Role of IPGRI in the Collection, Conservation and Utilization of Tropical and Subtropical Fruit Species Genetic Resources

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Introduction

Inportance of fruits in supplementing human diet is universally recognized and in this context, tropical and subtropical fruits provide a wide variety of choice. Changing consumption needs of society, availability of suitable varieties, better land use practices, new agro-techniques and effective transportation systems have opened further avenues for higher production of tropical and subtropical fruits. The data on world production of important fruits (FAO, 1992), point out that developing countries produce about 72% of orange/mandarin, 85% of avocado, and over 90% each of mango, pineapple, banana and plantain, and papaya (Table 1). Also, almost entire production of minor fruits such as rambutan, litchi, durian, mangosteen, longan, carambola, jackfruit, etc. comes from the developing countries. This situation highlights the importance of tropical fruits for the economy of developing countries, providing additional income to farmers. Furthermore, tropical and subtropical fruit species, often possess multipurpose attributes (they are used as edible fruits, for medicine, wood, in soil conservation and agro-forestry), and growing these is considered eco-friendly on a sustainable basis and adds further to overall rural development and welfare.

The need for genetic diversity is crucial to crop improvement and development. Relatively, fewer efforts have been put forth to collect, conserve and use the enormous diversity of perennial tropical fruit resources. IBPGR (now IPGRI) since its inception in 1974, has laid priority on this aspect and collaborated with the national programs to undertake PGR activities at national and regional level. It had supported several projects in the past 15 years in different regions on different PGR activities. This paper attempts to highlight the work carried out by IBPGR (now renamed as IPGRI) so far to promote conservation and use of tropical fruit species.

Table 1 World production of some important tropical and subtropical fruits

Crop	Production in 1000 mt.		Total production (1000 mt)
	Developing countries	Developed countries	
Orange/mandarin	41,405	15,643	57,048
Banana	48,743	887	49,630
Plantain	26,796	–	26,796
Mango	16,926	61	16,987
Pineapple	9,607	883	10,490
Papaya	3,866	63	3,929
Avocado	1,742	311	2,053

Source : FAO Production Year Book (46th issue), 1992.

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Floristic diversity and distribution

Rich diversity in tropical and subtropical fruits occurs in Asia, and in Central and South America. More than 600 edible fruits grow in the tropical and subtropical regions of the world (Nagy and Shaw, 1980) and 337 species belonging to 124 genera representing world diversity in less known fruits occur (Arora, 1985) with more than 80% of these originally from the tropical regions. This diversity is mainly distributed in the Chinese-Japanese, Indo-Chinese-Indonesian, Hindustani, Central and South American regions of diversity of crop plants (Zeven and de Wet, 1982), with relatively less representation in other regions. These regions are also a seat of domestication and/or cultivation and spread of both the major and minor tropical fruits. Prominent diversity belongs to the following phytogeographical regions:

Tropical American: Pineapple, soursop, custard apple and other Annonas, papaya, guava, passionfruit/*Passiflora* spp., sapota/sapotaceous group and avocado.

Tropical Asian: *Citrus* group, mongo, banana including plantain, jackfruit, rambutan, litchi, longan, carambola and durian;

and among others, breadfruit with wider distribution in the Pacific and plantains, to some extent in tropical Africa.

While much of the native diversity in wild species occurs in the moist tropical forests as components of primary or secondary vegetation, within-species variability is largely concentrated in small field gardens, backyards, marginal lands, open forest habitats, etc. and represents wide adaptability. Ethnic preferences have contributed to the preservation of native kinds, representing both conscious and unconscious folk selections, grown for meeting local needs and market demands. Some of these fruits such as the jackfruit even provide staple food in period of scarcity. Also, a large array of diversity of underutilized types and of the wild species in the above fruits, holds great promise for further exploitation and improvement.

IPGRI role and achievements

1. Germplasm collection

IPGRI/IBPGR around 1977-78 initiated germplasm collections with major concern to capture native diversity in cultivated and wild species of tropical fruits, in view of large scale genetic erosion due to overexploitation, habitat deterioration, etc. and local impact of crop diversification and better land use practices. Also, in the late 1970s and early 1980s (IBPGR, 1981), IBPGR had prioritized national and regional needs for crop explorations. Analysis of the IBPGR database on collecting missions, points out that between 1977-93 IBPGR has supported over 80 collecting missions on tropical fruit species relevant to national and regional needs. More organized efforts were made by the Southeast Asian Program (SEAP) under IBPGR umbrella (IBPGR, 1980, 1986 b), than in programs carried out in other parts of the world. Missions undertaken covered specific countries as well as groups of countries in view of the distribution of genetic diversity to be collected. Over 40 countries were surveyed and about 6,400 accessions collected (Table 2). Noteworthy features of these explorations and germplasm diversity collected are given below:

1) Asia, the Pacific and Oceania (APO) region

(1) ***Southeast Asia*** : IBPGR considered it as a priority region (IBPGR 1980, 1986 b) for collecting germplasm of tropical fruits in Indonesia, Malaysia, Thailand and Philippines, and supported explorations particularly between 1977-1991.

a) Indonesia: Six explorations were conducted during 1978-88, and diversity collected in durian, rambutan, banana — cultivated, and wild species of *Musa*, mango, including wild *Mangifera* spp., *Gracinia* spp., *Citrus* — cultivated spp., including hybrids and also wild relatives.

b) Thailand: Six explorations were undertaken between 1978-86 and germplasm of *Mangifera* spp., including cultivated varieties of mango, durian, rambutan, *Musa* spp., mangosteen, langsat (*Lansium domesticum*), *Citrus* group and tamarind was collected.

c) Malaysia: Five explorations were undertaken between 1980-88. Diversity collected included *Musa* spp., durian, wild species of *Durio*; mango and wild *Mangifera* spp., *Artocarpus* — jackfruit and *A.*

Table 2 Germplasm diversity collected in IBPGR supported collecting missions during 1978-1993

Region surveyed	Collection made (Approx. accessions)	Major diversity collected
APO Region Southeast Asia	4,473	Citrus, mango, banana, durian rambutan, Longsat, jackfruit, champeden, mangosteen
South Asia	494	Mango, citrus, jujube
Pacific	290	Breadfruit, *Artocarpus mariannensis*
WANA Region	90	Pomegranate
SSA & other areas	194	Datepalm, *Grewia*, guava, *Citrus* group, *Balanties*, *Annona*, *Musa*
Meso America/ Central America & Mexico	685	Papaya, tree tomato, passionfruit & *Passiflora* spp., guava, Annonas, avocado
Andes/South America	188	Passionfruit/*Passiflora* spp.
Total germplasm collected	6,414	

Source : Courtesy : Th. Hazekamp, IPGRI HQs, synthesized from computer print out.

champeden, mangosteen and wild *Garcinia* spp., rambutan and wild *Nephelium* spp., and *Lansium domesticum*.

d) Philippines : Three explorations were conducted during 1977-86 and diversity in durian, mango, rambutan and *Musa* spp. collected.

e) Papua New Guinea : Three explorations were undertaken between 1986-89 and germplasm of cultivated and wild *Musa* species and related taxa collected.

f) Vietnam : Diversity in cultivated species of *Citrus* was mainly collected during 1992-93.

(2) **Pacific Islands** : Fiji, Western Samoa, Solomon Islands, French Polynesia and Pacific islands were explored during 1987-88 and collections were mainly focused on breadfruit. *Artocarpus mariannensis* was also collected.

(3) **South Asia** : In 1978, mango diversity was collected from Sri Lanka. During multicrop collecting missions undertaken to the Maldives in 1986, collections made included diversity in Annonas, papaya, *Passiflora* spp., jujube, *Triphasia* and others. During 1984-87 in three explorations undertaken in Nepal, *Citrus* germplasm diversity was collected including mandarin orange, sweet orange, lime and other cultivated types. Germplasm of jujube was also collected.

2) West and North Africa (WANA) region : Representative diversity was collected mainly in pomegranate from Pakistan, Oman and Yemen, during the missions undertaken in 1986-88.

3) Sub-Saharan Africa (SSA) and other African countries : Mainly collections were performed during 1981-86 in East Africa in Sudan, Zaire, Zambia and Botswana. Germplasm collections included datepalm, *Balanites*, guava, and *Citrus*. *Musa* diversity was collected from Zaire. West Africa, Niger and Mali were mainly explored during 1986 and 1988 and diversity in *Grewia* spp., *Zizyphus* and *Balanites aegyptiaca* was collected.

4) Central America, Mexico and West Indies : Some explorations were conducted during the 1980s. From Mexico, diversity in Annonas, papaya, *Citrus*, sapota and avocado was collected. From Panama, diversity was collected mainly in avocado, from Honduras in avocado, from El Salvador and Costa Rica in Annonas, and from Guatemala in Annonas, avocado, *Passiflora* spp., and sapota and other sapotaceous

fruits, and in Cuba for *Musa*.

5) South America: Explorations were undertaken during 1982. From Colombia diversity was mainly collected in papaya, tree tomato, *Passiflora* spp., and guava, in Peru mainly for *Opuntia ficus-indica*, and in Venezuela particularly in pineapple. More general collections were conducted in Bolivia and other areas.

2. Germplasm characterization, evaluation and documentation

The role of IPGRI has been primarily to standardize descriptor lists of important fruit species, to help national programs in improving the recording of characterization/evaluation data. Several working group meetings were organized for this purpose (IBPGR, 1979; 1980). So far, such descriptor lists have been brought out for grapes (1983 b), banana (1984), *Citrus* (1988 a), papaya (1988 b), mango (1989) pineapple (1991). IBPGR advocates the use of similar standardized descriptor lists so that information catalogues by national programs can be better utilized. This information includes details on descriptors used for recording passport data, characterization data, preliminary evaluation and further evaluation data.

IPGRI has recently revised the "Directory of tropical and subtropical fruits and nuts (IBPGR, 1992)". Information synthesised indicates the following:

1) The directory covers 64,269 accessions, belonging to 191 genera and 879 species in 69 countries worldwide. This diversity is maintained by 242 institutes.
2) Total collections for some of the major fruits are (number is given in parenthesis):
- Fruits of tropical American origin: Annonas (986), guava (925), passionfruit (540), papaya (1,709), pineapple (1,618), avocado (4,147).
- Fruits of tropical Asian origin: citrus group (18,293), mango (5,676), banana group (8,694).
- Fruits of Pacific origin: Bread fruit (255).
- Information is also synthesized for fruits such as fig (2,205), and datepalm (1,152).
- Miscellaneous category includes 142 genera with 12,275 accessions of minor fruits and wild relatives of fruit trees. This includes jackfruit, durian, rambutan, longan, litchi, carambola, langsat and others.

3. Conservation

IPGRI pursues the concept of complementary conservation (IPGRI, 1993). The two basic approaches are *ex situ* and *in situ* conservation, and these should be considered as complementary.

In *ex situ* conservation IPGRI has promoted research on the mechanism of recalcitrance, physiological studies on seed storage aspects, *in vitro* conservation and cryopreservation techniques, maintenance of diversity in field gene banks i.e. *Musa* (Philippines) and *Citrus* (Malaysia). In *in situ* approach, it has promoted studies on ecogeographical surveys to understand more thoroughly the genetic diversity occurring in natural habitats i.e. studies on species biology, distribution, diversity, population patterns, etc. IPGRI earlier, had supported projects with different national programs to address such problems and some research findings are presented:

1) Genetic conservation of mango, litchi and longan: Physiological studies on the effect of desiccation, wet storage and cryopresevation on the viability of recalcitrant seeds of mango, litchi and longan were carried out under IPGRI-supported project at the Plant Physiology Laboratory, Zhongshan University, Guangzhou, China during 1989-92. Interesting findings have been reported and are given below from published results and progress reports.

(1) When mango seeds were stored at 15°C with optimal moisture content of 45-50%, the longevity of mango seeds could be extended to more than seven months (Fu *et al*., 1990).
(2) Optimal temperatures for germination of litchi and longan seeds were 30°C and 25°C, respectively.
(3) Storage of litchi and longan seeds in perlite with 20% moisture was preferable to storage in polythene bags (Xia *et al*., 1992).
(4) Litchi seeds stored in perlite with 20% moisture content and 5% chlorthalonil at 15°C for 280 days displayed about 60% germination and 1-1.4% vigor, while longan seeds stored in perlite with 20% moisture content and 4% chlorthalonil at 15°C for 250 days displayed about 67% viability and 0.97% vigor. The

moisture content of litchi and longan seeds was maintained at about 40-45% during the moist storage in perlite (Xia *et al*., 1992); the safe moisture content of litchi seeds was 40% and longan seeds 35%; critical moisture contents being 33% and 25% for litchi and longan, respectively (Fu *et al*., 1993).
(5) Studies on cryopreservation pointed out that only embryonic axes of longan seeds with moisture content of 18% can survive after 24 hour storage in liquid nitrogen (Fu *et al*., 1993).

2) Studies on the dehydration and preservation techniques of recalcitrant seeds have been carried out with IPGRI support at the Universiti Pertanian Malaysia (UPM), Selangor, Malaysia during 1989-90. For jackfruit, exposure to a combination of 10% DMSO and 0.5% proline for 12 h. adequately protected the embryos. Better growth was observed with a medium enriched with gibberellin and aminoacids. Well-developed cryopreserved seedlings could be raised/planted.

3) IPGRI supported studies on cryopreservation of banana and plantain at the Centre for Tropical Agronomy, Costa Rica, in 1991. Zygotic embryos of *Musa balbisiana* and *M. acuminata* have been successfully introduced into culture.

4) Studies on induction of quiescence in somatic embryos of mango for use in germplasm conservation were carried out at the University of Florida, USA. It was stressed that dehydration experiments should be carried out on both somatic and nucellar embryos isolated directly from polyembryonic mango fruits.

5) Under the ODA/IPGRI project at the National Facility for Plant Tissue Culture Repository, NBPGR, New Delhi, India, studies were carried out on the biological mechanism determining the recalcitrance of seeds of jackfruit. Embryonic axes of jackfruit at partially mature and fully mature stages could be desiccated to 13-14% moisture content. Embryonic axes of jackfruit desiccated to the lowest level up on rapid freezing to −196°C showed variable success during the three stages of seed maturity. Partially mature and fully mature axes of jackfruit were successfully preserved with a survival percentage of 30% (IPGRI-APO Newsletter, 13, 1993).

6) Recently a project on citrus germplasm preservation *in vitro* has been taken up by the Citrus Research Institute, (Genetic Resources Laboratory), CAAS, Beibei, China. Material of 13 spp./45 varieties including *Poncirus*, *Fortunella* and *Citrus* group-cultivated and wild spp. has been used for medium screening. Studies on tissue culture and multiplication will be carried out with the objective that technology developed is passed on to other national programs in the region for its wider application or adoption (Project Progress Report, 1993).

4. Ecogeographic surveys and *in situ* conservation

IPGRI also supported studies on ecogeographic surveys. These relate to synthesis of information on distribution of diversity and species richness in the region, based on field and herbarium studies, etc. Distribution maps and information on ecology of species could provide clues to the rich pockets of diversity suitable for *in situ* conservation. The first in this series was the publication on "Systematic and ecogeographic studies of crop genepools: 1. *Mangifera* L. (Mukherjee, 1985)". Several advisory committees and crop working groups meetings were also organized. In 1984, with WWF it supported the field surveys of wild populations of *Mangifera*, in areas of high diversity such as in Kalimantan, Sabah and Sarawak. This study: 1) provided an assessment of genetic erosion within populations and indications of possible sites for maintaining remaining diversity *in situ*; 2) the ecogeographic surveys of wild *Mangifera* species provided a model for *in situ* conservation efforts of the wild relatives. Surveys carried out in Sumatra between 1987-1990, for citrus and *Mangifera* species, pointed out to six areas for *in situ* conservation based on the distribution of diversity studied. Several wild *Mangifera* species were collected and their diversity described. This is fairly well recorded in the monograph on mango (Kostermans and Bompard, 1993), published recently by IPGRI and the Linnean Society of London.

IPGRI projects on tropical fruit species

1. APO Project – to promote conservation and use of tropical fruit species in Asia

This project was finalized by the APO Office and started operating in 1993. There are eight activities to be carried out under this project and these present major TFT : PGR concerns. These 8 Project Activities are :

1) Regional assessment to establish 2-3 genepools of both widely used and minor species.
2) Synthesize, document and catalogue information on tropical fruit tree genetic resources.
3) Use information on local knowledge, ethnic uses of minor/underutilized species and assess their potential.
4) Plan ecogeographic surveys to collect and assess genetic diversity in natural habitats.
5) Undertake study and classification of genetic diversity through use of morphological, biochemical and molecular techniques.
6) Develop/adopt seed conservation technology for tropical fruit tree species.
7) Develop cooperative links with the International Centre for Underutilized Crops (ICUC).
8) Promote *in situ* conservation of tropical fruit trees.

IPGRI's team in charge of handling these activities includes APO-region professional staff based at Singapore, Beijing and Delhi Offices; and the professional staff from three thematic groups at IPGRI Headquarters in Rome, namely Genetic Diversity (GD), Germplasm Maintenance and Use (GMU), and Documentation, Information and Training (DIT). Each activity is managed by an Activity Manager, with Project Coordinator as the overall team leader.

For most of the activities information gathering has been in progress. To prioritize TFT genepools in which work for improvement and development needs to be concertrated, ICUC-IPGRI TFT Questionnaire analysis studies under IPGRI Project with ICUC have been taken up. At the APO-TFT meeting on 15-16 December, 1993, preliminary findings pointed out that of the 61 fruit species listed as important for the region of Asia, ten of the most important fruits of major and minor importance are: mango, banana, jackfruit, litchi, guava, jujube, custard apple, jamun/*Syzygium cumini*, aonla/*Emblica officinalis* and bael/*Aegle marmelos*. This list was revised by APO-ICUC and criteria for identifying priority species reassessed keeping in view the recently published literature (Singh, 1993). Regionally the important genepools of tropical fruit species (excluding banana) were identified :

Major fruit species ; mango, citrus, jackfruit, rambutan, papaya, litchi,

Minor fruit species ; jujube, longan, durian, aonla, mangosteen, bael, guava, custard apple.

Recently, as a follow-up of the above meeting, an "Expert Consultation Meeting on Tropical Fruit Trees", was organized by IPGRI-APO at MARDI, Kuala Lumpur, Malaysia from 17-19 May 1994. The primary objective of this meeting was to identify a few priority genepools of tropical major and minor fruit tree species in Asia and assess their priorities for further research and improvement, to promote their conservation and use in the region. Experts from East Asia, Southeast Asia and South Asia participated and presented PGR status reports. The deliberations of this meeting could finalize the following priority species in major and minor tropical fruits :

Major fruits ; mango, citrus, rambutan,

Minor fruits ; jackfruit, durian, litchi.

Also, it was agreed to give attention to mangosteen, longan and carambola. Further, research and development activities were stressed, relating to specific need for collecting more germplasm diversity, undertaking genetic diversity studies, promotion and adoption of complementary conservation strategies, training needs and exchange of germplasm.

Based on the above deliberations, APO Office is currently engaged in processing the proceedings of the MARDI Expert Consultation Meeting. It is intended to include the information synthesized by IPGRI-APO on tropical fruit species and the regional synthesis provided in status reports of the experts. Also, on the basis of ICUC TFT Questionnaire information, APO will be preparing a directory of tropical fruit researchers/scientists to promote mutual dialogue among workers.

2. Projects/Activities in tropical fruits at IPGRI Office for the Americas

A project on behalf of 5 countries of Central America and 5 countries of South America/Andes Region, had been presented to IDB − on fruit germplasm for the Sapotaceae and the Passifloraceae, respectively. Crop selections and priorities were based on the recommendations of the two regional networks: REMERFI (for network for plant genetic resources for Meso America) and REDARFIT (for network for plant genetic resources of the Andes) at the annual meetings and workshops held for the last two years. The activities will deal with distribution and assessment of genetic diversity of economically important species of local and regional importance including their wild relatives, endangered species in native habitats, conservation strategies, local uses, local knowledge vis-a-vis conservation aspects. Two projects are proposed to be operated:

1) in Northern Andes on Passifloraceae involving Venezuela, Colombia and Ecuador.
2) in Central America on Sapotaceae involving Costa Rica, Nicaragua, Guatemala and Honduras.

It is proposed to hold a technical meeting soon in order to decide on a specific work plan. Inventory of resources country-wise or on region basis will be compiled. Some work has been supported on descriptor list of avocado in Central America (Office in Mexico) and on collection and descriptor list of pineapple in Northern South America in the Office in Colombia. Also, technical regional workshops on passionfruit and on pineapple were supported by IPGRI in 1991 and 1993 in Colombia.

Coordination/Network participation

IPGRI has been an active participant in activities on *Musa* genetic resources (IPGRI, 1977, 1982 b, 1990). It has also collaborated in activities on tropical fruits undertaken by FAO and other organizations. To promote production to consumption approach, RAPA/FAO organized a "Tropical Fruit Tree Network Meeting of Support Group" at Bangkok in April 1994. This was attended by ICUC, CIRAD-FLHOR, CIRAD, CSC, ODA-SEADD and IPGRI (represented by Dr. Ken Riley, Director, APO Regional Office).
The group recommended the formation of a network called "Underutilized Fruit Tree in Asia Network (UFTANET)". Network support group with 16 member organizations was proposed. IPGRI would join this group which includes countries such as Bangladesh, China, India, Indonesia, Malaysia, Myanmar, Nepal, Philippines, Sri Lanka, Thailand and Vietnam. A Steering Committee will be formed which will have a policy/decision making role in the network. Five Working Groups (Information, Genetic Resources, Production and Propagation, Post-Production and Socio-Economics) have been proposed to coordinate the above activities. IPGRI will have a leading role in "Genetic Resources Working Group's" activities. Also, interaction between IPGRI and other international groups such as ICUC, CSC, CIRAD-FHLOR, PROSEA, and CIFOR is envisaged.

Overview of PGR activities

The foregoing account points out the emphasis given by IPGRI (formerly IBPGR) in promoting germplasm collections, characterization, documentation, conservation and use of genetic resources of tropical and subtropical fruits. It has also played an active role in information dissemination and providing advisory − technical and scientific service, worldwide. Problem-oriented, more thematic topics have been of great concern and reports and reviews have been published to promote further research and development, particulary on conservation aspects of tropical fruit species (Chin, 1988; IBPGR, 1986 c, 1990; Vuylsteke, 1989; Withers and Williams, 1981); genetic diversity assessment (IBPGR 1982 a, 1983 a, 1986 a & b; Mukherjee, 1985; Kostermans and Bompard, 1993), on characterization/evaluation and documentation as have already been referred to above on IPGRI descriptors and the directory. Of equal concern to IPGRI has been the quarantine safeguards, and technical guidelines have been published for the safe movement of germplasum of tropical fruit species such as of *Musa* (Frison and Puttur, 1989) and *Citrus* (Frison and Taher, 1991). IPGRI has also been concerned with the development of resource persons and national/regional expertise to carry out such activities. In this context, it has also organized serveral training programs.

Several problems still remain to be addressed and these include development of guidelines for *in situ*

conservation, promotion of complementary conservation strategies, guidelines for establishment and maintenance of field genebanks, strengthening PGR information/database on tropical fruit species diversity assessment of important genepools and related studies to tap local knowledge.

IPGRI's teams working on research projects on tropical fruits have taken up diverse activities depending on the needs of the regions and of the national programs. The eco-regional approach to meet research and development needs, it is hoped, will further promote PGR activities on tropical and subtropical fruits as well as their conservation and use.

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Discussion

Uritani, I. (Japan): Could you indicate how fruit tree genetic resources are being maintained? Are they preserved as trees, tissue cultures or seeds?

Answer: IPGRI has advocted complementary conservation strategies, depending on the species. Largely species of fruit trees are maintained as live collections in field genebanks or as *in vitro* and cryopreserved materials. In the case of recalcitrant species (jackfruit, rambutan, longan, mango, litchi), basic studies are being carried out with IPGRI support.

Comment: Tandon, P. (India): I agree with Dr. Arora that conservation of plants requires careful studies. In my opinion, the various methods of preservation like field genebanks, *in vitro* methods and cryopreservation have certain limitations. It is important to understand the materials before attempting to conserve them. For example in the case of mango, attempts are being made to use tissue culture in India. Conservation is a global problem and it requires concerted efforts of all concerned.

Comment: Renveni, O. (Israel): In addition to India, it should be emphasized that *Citrus* is being conserved in Spain. *Musa* is conserved *in vitro* in Belgium, at IITA in Nigeria and *in situ* in Honduras and the Philippines. There are very promising results in the cryopreservation of *Musa*. More effort should be made to adapt the techniques, which requires funding. Before conservation, it is essential to evaluate the specific plants. Indeed it is important to determine the reason why a specific material should be conserved.