcador de la eficiencia de la transformación. Los resultados indicaron que el promotor de poliubiquitina de maíz es el más eficiente para producir alta expresión génica en células de banano. Los primeros bananos transformados estables se encuentran en el invernadero en KUL.

Apoyo al programa de mejoramiento de FHIA

Los híbridos FHIA-03, FHIA-18 y FHIA-21 son hitos en el programa de mejoramiento de FHIA. Son los primeros híbridos mejorados (junto con FHIA-01 que fue lanzado este año a los agricultores australianos de banano bajo el nombre 'Goldfinger') que han sido sembrados comercialmente debido a su superioridad en productividad y resistencia a enfermedades cuando son comparados con las variedades naturales tradicionales. El FHIA-03 es el primer banano de cocción mejorado que tiene varias cualidades superiores a aquellas de los cultivares naturales ABB. En Cuba, por ejemplo han sido sembradas 700 Ha de este híbrido. El FHIA-18, banano agridulce para postre, esta siendo muy bien aceptado. Este híbrido es de rápida floración y tiene un alto nivel de resistencia a la Sigatoka negra. El híbrido tipo plátano, FHIA-21, resistente a la Sigatoka negra fue evaluado en Honduras. Su producción fue el doble que la obtenida con el plátano cuerno AAB tradicional y muchos agricultores quieren sembrar solamente FHIA-21 de inmediato. Sin embargo este material tan prometedor no está disponible aún debido a que se detectó partículas virales baciliformes en la primera muestra recibida en ITC. Las investigaciones para obtener material limpio siguen en INIBAP.

La red de mejoradores

El mejoramiento para la resistencia a nemátodes fue identificado como el tercer objetivo para el mejoramiento global de *Musa* después de las enfermedades causadas por Sigatoka y la enfermedad de Panamá. Una taller organizado por el Instituto de Investigación Agrícola de Malasia (MARDI) e INIBAP reunió a nematólogos y mejoradores de *Musa* de 14 países así como a investigadores de *Musa* de Malasia. Se llegó a consenso sobre la necesidad de identificar nuevas fuentes de resistencia a los nemátodes mas importantes que afectan a los bananos, especialmente en tipos diploides fértiles para su incorporación en programas de mejoramiento. Se propusieron protocolos para tamizado y se sugirieron variedades susceptibles y resistentes para establecer un procedimiento común de evaluación de las líneas y variedades mejoradas. También se señaló la necesidad de desarrollar protocolos de tamizado confiables a ser usados en el invernadero. Finalmente los participantes acordaron que los métodos de mejoramiento, tanto los convencionales (hibridación) como los no convencionales (biotecnología), son complementarios.

El Programa Internacional de Evaluación de *Musa*

La fase I del PIEM (1990-1993) que se concentró exitosamente en la Sigatoka negra eventualmente recomendó tres híbridos FHIA para su ulterior distribución y evaluación a nivel nacional. Estas variedades están siendo evaluadas en 49 países diferentes. Los objetivos de la fase II son la Sigatoka negra, la Sigatoka amarilla y la marchitez por Fusarium. Después de su multiplicación, el ITC distribuyó más de 10 000 plántulas *in vitro* a colaboradores de 19 países para su evaluación en 37 sitios. Varios programas de mejoramiento contribuyeron con germoplasma nuevo y prometedor resistente a enfermedades y plagas para su posterior evaluación en 1997.
El germoplasma resistente a enfermedades deberá disminuir el uso de pesticidas con el correspondiente beneficio ambiental e incremento en rendimiento e ingreso para los pequeños agricultores.

Actividades regionales

América Latina y el Caribe

En 1995, la Corporación Colombiana de Investigación Agropecuaria (CORPOICA) e INIBAP firmaron un acuerdo con el objetivo de reforzar los esfuerzos nacionales para la caracterización de germoplasma de los principales cultivos alimenticios, incluyendo al germoplasma natural y mejorado de *Musa*.

INIBAP financió la visita de un experto en Sigatoka negra a las áreas mas afectadas de Venezuela para desarrollar un plan para el

control del patógeno. El Dr. Benjamin Dadzdie del *Natural Resources Institute* (NRI) completó exitosamente el proyecto colaborativo entre FHIA, *Overseas Development Administration* (ODA) e INIBAP para la caracterización de los bananos de cocción y de los plátanos en fase post-cosecha. Junto con sus descubrimientos científicos, el Dr. Dadzdie preparó manuales de referencia sobre las características de post-cosecha de los híbridos de FHIA los cuales serán publicados por INIBAP.

LACNET co-organizó junto con CATIE y CIRAD un taller de trabajo en transformación genética en Costa Rica. LACNET y el Centro Internacional de Investigaciones para el Desarrollo (CIID) financiaron la asistencia de cuatro participantes a un curso corto sobre 'Actualización tecnológica de la producción de plátano' organizado por CORPOICA.

Asia y el Pacífico

El germoplasma colectado en misiones anteriores en Viet Nam fue establecido en dos campos de colección para su caracterización. Un proyecto en Davao, Filipinas sobre el rescate y la conservación de la colección de germoplasma de banana del Sureste Asiático financiado por ODA reveló que todo el germoplasma transferido *in vitro* estaba libre del virus del cogollo racemoso del banano. El duplicado de la colección de germoplasma de *Musa* de Asia y el Pacífico en TBRI se completó en 1995. El TBRI también inició sus actividades de indización de virus durante el segundo trimestre de 1995 convirtiéndose en el tercer Centro de indización de virus de INIBAP. ASPNET recibió una donación de Taiwan para implementar el sistema regional de información de banano y plátano en Asia y el Pacífico. ASPNET co-organizó un curso de entrenamiento en 'Métodos de estimación del daño y manejo integrado de plagas contra el gorgojo y los nemátodos del banano' realizado en Tailandia en Septiembre de 1995. Asistieron 20 participantes de China, Indonesia, Malasia, Filipinas, Tonga, Viet Nam y el país hospedante, Tailandia. ASPNET también auspició cursos de capacitación individual en cultivo de tejidos de banano, indización de virus y tecnología de conservación *in vitro* de germoplasma de *Musa* en TBRI, Taiwan; y en clasificación de banano en Davao y Los Baños, Filipinas.

El representante de CGIAR en Filipinas anunció, en la reunión de la Semana de los Centros internacionales en Washington DC en Noviembre de 1995, una donación anual de US$ 20 000 a INIBAP.

Africa

Se envió germoplasma indizado para virus directamente desde ITC o a través del Centro de Investigaciones Regionales sobre Bananos y Plátanos (CRBP) quien, bajo los auspicios de INIBAP, actúa como un centro intermediario para la multiplicación y diseminación de germoplasma seleccionado. En 1995, el ITC envió 61 accesiones a 8 organizaciones diferentes en 7 países. El CRBP proveyó 2 214 plántulas *in vitro* las que comprendían 26 variedades diferentes a 4 agencias de desarrollo en Guinea, Chad y Gabón.

IITA en Nigeria, la Organización Nacional de Investigación Agrícola (NARO-KARI) en Uganda y CRBP en Camerún participaron activamente en las actividades del PIEM y del Sistema de Información sobre Germoplasma de *Musa* (MGIS). Se completaron los envíos a los sitios de evaluación del PIEM, entregando a NARO-KARI las 32 variedades necesarias para la evaluación de la resistencia a la Sigatoka negra y a la marchitez por Fusarium y el primer grupo de 13 variedades usadas como referencia fue enviado a los participantes del MGIS.

Información y comunicación

Herramientas y servicios de información

MGIS

En el marco del MGIS, y como primer paso de un estudio morfo-taxonómico de cultivares estándar, se envió a nuestros colaboradores, un juego de cultivares de referencia junto con guías técnicas sobre los descriptores morfo-taxonómicos. Se continuó con la preparación del catálogo *Musa*logue de las accesiones colectadas en Papua Nueva Guinea en 1988-89 por IBPGR y QDPI y evaluadas en la estación experimental de QDPI en South Johnstone. Se progresó significativamente en el desarrollo de la estructura de la base de datos del sistema de información de germoplasma.

Bases de datos de INIBAP

*MUSA*LIT, la base de datos bibliográficos trilingües de INIBAP, aumentó a 3 824 registros. Estos registros fueron publicados en *Musarama*, el boletín bibliográfico internacional sobre bananos y plátanos en tres idiomas. Se produjeron tres números de *Musarama* y un índice durante el año.

BRIS, el sistema de información sobre las investigaciones bananeras se esta actualizando. Los datos actualizados se publicarán bajo la forma de directorios.

Las bases de datos *MUSA*LIT y BRIS están en fase de prueba en 10 sitios en el mundo y se distribuirán de manera más amplia en 1996.

Visitas en las regiones

En septiembre, la Encargada del servicio de información de INIBAP visitó la Unión de Países Exportadores de Banano (UPEB) en Panamá donde discutió con la responsable de la red regional de información del futuro de las actividades de información en América Latina y el Caribe. Después, acudió a Cuba para presentar el sistema de información de INIBAP en varias ocasiones y luego a Venezuela para participar en la reunión del Comité Consultivo Regional de América Latina y el Caribe.

Publicaciones

En 1995 se publicaron el Informe Anual de 1994, una publicación regional, varios títulos trilingües incluyendo dos hojas divulgativas sobre enfermedades de *Musa*, dos números de INFO*MUSA* y tres de *Musarama*. Más de 16 000 copias de los títulos de INIBAP fueron distribuidos en el mundo entero durante el año.

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