Conservation and Use of Native Tropical Fruit Species Biodiversity in Asia

Proceedings of the First Annual Meeting of Tropical Fruit Genetic Resources Project, Pattaya, Thailand

6-9 February 2001

Bhag Mal, Y.S. Ramamani and V. Ramanatha Rao, editors
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The International Plant Genetic Resources Institute (IPGRI) is an autonomous international scientific organization, supported by the Consultative Group on International Agricultural Research (CGIAR). IPGRI’s mandate is to advance the conservation and use of genetic diversity for the well-being of present and future generations. IPGRI’s headquarters is based in Macaronesia, near Rome, Italy, with offices in another 19 countries worldwide. The Institute operates through three programmes: (1) the Plant Genetic Resources Programme, (2) the CGIAR Genetic Resource Support Programme and (3) the International Network for the Improvement of Banana and Plantain (INBAP).

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Foreword

The region of South, Southeast and East Asia has rich diversity in tropical fruits which are important sources of supplementary food, nutritionally balanced diet and several other multipurpose uses. Growing of tropical fruits is also environmentally friendly besides enhancing both household incomes and national revenues. Their conservation and use, thus, assume high priority. In 1994, IPGRI in collaboration with MARDI, organized an Expert Consultation meeting wherein 3 major fruits (mango, citrus and jackfruit), 3 minor fruits (rambutan, durian and litchi) and several other underutilized fruits (longan, carommbola, mangosteen, etc.) were identified as target species for work on several PGR related activities. Initially, IPGRI started to synthesize available information and has produced 23 status reports till date in collaboration with several national programmes. This information has been disseminated widely in the region for the use of scientists and institutes engaged in research and development of tropical fruits. Also, several programmes on conservation techniques and maintenance of diversity have been carried out in the region with IPGRI support.

In view of the increased importance of R&D needs in tropical fruits in this region as indicated by the priority position of this commodity in their national agricultural development plans, further strengthening of above integrated approach on PGR activities was considered necessary. The work was thus continued mainly through the Asian Development Bank funded Tropical Fruit Trees Project on Conservation and Use of Native Tropical Fruit Species Biodiversity in Asia. This project is operational now in collaboration with ten Asian countries, viz., Bangladesh, China, India, Indonesia, Malaysia, Nepal, Philippines, Sri Lanka, Thailand and Vietnam.

These proceedings deal with the deliberations of the first annual meeting of the project organized by IPGRI-APO at Pattaya, Thailand from 6-9 February 2001. The objectives of this meeting were to review the progress and outputs of different activities in the collaborating countries, enhance collaboration with regional and international organizations, provide a platform to country coordinators to mutually interact and update their information, and to develop annual work plans. These activities and concerns were well covered in four technical sessions. The proceedings include highlights of the meeting and a follow-up action, and nine papers on PGR activities on tropical fruits covering status of diversity, collection and conservation strategies, germplasm exchange and use, information and documentation, and network activities on tropical fruits (FAO, UTFANET, TFNet) and prospects of CITRAD’s collaboration.

I am indeed thankful to the national coordinators for their cooperation and contribution to the success of this meeting, as also to the other regional and international partners. I am also thankful to my colleagues Dr Bhag Mal, Dr V. Ramanacha Rao and Mr Y. S. Ramamuni for having synthesized the information in the form of this publication. I would also like to express my great appreciation for the organizational effort of our host and collaborating agency in Thailand, the Horticulture Research Institute, Department of Agriculture, in ensuring the successful conduct of the meeting. I am sure, the wider coverage on PGR activities as presented in these proceedings will be very useful to converged national programmes and also to other organizations in the region interested in conservation and use of tropical fruits.

Percy E. Sajise
Regional Director.
IPGRI-APO
Preface

The Asia-Pacific region has a rich diversity in tropical fruits. About 500 edible fruit species are reported to occur in Asia. People in the region are increasingly becoming aware of the potential importance of these species which are largely underexploited. They are good sources of dietary vitamins, minerals and energy. They can also play a very significant role in the well-being of the population through enhancing household income, employment generation particularly for women and environmental protection. Many of the species are threatened due to various human interventions and concerted efforts are required to take corrective measures. The International Plant Genetic Resources Institute (IPGRI) is highly concerned for the effective conservation and sustainable use of plant genetic resources and has taken several initiatives in this direction.

IPGRI, through its project on tropical fruit genetic resources funded by Asian Development Bank (ADB), is supporting the national programmes in 10 Asian countries, namely, Bangladesh, China, India, Indonesia, Malaysia, Nepal, the Philippines, Sri Lanka, Thailand and Vietnam for the conservation and use of native tropical fruit species biodiversity. The project focuses on locating and collecting diversity; characterization, evaluation and utilization; in situ and ex situ conservation; information, documentation and dissemination; socio-economic studies and human resources development.

This publication reports the proceedings of the first annual meeting of the Tropical Fruit Genetic Resources Project held at Pattaya, Thailand from 6-9 February 2001. During this meeting, the progress of work done under the project during 2000 was reviewed and the work plan for 2001 was developed. Besides, several thematic presentations from the national and international experts were made which focused attention on the need for greater regional collaboration for furthering the cause of efficient and effective conservation and use of tropical fruit genetic resources in the region. Information required to make sound conservation decisions, based on scientific principles was also provided to the partners. The deliberations of the Steering Committee of this project were also very fruitful which set the direction for future work.

We are confident that this publication will be immensely useful to the researchers, policy makers and others concerned with conservation and use of tropical fruit genetic resources. We are highly thankful to the Department of Agriculture, Government of Thailand for providing the venue and other required support in organizing this meeting and to the Asian Development Bank for the funding support.

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First Annual Meeting of the Project on Conservation and Use of Native Tropical Fruit Species Biodiversity in Asia held at Pattaya, Thailand

6-9 February 2001

Summary of the proceedings

The first meeting of Asian Development Bank funded Tropical Fruit Trees (ADB-TFT) Project on Conservation and Use of Native Tropical Fruit Species Biodiversity in Asia was organized at the Ambassador City Jomtien Hotel, Pattaya, Thailand, from 6-9 February 2001. The objectives of this meeting were: (i) to review the progress and the outputs of different activities in the collaborating countries, (ii) to explore the possibilities of enhanced collaboration with regional and international organizations, (iii) to update the Country Coordinators on the work being done in participating countries, and (iv) to develop work plans for the year 2001.

The meeting was organized in four technical sessions, namely, (i) Review of progress and outputs, (ii) Thematic activities, (iii) International/Regional collaboration and linkages, and (iv) Developing work plans for 2001. Twenty-one participants, including Country Coordinators, resource persons from the Food and Agriculture Organization of the United Nations (FAO), Underutilized Tropical Fruits in Asia Network (UTFANET), International Tropical Fruits Network (TFNet) and Centre de Cooperation Internationale en Recherche Agronomique pour le Development (CIRAD), and IPGRI staff participated in the meeting.

In the Technical Session I, Dr Bhag Mal, Technical Coordinator of the project, presented a comprehensive overview of the progress and summary of the achievements of the project. Country Coordinators from 10 countries presented the progress of work and the achievements made under the project in their respective countries. Technical Session II was devoted to thematic presentations by IPGRI/TFNet staff on different topics, namely, Locating genetic diversity, collecting strategy, and information action plan (Z. Zengyen); In situ conservation of tropical fruit species in Asia (Deborah Nares); Tropical fruit trees: Enhancing germplasm exchange and use (J. Sajise) and Cryopreservation of citrus and some other tropical fruits: Recent research results (Cho Eun-Gi). The Technical Session III embraced presentations on international/regional collaboration by representatives from FAO, CIRAD, TFNet and UTFANET. The presentations included FAO experience on network activities on tropical fruit species (M.K. Papademetriou), Activities of TFNet in Asia Pacific region and prospects of its linkage with IPGRI-TFT Project (K.M. Taher), UTFANET collaboration with IPGRI-TFT project (Ma. Floroliza D. Tamzon) and Prospects of CIRAD's collaboration with IPGRI-TFT Project (Philippe Cao-Van). Working groups on different fruit tree species, namely, mango, citrus, rambutan, jackfruit, litchi and Garcinia deliberated at length on developing the work plans for 2001. The major recommendations and the salient points that emerged are given below:

Review of progress and outputs

It was noted that the project activities, in general, were going on well in each of the countries and the progress made during the period May-December 2000 was satisfactory. The constraints and opportunities for implementing the project activities were identified for the project as a whole. The recommendations and suggestions were proposed to improve the management of the activities. Detailed information on the progress of activities was provided by each Country Coordinator. It not only covered the progress and achievements, but also included the work plans for 2001.

Administrative aspects

The discussion mainly focused on the late arrival of funds. It was identified as a major constraint to the progress of activities. IPGRI Coordinator explained the reasons for the late release of funds to national partners, the major reasons being the significant time spent on developing
the proposed activities (individual country proposals) and the delay in signing the Letters of Agreement (LoAs) and their return to IPGRI-APO by the partners. Some countries took a long time in getting approval from the relevant authorities for signing the LoAs or making agreement with local collaborating organizations for the proposed activities. To bring an improvement in this situation, IPGRI-APO will closely work with the partners in order to issue LoAs for a quick release of funds in 2001.

Marketing and production aspects

Questions were raised on how to promote the production and marketing aspects in this project. The immediate need for conservation and the urgent need for conservation and use of species threatened by genetic erosion in different countries. The production and marketing aspects are being handled by other organizations such as FAO, TFSNet and UTPANET. IPGRI was seeking linkage with these organizations for improving the utility aspects of germplasm. The potential areas for cooperation were to be identified.

Another point raised was about developing off-season varieties to meet the market demand. This could be solved through introduction or exchange of diverse germplasm between different countries to make available a variety of species possessing desirable genes for late or early maturity, disease resistance, quality traits, etc.

Socio-economic information was considered very useful for both conservation and marketing, particularly for the sustainability aspects. This information should be well documented and shared among partners.

Germplasm collecting, characterization, documentation and conservation

The theoretical basis for germplasm collecting in the case of tropical fruit species was discussed. It was emphasized that there was a need for collecting, but number of samples/Accessions to be collected should be based on the capacity to conserve them. However, while exploring, it would be important to collect information on populations observed and document it for any future use. Use of Geographic Information System (GIS) to locate genetic diversity was emphasized.

The work presented by the Country Coordinators included project activities other than outputs of IPGRI/ADB project, but not many details were included. So it was agreed that in the future reports, details of work done on the target species with funding from other sources, including national funding, would be provided. Other partners including international or regional organizations, particularly national governments, non-governmental organizations should be listed in the reports.

While discussing germplasm exchange and Intellectual Property Rights (IPR), it was noted that the agreement for germplasm transfer and exchange should be based on the willingness of partners based on their mutual interests, and there was a need to develop guidelines in this regard. As no country is self-sufficient in plant genetic resources that it requires, increased cooperation is necessary between partner countries on different aspects including exchange of germplasm. Two options were considered: (i) bilateral, and (ii) multilateral agreements. It was agreed that the germplasm exchange and feasibility of establishing a regional genebank need to be further discussed so as to develop appropriate action plan on this aspect. Country Coordinators agreed to look into this matter seriously for the success of the project.

It is well recognized that if there were no economic or social benefits, the farmers would discontinue growing landraces which would result in a significant erosion of tropical fruit species genetic resources. It was a matter of great concern particularly for in situ conservation of tropical fruit tree species. For conserving germplasm in situ on a sustainable basis, the farmers would have to rely only on themselves, through several types of incentives can be provided to them to continue growing landraces. It is noted that providing financial support was neither practical nor sustainable. However, other types of incentives such as niche markets, product
diversification and genetic improvement of existing landraces for specific traits would go a long way in this regard.

The possible scenario for conservation of tropical fruit species on-farm as well as in-home gardens was discussed. Some partners expressed concern for depending on in situ conservation, since the farmers tend to change (cut down) crops quite often. The representative from CIRAD pointed out that the in situ conservation of tropical fruit trees was useless due to the severity of several diseases in the region, especially in the case of citrus. However, it was also noted that the in situ conservation was dynamic and change in the genetic composition of material grown were expected to occur which was a part of evolutionary process. It was noted that the in situ conservation would be possible only when the genetic diversity is useful and profitable to the growers and only at certain sites, which have to be identified based on a careful analysis of various factors, including socio-economic aspects. There is a need to develop some modules of in situ conservation with regard to economic analysis to see how it may benefit farmers/organizations as well as governments. It is also important for the researchers to realize that the farmers-growers are also caretakers of plant genetic diversity and should be considered as partners. In situ conservation is not just the conservation of genetic diversity but also embraces development.

Information on the latest protocols that could be used for long-term conservation of tropical fruit species was provided to the group. It was concluded that:

(i) There were a number of protocols for cryopreservation of tropical fruit species. The exact protocol that can be used successfully will depend on the species and plant material/tissue used.

(ii) Depending on the availability of liquid nitrogen, cryopreservation was considered as one of the cheapest methods for conservation of plant genetic resources.

(iii) While initiating work on cryopreservation of any species, it is best to start with easy method and then proceed to more complex methods ensuring greater survival.

(iv) For attempting cryopreservation within the ambit of the project, it was best to focus on practical aspects. Much of the basic work has already been done, and only protocols that could be used routinely were needed.

(v) A training course could be possible for researchers from the participating countries where work on cryopreservation is already in progress.

(vi) IPGRI plans to publish the protocols for cryopreservation of some of the citrus species in 2001.

Documentation work was the major concern expressed by some national programmes. The standardized formats for data management need to be developed. Also, there was a need to share information through web among different organizations. The information action plan developed during the TIF information documentation training, was presented to provide information to the Country Coordinators and they were requested to furnish their preferences for the name of the web site as well as its contents. It was also emphasized that the persons who have received training should be the focal points for coordinating the documentation activities in the respective countries.

International/regional collaboration

It was noted that at present there was a reasonable degree of collaboration among network stakeholders. However, much more remained to be done in this direction. There was a need and scope to further strengthen collaboration among stakeholders in order to avoid unnecessary duplication of efforts by the various agencies and to enhance the sustainability of the networks. The areas of collaboration between IPGRI and TIFNet could include:

(i) Implementation of in situ conservation projects, e.g. on-farm conservation (assist in socio-economic survey, training, project design and execution).
(ii) Identification of appropriate species/varieties for intercropping/crop diversification projects to be used by TFNet's projects in farmer's production and commercial plantation.

(iii) Identification of appropriate species/varieties for downstream processing, food and non-food uses.

(iv) Linking IFPRI/TFI information base to TFNet's global fruit information system.

A detailed work plan, both on short-term and long-term basis, should be formulated taking into consideration the existing work being done by IFPRI and various networks, namely, TFNet, UFTANET, CRCAD, REMUFRUT, RESEA-PCG and others. Since representatives of TFNet, UFTANET and CRCAD were the only ones present at this meeting, the possible areas identified for collaboration were: (i) conservation/characterization/evaluation/ utilization (IFPRI/NARS); (ii) collecting baseline data consisting of ecogeographic data/information, indigenous knowledge on both production and uses, and market information (UFTANET/TFNet/NARS); (iii) conservation/evaluation of promising clonal lines and other promising species (IFPRI/ UFTANET/NARS); (iv) production, multiplication, distribution (UFTANET/NARS); comprehensive socio-economic analysis; cost benefit/market analysis (TFNet/NARS); (v) gender studies (UFTANET); (vi) capacity building/training on production, propagation, post-management, databases, application/use of existing software (IFPRI/ UFTANET); (vii) product development and marketing (TFNet/ UFTANET/NARS); (viii) information technology; (ix) production of extension/IED materials (training manuals, fact sheets, etc.) (UFTANET in collaboration with IFPRI/CIRAD and TFNet/ NARS); and (x) production to consumption constraint analysis (TFNet/UFTANET/NARS).

It was agreed that there was a need to develop complementary conservation strategies for conservation of tropical fruit species genetic resources by balancing in situ and ex situ approaches. For example, due to the high risk of debilitating diseases occurring in Asia (mainly Citrus Canker Disease that can kill the trees, in situ conservation for Citrus species/varieties could be a problem and required careful analysis of the situation and the specific sites identified for the in situ conservation. Ex situ conservation should be done with disease-free material and kept under insect-proof facilities to avoid re-contamination through insect vectors. This involved a pre-liberation step. As the wild relatives of most fruit species are forest species, there is a need to link with forestry conservation and that would be in situ conservation in protected areas, etc. Cryopreservation was shown to be the most cost-effective. Seed conservation might be considered for conservation of genes of tropical fruit species that produced orthodox seeds.

As some pests and diseases were found to be strong limiting factors for the development of a crop, sustainability and profitability were important key issues for farmers. In order to develop fruit varieties for better market opportunities, these should be evaluated for resistance/tolerance to fruit injuries, shelf-life, packaging behaviour, transportation, storage and processing, etc.

A need to identify pollinators to develop/improve "private botanical gardens" wherein native species could be kept and managed in the "green" or "nature" framework, with a possible access for R&D was expressed. This could complement in situ conservation of wild species of tropical fruits.

For management of data from characterization/evaluation of Citrus, EGO software from CIRAD could be used as it was recognized by FAO and IFPRI. The IFPRI agreed to contact CIRAD through Philippe Cao-Van and see how best this offer could be used for documenting information on tropical fruit species genetic resources.

It was noted that the efforts should be made to carry out Citrus evaluation on disease-free trees/samples to avoid the effect of the debilitating diseases on the tree and the fruit and other characters (e.g. size, sugar content, acidity, etc.). While presenting characterization and evaluation information, details about the combinations evaluated (ecotype/stock tree) should be provided, as the rootstock can influence the yield and the fruit characteristics.
As an output of the presentations by the representatives of Regional and International Organizations and based on response on a questionnaire circulated to these representatives during the meeting, several important points related to collaboration with different organizations emerged. The suggested areas for collaboration with UTPANET were: (i) information technology/database generation for underutilized fruit species; exchange of information/data; (ii) socio-economic surveys in the region, including market demand, trade in the context of World Trade Organization (WTO) regulations; cost-benefit analysis for three fruit species, mango, gooseberry, and pummelo, and (iii) post-harvest losses and transport. Funding sources could be UTPANET, TFNet, and IPGRI. The timeframe could be three years initially. Dr Nazmul Haq, Director UTPANET, were assigned the responsibility of this collaboration. The collaboration can be concretized through a joint proposal involving UTPANET and IPGRI.

Operational linkages with TFNet could be developed and concretized through joint planning and designing of projects, e.g. on-farm conservation, implementing pilot projects and linking databases. There could be joint funding depending on the level of commitment of joint proposal can be developed for funding by donors. The time frame will be three years and the Chief Executive Officer (CEO) TFNet will be responsible for collaboration.

The areas of collaboration with CIRAD include standardization of characterization/evaluation data for exchanging information among partners; and with CIRAD. The collaboration could be furthered by promoting the use of EGI software-based on IPGRI Citrus descriptors. Dr Roland Cotin and Dr Philippe Cao Van will be responsible for this collaboration.

Collaboration with FAO would be in terms of communication linkages, to keep all concerned informed about the initiatives, activities, projects/programmes. Dr N. Murthi Anuradha and Ms Nuria Uquía will be responsible for collaboration with FAO.

**Working groups**
The working groups deliberated at length to develop the work plan for 2001 and the following important points emerged:

(i) To meet market demand and fetch a better price, off-season varieties need to be developed.

(ii) Standard descriptors need to be developed for the three target species, viz., rambutan, mango, and litchi.

(iii) For characterization and evaluation, standard descriptors should be used for the species for which IPGRI descriptors are already available, and for other species, the descriptors need to be developed and used.

(iv) The optimum and minimum number of plants to be conserved and to be used for data recording were decided for different species as follows:

<table>
<thead>
<tr>
<th>Crop</th>
<th>Minimum number of trees</th>
<th>Optimum number of trees</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mango</td>
<td>3</td>
<td>5</td>
</tr>
<tr>
<td>Citrus</td>
<td>3</td>
<td>5</td>
</tr>
<tr>
<td>Rambutan</td>
<td>3</td>
<td>5</td>
</tr>
<tr>
<td>Mangooseen</td>
<td>3</td>
<td>5</td>
</tr>
<tr>
<td>Litchi</td>
<td>3</td>
<td>5</td>
</tr>
<tr>
<td>Jackfruit</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Seed</td>
<td>16</td>
<td>50</td>
</tr>
</tbody>
</table>

(v) A need was felt to specify information on collection sites as well as on the plants (on its own or on rootstock).

(vi) It was agreed to bring out publications on the completed studies.

(vii) Information on genetic erosion need to be gathered for different species.

(viii) Continuity of Country Coordinators was considered essential for a better implementation of project activities, and
(ix) The salient research results emanating from the projects, other than ADB funded TFP Project, should also be included in the country reports for the benefit of other concerned.

**Work plan for 2001**

Inspite of the fact that the funds were received late, most of the countries have undertaken activities using their own resources. Some activities which were envisaged to be carried out during 2000, could not be completed. These will be completed during 2001 along with the activities earmarked for 2001. The work plan for 2001 was developed which includes the activities originally planned for 2001 as well as the activities that could not be completed during the year 2000.

**Steering Committee Meeting**

The meeting of the Steering Committee was held on 9 February 2001 under the chairmanship of Dr. Felipe dela Cruz. The Steering Committee discussed the following agenda items and the minutes of the meeting are appended:

(i) Adoption of agenda
(ii) Approval of the minutes of the first meeting
(iii) Matters arising out of the first meeting
(iv) Objectives of the project
(v) Release of funds
(vi) Development of database using available characterization data
(vii) Germplasm exchange and establishment of a regional genebank
(viii) Training needs
(ix) Development of descriptors
(x) Proposals for submission to funding institutions
(xi) Update on website and publication of in-house newsletter
(xii) Format and submission of revised annual report
(xiii) Election of Chair and Vice-Chair of the Committee
(xiv) Venue of next meeting
(xv) Equipment.
Conservation and use of native tropical fruit species biodiversity in Asia

Bhag Mal and V. Ramanatha Rao

Introduction

Countries in Asia are becoming increasingly aware about the potential importance of native tropical fruit species as largely underexploited sources of income and employment, particularly for women, and as good sources of dietary vitamins, minerals and energy. It is recognized that improved production and marketing can help to meet the rural and urban demands, resulting in increased national revenues. In addition, the role of Asia’s enormous diversity of fruit species, both cultivated and wild, as components of stable ecosystems, is now becoming clearer.

Over 400 edible fruit species are found in Asia. They are important for the well being of the population in the region, as sources of supplemental food, nutritionally balanced diets, and enhancing both household incomes and national revenues. Some species have specific medicinal uses, while others are used for timber, fuel wood and livestock feed. Diversity present in these species is eroding at a rapid pace.

In forest areas, the rich diversity of fruit species plays an important role as sources of food and shelter to other species of plants and animals, providing stability in complex natural ecosystems. In agricultural areas, fruit trees are important components of multi-crop systems, under which other vegetables, cereals, legumes, root and tuber crops, forages and livestock can thrive.

Fruit plant genetic diversity is seriously threatened due to various human activities. In recent years, steps have been taken to mitigate the loss of valuable genetic diversity in many parts of the world. The International Plant Genetic Resources Institute (IPGRI) is highly concerned with the effective conservation and sustainable utilization of plant genetic resources for the present and future generations and has been doing a pioneering work over the last two decades in this important area. It has assisted the countries in the Asian region and around the world to locate, collect, conserve, document and use native biodiversity, including fruit species.

In view of the need for further strengthening this work, IPGRI has initiated a project on ‘Conservation and Use of Tropical Fruit Species Biodiversity in Asia’ which is operational in ten countries, namely, Bangladesh, China, India, Indonesia, Malaysia, Nepal, Philippines, Thailand, Sri Lanka and Vietnam. This work is mainly funded through grant by the Asian Development Bank (ADB). The progress update of this project is briefly summarized below:

Project planning meeting

A Project Planning Meeting was organized at the Mines Beach Resort and Spa, Selangor, Malaysia, during 5-18 February 2000. The objectives of the Meeting were: (i) to acquaint the Country Coordinators from ten collaborating countries, with administrative and financial arrangements, (ii) to provide a platform to the Country Coordinators to interact and understand the ongoing research activities in collaborating countries, (iii) to explain the project implementation arrangements to the Country Coordinators, and (iv) to discuss and finalize the workplan for the project duration of three years.

Twenty participants comprising Country Coordinators from ten countries, representatives from international/regional organizations, IPGRI staff and observers attended the meeting. The meeting was organized in five technical sessions, namely, (i) Logistic arrangements, (ii) Current status of work, (iii) Developing work plans, (iv) International/regional collaboration, and (v) Finalization of work plans and budget.
The session that dealt with the logistic arrangements was aimed at providing the partners with the details on the administrative, financial and technical aspects and the implementation arrangements for effective functioning of the project. The administrative and financial aspects are being coordinated from IPGRI-APO, Serdang, Malaysia by Dr V. Ramana Sree, Project Coordinator and the technical aspects are governed from IPGRI South Asia Office, New Delhi, India, by Dr Bhag Mal, Technical Coordinator for this project. The summary of proceedings of the meeting is given in Annexure V.

Steering Committee

The Steering Committee (SC) constituted for this project has the responsibility of monitoring the activities, providing direction and developing additional complimentary funding proposals. All the Country Coordinators are the members of the Steering Committee. The Project Coordinator and the Technical Coordinator from IPGRI are the ex-officio members. The Technical Coordinator also acts as the Secretary of the Steering Committee. The Country Coordinators elected, by consensus, Dr S.P. Ghosh (India), as the chairperson and Dr Felipe S. de la Cruz (Philippines) as the vice-chairperson for a two-year term. The terms of reference of the Steering Committee were finalized.

The first meeting of the Steering Committee was also organized, in which the chairperson explained the role and responsibilities of the Steering Committee and asked the members to make it fully effective. The Steering Committee discussed the work plan for the project period of three years and identified the major activities in each crop on which the thrust is to be given during the year 2000.

Task Force

A Task Force was constituted for determining the population size for conservation of target fruit species. It comprised Dr S.P. Ghosh (India) as the chairman, and Dr Sureshtra Kukunor from Indonesia, Dr Felipe S. de la Cruz from Philippines, Dr V. Ramana Sree, IPGRI-APO, Serdang and Dr Bhag Mal, IPGRI, Delhi, as the members. The Task Force would recommend to the SC on: (i) the minimum number of trees required to be conserved for maintaining the diversity in the selected fruit tree species, and (ii) the minimum and optimum number of plants on which data should be recorded for characterization and evaluation of germplasm collections.

Administrative aspects

a) Personnel

Two support staff, i.e. Programme Assistant and Documentation Assistant, were recruited to assist the Project Coordinator at IPGRI-APO Serdang, Malaysia. One Scientific Assistant has also been recruited to provide assistance to the Technical Coordinator and Activity Manager, Tropical Fruits at IPGRI-Delhi, India. The details are given in Annexure VI.

b) Equipments

As a result of delay in receipt of funds at the project implementing institutions/countries due to procedural complexities in the collaborating countries, only a few countries could procure equipments. The procurement of equipments, in other countries is in process.

c) Administrative changes

The Country Coordinators were changed in some countries, and the new coordinators are Dr R. N. Pal for India, Dr Kedar Sudathoki for Nepal, and Dr Shantha Peris for Sri Lanka. Since the Country Coordinator for India, who was also the chairperson of the Steering Committee, has taken voluntary retirement, a new chairperson was elected in the SC meeting held at Pathaya, Thailand on 9 February 2001.
d) Finalization of Letters of Agreements (LoAs) and release of funds
The IPGRI’s projects are implemented through the Letters of Agreements (LoAs) with the participating institutions. The LoAs were finalized and funds were released to six countries, namely, Indonesia, Malaysia, Nepal, the Philippines, Thailand and Vietnam, by 31 July 2000. The LoAs for the remaining four countries, namely, Bangladesh, India, China and Sri Lanka, were finalized later and the funds were released by 31 August 2000.

e) Research achievements
1. Locating and collecting diversity
A total of 317 accessions of different fruit tree species were collected in different countries based on eco-geographic studies and the species-wise details are given in Table 1.

Table 1: Tropical fruit tree species germplasm collected during 2000

<table>
<thead>
<tr>
<th>Species</th>
<th>Countries</th>
<th>Area/Region</th>
<th>No. of accessions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mango</td>
<td>India</td>
<td>Southern, northern</td>
<td>34</td>
</tr>
<tr>
<td></td>
<td>Philippines</td>
<td>region</td>
<td>11</td>
</tr>
<tr>
<td></td>
<td>Malaysia</td>
<td>Peninsular region</td>
<td>34</td>
</tr>
<tr>
<td>Citrus</td>
<td>India</td>
<td>Northeastern hill</td>
<td>16</td>
</tr>
<tr>
<td></td>
<td>China</td>
<td>region</td>
<td>26</td>
</tr>
<tr>
<td></td>
<td>Vietnam</td>
<td></td>
<td>139</td>
</tr>
<tr>
<td>Rambutan</td>
<td>Indonesia</td>
<td>West Java, West Sumatra</td>
<td>16</td>
</tr>
<tr>
<td></td>
<td>Malaysia</td>
<td>Peninsular States</td>
<td>17</td>
</tr>
<tr>
<td>Litchi</td>
<td>Vietnam</td>
<td></td>
<td>14</td>
</tr>
<tr>
<td>Mangosteen</td>
<td>Indonesia</td>
<td>West Java, Sumatra</td>
<td>10</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td></td>
<td>317</td>
</tr>
</tbody>
</table>

Mango:
In India, eco-geographic studies were conducted to locate the diversity of traditional varieties of mango. Thirty three genotypes were located and their seeds will be collected. Preparation of distribution maps, using geo-referenced data and Geographic Information System (GIS), has been initiated. Ten varieties were collected from southern India and these were grafted and field planted. A total of 24 accessions were also collected from north India. A part of the existing germplasm was multiplied clonally for planting in the field genebank. The review of literature conducted in Thailand indicated that geographical survey could be important in 13 provinces from where 15 species of Mangifera could be collected. Eco-geographic studies conducted in the Philippines indicated that cultivated varieties were mainly grown in areas with distinct dry and wet seasons. Distribution maps were prepared to indicate sources of mango germplasm. Eleven new accessions were collected and 17 accessions were introduced from abroad. The newly collected seeds were germinated, while the scions were grafted in the nursery for maintenance until they were ready for field establishment. In Malaysia, eco-geographic studies revealed the locations of 135 accessions of Kluini (Mangifera odorata). Twenty four accessions were collected from the states in Peninsular Malaysia and 27 accessions were received from the Universiti Putra Malaysia (UPM). These were planted in the field genebank. An eco-geographic study was initiated in Vietnam to identify the diversity of different Mangifera species. Exploration activities were also initiated in Sri Lanka.

Citrus:
Sixteen accessions, mostly endangered and threatened species/types, were collected from Northeastern Hill (NEH) Region, Meghalaya in India. In China, 26 accessions of 6 species were
collected. In the Philippines, many *Citrus* species are widely distributed but rarely cultivated except for recently introduced species. Distribution maps were prepared to indicate sources of living germplasm of *Citrus* species. The eco-geographic survey in Vietnam showed three main regions of habitat where *Citrus* cultivation is traditional and great diversity exists. A total of 129 accessions of different species/cultivar groups have been collected so far. Ecogeographic study has been carried out on *Citrus* in Nepal and preparation of distribution maps is underway.

**Rambutan:**

Eco-geographic study was conducted in West Java, Indonesia and the distribution map showing rambutan diversity was prepared. Seven varieties and one species from West Java and seven varieties and one species from West Sumatera were collected and planted in the field genebank. The literature survey in Thailand revealed the occurrence of seven species of *Nephelium* in 30 provinces and the distribution maps will be prepared accordingly. Based on eco-geographic studies in Malaysia, the exact locations of 52 pulasan (*Nephelium ramboutan-akel*) trees were found out and the latitude and longitude of these locations were determined. Seventeen accessions were collected from different states in Peninsular Malaysia.

**Jackfruit:**

A total of 120 germplasm of jackfruit has been located in Bangladesh through farmers' participatory survey. The seeds and shoots of the identified germplasm will be collected in next fruiting season.

**Litchi:**

In Vietnam, an eco-geographic survey was conducted and distribution maps were prepared. Fourteen accessions were collected.

**Mangosteen:**

In Indonesia, 5 accessions were collected from West Java and were planted in field genebank at Subang, West Java, while another 5 accessions collected from Sumatera were maintained in the field genebank at Solok, West Sumatera. In the Philippines, many species were found to be widely distributed at low and medium elevations and distribution maps were prepared to indicate sources of living germplasm from where collecting would be done.

2. **Germplasm characterization, evaluation and utilization**

A sizeable number of accessions of different tropical fruit tree species were characterized and evaluated and the details are given in Table 2.

**Mango:**

In India, 78 accessions were characterized using 24 descriptors and the information was databased. Also, fifty varieties were evaluated morphologically and described as per IPRG descriptors. Out of 269 accessions of mango presently maintained in field genebank in the Philippines, 124 accessions were characterized for fruit characters. Twenty-four accessions of kulai (*Mangifera odora*) were characterized for fruit characters in Malaysia. Germplasm characterization was initiated in Vietnam.

**Citrus:**

One accession of *Citrus lemon* was characterized in the Philippines. In China, 40 accessions planted 4 years ago were evaluated and characterized for tree behaviour, fruit maturity, fruit yield and quality. Elite materials with valuable traits such as high fruit quality novel orange selections; seedless or late ripening pomelo selections; seedless, good flavoured and easy peeling tangerines were being identified. A rootstock trial was carried out in pummelo to identify dwarf,
Table 2: Tropical fruit tree species germplasm characterized

<table>
<thead>
<tr>
<th>Species</th>
<th>Countries</th>
<th>Accession characterized</th>
<th>Descriptors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mango</td>
<td>India</td>
<td>78</td>
<td>24 characters</td>
</tr>
<tr>
<td></td>
<td>Philippines</td>
<td>50</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Malaysia</td>
<td>124</td>
<td>Fruit characters</td>
</tr>
<tr>
<td>Citrus</td>
<td>China</td>
<td>24</td>
<td>Fruit characters</td>
</tr>
<tr>
<td></td>
<td>Philippines</td>
<td>40</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Evaluation trial</td>
<td>1</td>
<td>Rootstock characters</td>
</tr>
<tr>
<td>Rambutan</td>
<td>Philippines</td>
<td>17</td>
<td>-</td>
</tr>
<tr>
<td>Jackfruit</td>
<td>Sri Lanka</td>
<td>13</td>
<td>IPGRI descriptors</td>
</tr>
<tr>
<td>Litchi</td>
<td>India</td>
<td>49</td>
<td>Morphological traits</td>
</tr>
<tr>
<td></td>
<td>Malaysia</td>
<td>14</td>
<td>Fruit characters</td>
</tr>
<tr>
<td>Mangosteen</td>
<td>Philippines</td>
<td>3 species</td>
<td>-</td>
</tr>
</tbody>
</table>

early bearing root stocks with good quality and high productivity. Germplasm characterization was initiated in Vietnam.

Rambutan: Seventeen accessions of pulasan (*Nephelium rambutan-ake*) were characterized in Malaysia. In Indonesia, elite lines/germplasm with valuable traits for tree/crown form, fruit yield, fruits per cluster, fruit form, size, colour, flesh and taste were identified.

Jackfruit: Thirteen cultivars of jackfruit were characterized using IPGRI descriptors in Sri Lanka.

Litchi: Germplasm characterization was initiated in Vietnam. In India, morphological characterization of 49 genotypes was carried out and fruit characters were recorded on 14 genotypes.

Mangosteen: In the Philippines, three species, namely, *Garcinia binucata*, *G. kydia* and *G. xanthochymus*, were characterized. Elite germplasm lines with valuable traits were identified in Indonesia.

2. In situ conservation

Citrus: In India, links were established with District Forest Officer (DFO), Chief Conservator of Forests (CCF), District Health Officer (DHO) and Headmen of different villages around the already established *Citrus* gene sanctuary at Garo hills of Meghalaya for efficient management of *in situ* conservation sites. *In situ* conservation sites were identified for mandarin, orange and pummelo in Vietnam.

Litchi: *In situ* conservation site was identified for litchi in Vietnam.

Jackfruit: Sites of *in situ* conservation were identified in the home gardens and small orchards throughout Bangladesh.
4. *Ex situ* conservation

**Mango:**
A field genebank was established at the Central Institute of Subtropical Horticulture (CISH), at Lucknow (India), with 600 accessions from north India and another at the Indian Institute of Horticultural Research (IIHR), Bangalore, for the germplasm collected from south India. In the Philippines, a field genebank with 259 accessions was established and 30 accessions were being maintained in the nursery, which would be transferred to the field genebank in the due course of time. Establishment of duplicate collection of mango, particularly ‘Canhao’ variety and exotic accessions were in progress at two State Universities as a complementary measure. Twenty-seven accessions of Livini (Mangifera odorata) were planted in the field genebank in Malaysia.

In Thailand, the collected germplasm would be established in the field genebank at Staket Horticultural Research Centre and 200 mango rootstocks of ‘Kaew’ have already been planted.

**Citrus:**
In India, *Citrus* germplasm comprising 19 rootstocks from exotic sources and 110 rootstocks from indigenous sources were being maintained in the field genebank at the National Research Centre (Citrus) at Nagpur. The indigenous collection included 26 Rangpur lime, 24 rough lemon, 12 cleopatra mandarins, 14 trifoliate orange, 16 trifoliate orange hybrids and 18 other rootstocks. Seven *Citrus* species collected locally were established in the field genebank in the Philippines. In addition, 2 accessions of *C. macrocarpa* were established in the field. A field genebank comprising 137 accessions of sweet orange was established in China. The cryopreservation studies revealed that precultures on MT medium supplemented with 5% Dimethyl Sulfoxide (DMSO) was found to improve the survival rate after cryopreservation. Loading was found to be necessary for cryopreservation of *Citrus* shoot tips and the best results were obtained for 30-minute loading time. The highest survival rate was found when shoot tips were treated with PVS2 for 50-60 minutes at -1°C with highly concentrated vitrification solution. In Vietnam, all 139 accessions of *Citrus* were grafted budding and were grown in greenhouse and the field at Huong Fruit Research Centre and Vietnam Agriculture Science Institute (VAST). A potential conservation method was developed for the maintenance of *Citrus* in greenhouse.

**Rambutan:**
Germplasm collected from Java and West Sumatra have been planted in the field genebank at Sabang, West Java. In Thailand, more than 200 rootstocks were prepared in the nursery for further grafting or budding with collected materials at Chanthaburi Horticultural Research Centre.

**Jackfruit:**
Several promising genotypes of jackfruit were conserved in field genebank in Sri Lanka.

**Litchi:**
A field genebank has been established with 49 genotypes at the Central Horticultural Experimental Station (CHES) of Indian Institute of Horticultural Research (IIHR) at Ranchi in India.

**Mangosteen:**
Five *Garcinia* species, namely, *G. kirsiaea*, *G. dulis*, *G. syosa*, *G. lateritia*, and *G. xanthochrysum*, have been established in the field genebank in the Philippines. In addition, 4 accessions of *G. mangostana* are being maintained in the nursery.

5. Information and documentation

**Mango:**
In India, cataloguing of 78 accessions was undertaken at the Central Institute of Subtropical Horticulture, Lucknow and of 30 accessions at the Indian Institute of Horticultural Research, Bangalore. In the Philippines, passport and characterization data were documented using MIS-
Excel. In Malaysia, fruit characters of 24 accessions of kuini (Mangifera odorata) were stored using MS-Excel. Passport and collection data were gathered and entered in the database in Vietnam. Collection of information on extant mango diversity was initiated in Sri Lanka.

Citrus:
In the Philippines, passport and characterization data of Citrus accessions were documented using MS-Excel. In China, work on measuring and collecting information on specific characteristics as per IPGR descriptors was initiated in order to complement the existing database. Passport and data were gathered and database development was initiated in Vietnam. In Nepal, documentation of information on genetic resources of Citrus was initiated and information on current practices and conservation methods in Citrus was compiled.

Rambutan:
The work on information and documentation of rambutan germplasm was initiated in Indonesia.

Jackfruit:
In Sri Lanka, information on jackfruit cultivars available at different research stations, farms and other government institutions was recorded and documented.

Litchi:
In India, the minimum descriptors for litchi were prepared. Passport and collection data were gathered and database development was initiated in Vietnam.

Mangosteen:
Passport and characterization data on Garcinia accessions were documented using MS-Excel in the Philippines.

6. Socio-economic studies
Rambutan:
A study was conducted in West Sumatera, Indonesia, to determine various socio-economic aspects of rambutan production. The results revealed that (i) rambutan farmers were still using traditional pre- and post-harvest technology, (ii) the magnitude of cultivation ranged from 10-70 trees with productivity of 5-10 kg/tree at 3 years age and 250 kg/tree at 10 years age, (iii) the highest return of Rp 720/kg was obtained when the marketing channel was direct from farmers to consumers, (iv) fruits with stalks packed in carton and sprayed with beer maintained freshness up to 6 days, and (v) excessive fruit production in the main season caused reduction in the selling price at the minimum level. Based on the results, a model of collective farming was proposed in order to improve farmers’ income.

Other species:
A survey was conducted with fruit growers and lot of information on the production and marketing aspects of mango, citrus and litchi was collected in Vietnam. The information is being analysed in order to interpret it meaningfully. In Bangladesh, a questionnaire was developed for the socio-economic survey. The socio-economic studies relating to citrus farming, production and post-production problems and consumer preferences were conducted in Nepal and the results were being analyzed.

7. Human resource development and capacity building
A Regional Training Course on Strengthening National Capacity to Manage Information on Tropical Fruit Species Genetic Resources was organized as the Institute of Plant Breeding (IPB), UPLB, Los Baños, the Philippines, from 9 to 20 October, 2000. The persons associated with the project in India, the Philippines, Bangladesh, Indonesia, Malaysia, Nepal, Thailand, Sri Lanka
and Vietnam participated in the training course to enhance their skills in information database management. The participant from China could not attend this training course. However, two IPGRI experts, who happened to be in China, organized a short training course on information documentation for the benefit of the person who could not participate in the training organized in the Philippines.

In Vietnam, a meeting of staff concerned with germplasm collection was organized at Vietnam Agriculture Science Institute (VASS) to apprise the participants as to how to carry out exploration and collection in urgent fruit tree species.

Training

A Regional Training Course on ‘Strengthening National Capacity to Manage Information on Tropical Fruit Tree Genetic Resources’ was organized at Las Bune in the Philippines from 9 to 21 October 2000. The main topics covered during the training course included: Introduction to types of genebanks and PGR documentation; Identifying requirements for efficient documentation system for tropical fruit species database; Introduction to approaches for developing documentation system with software diversity; Presentation of other software for PGR documentation (LCCRD, CD, MGIS, etc.); Introduction to genus and the development of genebank management software; File types, data exchange on Windows platform and concept of Data Interchange Protocol (DIP). Presentation and practical of DIP/DB software (both DOS and Windows version) and its use for PGR data exchange, electronic germplasm catalogue and directories. Use of Excel for PGR database using sample of TAROGEN Network (TAROGEN) 2000 developed for taro descriptors and data documentation; Practical on developing electronic descriptors and its use for PGR database development; Developing electronic descriptors for mango, citrus and jackfruit; Introduction to basic statistical concepts for PGR data analysis (estimation of means, variances, and other important parameters, construction of frequency distribution tables, comparison of two populations, hypothesis testing, sample size determination, etc.); Practical on use of Excel for statistical analysis of PGR data and discussion on basic principles for experimental design for germplasm characterization and evaluation—setting up layout and analysis of Completely Randomized Design, Randomized Complete Block Design and Augmented Block Design analysis; introduction to HTML and PDF formats and Web page development; PGR resources information on the Internet and computer practical: Introduction to Global Positioning System (GPS) and Geographic Information System (GIS) software (Floormap and DfA) and its application to plant genetic resources; etc.

During the training course, an action plan to undertake the various documentation activities under the ADD-TTT project was developed, presented and discussed in great detail and finalized in consultation with all the participants of the course. It was also agreed that the action plan would be submitted to all the respective Country Coordinators of the project for its effective implementation.

In Vietnam, a meeting of the staff concerned with germplasm collection was organized at Vietnam Agriculture Science Institute (VASS) to apprise the participants as to how to carry out exploration and collection in target fruit tree species.

A Regional Training Course on ‘Characterization, Evaluation and Conservation of Tropical Fruit Genetic Resources’ and another training course on ‘Use of Molecular Markers for Characterization of Tropical Fruit Genetic Resources,’ are planned to be organized at the Indian Institute of Horticultural Research (IIHR), Bangalore, India, in May 2001 and at Zhongshang University, Wuhan, China in October 2001, respectively.

Collaborative projects funded by other donors

The work on tropical fruit tree species is supported by national and international organizations in the participating countries in order to achieve faster progress and development. The details provided by the Country Coordinators are as follows:
India
(i) Improvement of mango breeding is supported by the Indian Council of Agricultural Research (ICAR)
(ii) National Agriculture Technology Project (NATP) on Plant Biodiversity funded by the World Bank.

Vietnam
(i) Project on strengthening the seedling production system supported by the Govt. of Vietnam.

Constraints, opportunities and recommendations
The collaborators' views regarding the constraints faced, possible opportunities and the recommendations are briefly mentioned below:

Constraints:
1. One of the constraints faced by the participating countries was the late receipt of funds. This was primarily due to the procedural delay in signing the LoAs by the participating countries. In some countries, the procedure of transfer of funds is little complicated and hence consuming time. The funds are received first at the Headquarter of the concerned organizations and are then transferred to the respective institute(s)/centre(s) where the work is undertaken. This initial constraint will now be taken care of by impressing upon the relevant organizations for a faster flow of funds.
2. Pulasan (Nephelium rambouta-vake) and kulint (Mangifera odonata) are seasonal crops in Malaysia and did not bear flowers and fruits during the last flowering and fruiting season and hence, some of the activities could not be undertaken as per schedule.
3. There could be a constraint of language in exchange of information between partners.
4. The funds earmarked for equipment should have been provided in the beginning itself so as to enable their procurement in time and to start the research activities accordingly.
5. Germplasm characterization is a new activity in some countries such as Vietnam and all researchers are not equally competent in dealing with this task and therefore curators need to be given training in characterization.
6. There were changes in the Country Coordinators in some countries, e.g., India, Sri Lanka and Nepal, which affected the progress to some extent in these countries.

Opportunities:
1. This project has provided an opportunity for initiating another collaborative project by ACIAR to complement the activities under ADB supported project in a few selected countries, namely, Malaysia, Thailand, Vietnam and the Philippines.
2. This project has stimulated fruit curators and breeders to manage germplasm properly for the improvement of agribusiness, e.g., rambutan and mangosteen in Indonesia.

Recommendations:
1. It was suggested that the project should stress more on germplasm utilization and conduct training courses on fruit breeding.
2. There should be a provision of organizing training courses before the start of new activities. This will help the researchers in enhancing their skills in the relevant field, which will enable them to carry out the work more efficiently.
3. To record location data, GPS with altimeter should be provided to all countries that will be doing collecting of germplasm under the project.
4. The research papers, abstracts/summary may be translated into English and provided to the partners.
Locating genetic diversity of tropical fruit tree species

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Introduction
Asia, the Pacific and Oceania (APo) region covers a large area of tropical zone and is rich in tropical fruit tree genetic resources. Many tropical fruit tree species originated in this region. IPGRI-APo has recognized the importance of these species and initiated a series of activities on conservation and use of various tropical fruit tree genetic resources in the region since 1995. The activities mainly focused on the priority species including major fruits (mango, citrus, and rambutan) and minor fruits (durian, litchi and jackfruit) identified during an expert consultation meeting and synthesis of information on distribution, diversity and status of these species and development of complementary conservation strategies (Arora 1996; Arora and Rao 1996; Arora 1998). In 2000, a project supported by the Asian Development Bank (ADB), was initiated by IPGRI-APo in collaboration with national programmes of 10 countries, namely Bangladesh, China, India, Indonesia, Malaysia, Nepal, the Philippines, Sri Lanka, Thailand and Vietnam. The project aims to promote conservation and use of native tropical fruit tree species important in the region for local economic development and income generation.

Diversity of major tropical fruit tree species
It is estimated that there are about 500 species of tropical fruit trees in APo region, which involve 30 families and 59 genera (Arora 1998). In Southeast Asia alone, there are 120 major fruit species, and 275 minor fruit species (Verheij and Cornel 1992; Arori 1998). Among these species, about 50-60 species are the most important indigenous fruits in Asia (Arora and Rao 1996, Arora 1998). Citrus, mango, rambutan, jackfruit, litchi and durian occupy 80% of total fruit production in the region.

Citrus has 16 species which are distributed in East Asia, South Asia and Southeast Asia. There are two sections in Citrus genus: Papeda and Citrus. The major cultivated species include C. reticulata (mandarin), C. sinensis (sweet orange), C. aurantiifolia (your lime), C. limon (lemon) and C. grandis (pummelo). The diversity of mango includes 57 species in Mangifera genus. In section Mangifera, M. indica, M. abbreviata, M. griffithii, M. laurina, M. minor, M. monandra, M. pentandra, M. quadrifida and M. simile are important cultivated species which are distributed mainly in Southeast Asia. Section Limus includes M. caesia, M. foetida, M. kermansh, M. odorata and M. pajaz, which are wild species and mainly distributed in Malaysia, Kalimantan, Sumatra and Borneo.

Rambutan is related to more than 20 Nephelium species distributed mainly in Southeast Asia. Of these, a produce edible fruits, including V. kappaceae, N. rambutan-ake, N. cuspidatum, etc. Litchi is the only species of genus Litchi and is mainly distributed in southern China, Vietnam, the Philippines and Malaysia. There are 3 sub-species / varieties, i.e. chinensis, philippinensis and javanica. Jackfruit belongs to 11 species in the genus Artocarpus and more diversity is distributed in South Asia. A. heterophyllus (jackfruit), A. integer (chempedak), A. elasticus and A. nitidus are distributed in different countries in the region and popularly used as fruits. Mangosteen belongs to Glicinea genus, which possesses more than 200 species. Of these, 8-16 species are important. Garcinia mangostana is a cultivated species and distributed in Malaysia, Indonesia, the Philippines and Indo-China, Thailand, Vietnam and Myanmar (Arora 1998).
Considerable genetic diversity could be found within each species. The countries in the region have made efforts to collect and conserve the genetic diversity of tropical fruit trees. The various types and ecotypes were found in different species.

Locating diversity

It is recognized that the diversity is not evenly distributed within the geographical regions (Guarino et al. 1995). Some areas may be richer in biodiversity than other areas, and some species may also have more variation than others in a particular area. Types, lines or genes may be present in some populations, but not in others even in the same area. All these differences might be closely associated with ecogeographical conditions in a particular area. How the diversity is distributed within a given gene pool is an interesting topic and a fundamental question? Therefore, it is necessary to know where particular material of interest occurs and what is the pattern of diversity in individuals, or populations in order to capture the maximum diversity while collecting germplasm and design proper conservation strategies, particularly for in situ conservation.

Understanding diversity patterns

Site data are usually recorded during collecting missions. These data are essential for the analysis of ecogeographic distribution. The analysis of taxonomic, ecological and geographic data can help to identify the habitats favoured by the target taxa and the geographic limits of its distribution (Maxted et al. 1995). The analysis of taxonomic, ecological and geographic data can predict the potential areas for conservation of a particular species. For example, the percentage of sites for each climatic region where a species occurs and the percentage of sites of each soil type in which a number of taxa occur; influence of both the climatic factors and soil types on the distribution of various species diversity can be predicted.

Usually, the ecogeographic data are multivariate. To analyse these data, the most popular method is the cluster analysis which produces hierarchical clustering showing relationships of different taxa or groups of a species. The analysis defines groups of objects, i.e. clusters. The overall similarity between two objects within the same cluster will be more than that between two objects in different clusters (Guarino 1995).

There are several methods for calculating the similarity or dissimilarity according to the type of the data. For example, the data recorded in nominal scale are good for calculating the simple matching coefficient; the data recorded in binary scale are good for calculating the Jaccard coefficient; and the continuous data for Euclidean distance. The principal component analysis (PCA) is a useful tool for analysing ecogeographic data, which will carry out multivariate analysis and produce new independent variables, a linear combination of original variables. Using this method, a long list of original variables can be reduced to just a few, which can cover most of the variation represented in the original variables. How much of the original variation is represented by each principal component can also be revealed. Through such analysis, the role of each of the ecogeographic factors can be identified.

Mapping ecogeographic diversity

Mapping collecting sites is an effective way to represent genetic diversity in conjunction with topographical, climatic, geological and soil information. There are many ways to plot ecogeographic data on distribution maps, but the most popularly used method is the point map, which shows exact locations of accessions (Guarino 1995). The points are defined in two dimensions represented by latitude and longitude on a map. Each point represents a population or accession. The point can also be accompanied by many other information including collecting site and population data, taxonomy data, characterization data, etc., which will be useful in planning survey and collecting missions.
Contour map is also popularly used in mapping the distribution of classes of plant populations. The map can be combined with ecogeographic data to show the relations between the particular characters and environmental factors. For example, protein content of the accessions of a particular crop will be shown by the length of a particular glyph, which may be associated with the ecogeographic parameters such as temperature, or rainfall. It is useful to identify the relation between such characters and environmental conditions. On a contour map, lines are drawn to join all the points where a variable of interest takes particular values. If the variable is the number of taxa, contour lines are called isoflor. For climatic data, the lines of equal temperature are called isotherms, and lines of equal rainfall, isolytes.

**Use of GIS to locate distribution of diversity**

Geographic Information System (GIS) is widely used in management of natural resources. Now-a-days, GIS is being widely used in mapping biodiversity by different organizations. GIS is a database management system with specific functions to handle spatial data, i.e. latitude and longitude. Many applications of GIS have been developed for commercial purposes or for specific management purposes, for example, ArcMap, MapInfo for Windows, Arc/Info, etc. for commercial use, and GRID, FloraMap, DIVA, etc. for specific purpose of mapping biodiversity. For mapping biodiversity and its assessment for tropical fruit tree species, there is no need to have expensive software such as ArcInfo, which will cost around US$ 26,000. Most of the plant genetic resources related activities can be achieved either with cheaper or free software such as FloraMap and DIVA which were developed by the International Potato Centre (CIP) and International Centre for Tropical Agriculture (CIAT) for research purpose. GIS has two kinds of software, viz., vector-based system and raster-based system. The raster-based system stores geographic data as points, while the raster-based system stores data as grid cell. For mapping genetic diversity, raster-based system is popularly used.

**Data preparation**

GIS database can be classified into the two types of data: spatial and attribute data. The spatial data are referred to geographic data, including latitude, longitude and altitude of collecting sites. The spatial data are essential for the system operation. Attribute data are geoplasms characterization data, which may be recorded in a different system, such as genebank management system. Data preparation and database building are important steps for using GIS. The latitude and longitude are essential in the data structure of GIS software. Input of data into the software is a heavy work. However, the GIS can take the database from other formats, such as Fox Pro, Oracle, etc. If passport data and characterization data have been computerized in other database systems, GIS software can directly take the data from these systems.

For locating diversity of geoplasms collections, the latitude and longitude of geoplasms collecting site are to be used. The latitude and longitude are usually recorded during the geographical survey and field collecting missions. According to descriptor list of International Plant Genetic Resources Institute (IPGRI), the geographic data are recorded in the format of degree, minute and second. However, most of the GIS take digital numbers for latitude and longitude. Therefore, it needs to convert the degree format to digital format with at least 3 decimal places.

**Data processing**

The spatial processing system and database management system of a GIS can use diverse data sets, analyse and combine them in different ways, and display the results as a map or statistics on a computer screen or hard copy. The GIS usually includes the following major data analysis tools (Guarino 1995):

- **Digital terrain model analysis** The altitude contours on a topographical map may be used to produce maps of slopes, aspects, inter-visibility, shaded relief, etc.
- Interpolation: Point data may be used to create isopleth (equal-value contour) maps.
- Overlay analysis: Different maps of the same area may be combined to produce a new map, e.g. maps of slope, soil, wind speed and vegetation cover may be overlaid to synthesize a map of potential soil erosion.
- Proximity analysis: Based on climate and ecogeographic data, relationships of different varieties, populations, or sub-species can be produced.
- Computation of statistics: Means, counts, lengths and areas may be calculated for different weather.
- Location: Entities having defined sets of attributes may be located.

Use of GIS for planning germplasm collecting

Use of GIS is helpful in germplasm collecting and management activities. In addition to data analysis and management, the GIS can be used to map distribution of genetic diversity, identify gaps in existing collections and plan collecting missions.

- Identification of gaps in existing collections: Through mapping the distribution of diversity, it will be possible to find the gaps within a region. The probability analysis also can help to determine the possibility of existing diversity in the similar geographical environments of existing collections. Accordingly, a collecting mission could be planned.
- Identification of particular geographical conditions: The particular characteristics are usually associated with specific environments. The soil types, rainfall, temperature, etc. are used to produce isohyets in a contour map. The possible relations between the characters and environmental conditions can be established. This is particularly useful for the collecting mission targeted to particular characters.
- Organization of collecting missions: GIS can help to organize collecting missions by providing city and village maps, road maps, and other geographical parameters. Based on this information, the routes for the travel and stops or sites for sampling diversity can be planned/organized.

Conclusions

Usually the distribution of genetic diversity of a species is closely associated with geographical environments. Understanding the distribution patterns of diversity in a region is an essential pre-requisite for planning germplasm collecting, ex situ conservation and developing conservation strategies, particularly for in situ conservation. Locating diversity with proper tools can help researchers to understand the patterns and distribution of diversity of a given gene pool in particular environments and relationships between attributes and geographical parameters. GIS is a useful tool for managing accession data, locating diversity, and planning collecting missions for tropical fruit genetic resources.

References


Collecting strategies for targeted tropical fruit tree species

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Introduction
IPGRI Office for Asia, the Pacific and Oceania, in collaboration with 10 countries in the region, is implementing the Asian Development Bank (ADB) supported project on "Conservation and Use of Native Tropical Fruit Tree Species Biodiversity in Asia". Collecting and locating diversity is one of the planned activities of this project. The collecting activity will involve all the 10 countries, namely Bangladesh, China, India, Indonesia, Malaysia, Nepal, the Philippines, Sri Lanka, Thailand and Vietnam and 6 fruit tree species, namely, citrus (Citrus spp.), mango (Mangifera spp.), jackfruit (Artocarpus heterophyllus Linn.), litchi (Litchi chinensis Sonn.), rambutan (Nephelium spp.) and mangosteen (Garcinia spp.). Most of the tropical fruit tree species are problem species characterized by vegetative propagation and production of recalcitrant seeds. Also, there is not much technical information available on collecting these species. Therefore, it is necessary to develop strategies for collecting these important species for genetic conservation and use.

Preparation and planning
Before carrying out a collecting mission, a detailed preparation should be made by the organizer of the mission. The preparation work includes the understanding of the reasons for germplasm collecting, gathering information about the region to be explored, and preparing necessary equipments which are essential for a collecting mission (Guarino et al. 1995, Ramanatha Rao 1998).

Why to collect
The main reasons for collecting tropical fruit tree species are as follows:
- To safeguard the diversity threatened by genetic erosion and/or extinction
- To meet the needs of breeding programmes for particular traits or materials
- To fill up gaps in the existing collections

Where to collect
According to the purpose of collecting missions, the locations should be identified for sampling genetic diversity. Generally, the following principles should be considered while determining the localities/areas for collecting:
- The region which is rich in diversity of tropical fruit tree species
- The region where there exists the germplasm possessing special traits or types requested by breeders and other researchers, and
- The remote areas from where there are no representatives in the existing collections

To identify the regions for collecting, it is necessary to review the existing data, including the literature, herbarium collections and other information. Once the collecting locations are identified, the route for collecting trip should be designed and transportation should be arranged accordingly.

When to collect
The collecting time is critical for a successful mission. Although collecting can be performed during the whole year, the most suitable period for observation and collecting is the fruit maturity period, during which the best traits and the plants or fruits can be easily identified. Usually, a mission takes several weeks to complete according to the purpose of collecting,
Therefore, the time of carrying out collecting should be carefully considered during the planning of the mission.

Types of collecting
There are many types of collections depending on the purpose of the mission. Following are some types of missions suitable for collecting tropical fruit tree species:

- **Multi-species**: In such collecting missions, a region is targeted and an attempt is made to sample as much diversity as possible of as many species as possible (Engels et al. 1995). Multi-species collecting mission is to be performed by a multi-disciplinary team composed of experts working on different relevant species.
- **Species-specific**: The species-specific collecting mission is targeted on a broad gene pool of specific crop, including wild species. But sometimes, it may also just focus on particular needs and sample specific genes or genotypes. The collecting team may be composed of experts working only on the targeted crop.

Sampling strategy
Development of sampling strategies is important for collecting missions. How the collectors sample the germplasm in the field will largely rely on such strategies. Defining a strategy is often difficult because species differ in crucial ways. Many plant populations have different complex genetic structures and samples may be used in different ways (Brown and Marshall 1995). A sampling strategy will provide information on understanding the breeding system, regeneration methods, seed storage behaviour, and genetic structure of the target species.

Breeding system
Although many tropical fruit tree species are outcrossing, they are mostly clonally propagated crops. Thus, the sampling strategy depends on whether one is collecting clonally propagated material from orchards and home gardens or from natural populations. In the clonally propagated material, there is almost no gene flow between populations. There are more variations among populations than within populations or types. The extent and level of genetic divergence among populations are crucial for determining the sampling. The variation both within and among populations should be sampled during germplasm collecting. There are many parameters used to describe genetic variation within and between populations. The most popular parameter used is allele numbers or richness because the users of genetic resources can adjust the frequencies of the desired alleles at their will. The samples should include average number of alleles for a large number of marker loci or the natural populations.

Regeneration method
Most of the tropical fruits are clonally propagated through grafting buds and other tissues (Table 1). Therefore, there is no doubt that shoot cutting with a number of nodes is the most ideal for sampling. However, few species such as jujube and tomato propagating and, therefore, seeds should be collected for these species.

<table>
<thead>
<tr>
<th>Fruit species</th>
<th>Methods of regeneration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Citrus</td>
<td>Vegetative, seed</td>
</tr>
<tr>
<td>Jackfruit</td>
<td>Seed</td>
</tr>
<tr>
<td>Litchi</td>
<td>Vegetative</td>
</tr>
<tr>
<td>Mango</td>
<td>Vegetative</td>
</tr>
<tr>
<td>Mangosteen</td>
<td>Vegetative</td>
</tr>
<tr>
<td>Nopahutan</td>
<td>Vegetative</td>
</tr>
</tbody>
</table>
Seed behaviour
According to the early studies, the seed storage behaviour of relevant species is given in Table 2 (IPGRI 1996). Most of the tropical fruit trees produce recalcitrant seeds, but a few species in Citrus and Garcinia produce orthodox seeds. This information will help collectors to determine which methods are to be used to process and store the collected seeds.

Table 2. Seed storage behaviour of tropical fruit tree species

<table>
<thead>
<tr>
<th>Fruit species</th>
<th>Seed storage behaviour</th>
</tr>
</thead>
<tbody>
<tr>
<td>Citrus</td>
<td>Recalcitrant, intermediate, orthodox</td>
</tr>
<tr>
<td>Jackfruit</td>
<td>Recalcitrant, recalcitrant?</td>
</tr>
<tr>
<td>Litchi</td>
<td>Recalcitrant</td>
</tr>
<tr>
<td>Mango</td>
<td>Recalcitrant, recalcitrant?</td>
</tr>
<tr>
<td>Mangosteen</td>
<td>Recalcitrant, recalcitrant?, orthodox, orthodox?</td>
</tr>
<tr>
<td>Rambutan</td>
<td>Recalcitrant</td>
</tr>
</tbody>
</table>

Sampling diversity
Theoretically, the number of alleles in a population will increase in proportion to the logarithm of sample size. However, the size of a sample should be determined in view of the resources available and the cost per sample. It was suggested that the sample should cover 95 per cent of the alleles that occurred in the target population at frequencies greater than 0.05 (Marshall and Brown 1975). Increasing the certainty level higher than 95 per cent or decreasing the allele frequency to lower than 0.05 will dramatically increase sample size.

Number of sampling sites
For a target region, 50 sites should be considered optimum for each species. Of course, the number can be adjusted according to the size and ecogeographic conditions of the region (Brown and Marshall 1995). For example, if a collecting mission is planned for Southern Yunnan, China, the first step is to divide the region into a number of sub-regions (10-12), according to ecological conditions. Then the sampling activities should be carried out in each sub-region.

Number of plants per population
From each site, the seeds or cuttings of 10-15 plants per population should be sampled if the fruit trees are propagated by seeds, e.g. Jackfruit. If the trees are clonally propagated, a bulk sample of 2-4 vegetative propagules should be taken from 10-15 randomly chosen individual clones (Hawkes 1980). However, there is always the possibility of loss of samples during the transportation, and hence the number should be increased, and usually double the number is recommended. If the number of individual plants cannot reach 10-15, more sites should be considered in a region. If seeds are collected from clonally propagated cultivar at a given site, it can either be kept as single-tree samples and given the same number as any vegetative sample or bulked in a cultivar sample and assigned a distinct number (FAO 1995).

Choice of individuals
Generally, random sampling is used in selecting individuals at a site. However, biased sampling of rare phenotypic individuals is used to capture some important genes such as disease resistance (Brown and Marshall 1995, Engels et al. 1995). Additionally, keeping phytosanitary conditions in mind, it is recommended that the sampling be done from apparently healthy trees. This would help to reduce the risk of bringing diseased propagules into genebank.
Number and type of propagules per plant
For tropical fruit tree species, vegetative cuttings, fruits, seeds or pollens can be collected according to species and purpose of the collecting mission. Vegetative cuttings are most popularly used for collecting fruit tree species as they produce recalcitrant seeds, or even no seeds. The number of cuttings for collection will depend on the needs for conservation and use. If the collected materials need to be distributed to other researchers or genebanks, more cuttings should be collected. Otherwise, 5-10 cuttings/propagules per plant should be enough. As seeds or pollen require less space in the transportation or storage in genebank, adequate amount should be collected (FAO 1995).

Equipment
Collecting of germplasm involves working on trees in the field. Sometimes, collectors also need to stay overnight in the open. The equipments should meet the needs of transportation, camping and medical care and, therefore, availability of sufficient equipments, is the pre-requisite for a successful collecting mission. The detailed list of equipments for a collecting mission is given in Appendix I (Guarino et al. 1995).

Training
A training should be organized for the members of a collecting team so that they understand the objectives of the mission, sampling techniques, use of relevant equipments, familiarity with route and possible environments, etc.

Collecting of samples
The survey and collecting mission should be carried out in time according to the plan. As collecting mission involves working in fields and orchards, it will be greatly affected by local climatic changes. Some extra time should be allocated in order to get enough time for the planned activities.

In the field
The team should work closely with local farmers or guides, who know where different types of target fruit species are grown in the field or home gardens by the communities. At the same time, interviews with farmers should be conducted about the uses of local varieties, particularly the value traits, e.g. fruit quality, disease resistance and other specific traits including specific uses. The germplasm should be sampled according to the strategies for different species.

Collecting shoot cuttings
The middle portion of stem with several nodes should be collected. Leaves should be removed or reduced in number. The cut ends of shoots can be dipped in a disinfectant or soaked for 10 minutes in soap water to prevent rotting. The proximal end of shoots or cuttings should be wrapped in slightly wet paper towels or papers. Then, the cuttings or shoots are stored in insulated cool boxes and checked regularly to keep the wrapping paper moist and help developing roots (FAO 1995).

Collecting seed samples
Most of the tropical fruit tree species produce recalcitrant seeds. They cannot withstand drying and need high relative humidity (RH) during storage. Generally, over 95 per cent equilibrium in RH is needed during storage. Such high ambient relative humidity is rarely found in nature. If the seeds are in a fleshy fruit, such as mango or mangosteen, the flesh will act as a reservoir of moisture to prevent seeds from drying (Smith 1995). Therefore, the problems of recalcitrance can be overcome by keeping the seeds in the fleshy fruits, but for this a large amount of fruits are needed which will add to the cost of transportation.
Another way to maintain the high moisture in the seeds is to put them in impervious containers such as plastic bags, but lack of oxygen is a problem as the seeds are metabolically active and take oxygen and release carbon dioxide and water. The problem can be resolved by using the relatively light gauge polythene bags and regularly re-oxygenating the internal atmosphere by deflating and refilling the bags (Tomsett 1994). The well-developed seeds are more tolerant and have better ability for storage. Therefore, the seeds should be harvested at maturity whenever possible.

The duration is also very important for collecting tropical fruit tree seeds. The collecting, transportation and processing should be completed within 30 days in order to maintain the viability of the seeds.

Processing and transporting samples
During a collecting mission, the samples should be treated immediately after returning to the base centre. The seeds and shoot cuttings should be processed separately for transportation and distribution. For collecting tropical fruit tree species, vegetative materials have to be treated differently than seeds, as they deteriorate easily after collecting. The infection by insects or diseases is also a problem for vegetative collections.

Packing
For recalcitrant seeds, e.g. jackfruit, the arrangement should be made at the mission planning stage to ensure the rapid receipt and early planting of the seeds by the recipient institutes. Special precautions should be taken to keep the seeds alive. The most important step is to maintain the moisture as near to the fully imbibed state as possible. The seeds can be kept in the fruits or in plastic bags and packed in suitable containers for transportation.

For vegetative materials, they should be wrapped in semi-absorbent material and packed firmly, but not too tightly, into a box or carton.

Transportation
Most of the recalcitrant seeds may germinate soon after they are collected, sometimes over 60 per cent after ten days (FAO 1995). Therefore, fast transportation tools should be used to deliver the materials to the genebank or users.

Documenting the collecting
It is important to properly record the relevant information during collecting as well as after returning to the base centre.

Labelling of samples
Sample labelling (Moss and Guarino 1995) includes:

- **Collecting identifier (or collecting organization)**: Collecting mission should have a name or code, which could be printed in the collecting form.
- **Name(s) of collector(s)**: The name of person(s) who collected the sample should always go with the sample, since it is one of the important identities of the sample.
- **Collecting number (or collector’s number)**: The number assigned by collectors in each collecting mission is as important as collector’s name. If both seeds and vegetative samples are taken and not exactly taken from the same plants, separate numbers should be assigned to seed sample and vegetative sample and the same should be properly recorded. If several persons are involved in the collecting mission, they should reach agreement in advance about the system to be followed. The collector’s number should be written in indelible ink on whatever containers are used.
- **Collecting date**: The date on which a sample is collected should be recorded. It is helpful for the users of the sample to know when the sample was collected and the interval
between collecting and registration. It should be recorded in the format of date, month and year (dd.mm/yyyy).

- **Type of material**: The type of material could be seed, vegetative material, pollen, *in vitro* material, etc. It is important to decide in advance how to process the material and which method will be used to conserve the material.

**Filling collecting form**

When a site is selected and samples are taken, relevant data should be recorded on a collecting form. IPGRI has developed a collecting form covering information on description of environments of a site, identity of the sample, basic traits of the sample, etc. (This form is given in Appendix II or can be obtained by writing to the author).

Some data are recorded during collecting in the field, e.g., identities, and environmental data including altitude, latitude and longitude. Other data, e.g., description of major traits, etc., can be recorded after coming back to the base centre.

**Recording traditional knowledge**

Mostly the knowledge of farmers or growers is associated with germplasm and this is usually referred to as indigenous knowledge or traditional knowledge, which is not only useful to local farmers, but also for the scientists to further develop and use the germplasm. Local farmers should be asked about the methods of propagation of the trees, major features of different varieties and the differentiation between varieties in the village. Also, the genetic information including the sources of mother trees, adaptability, resistance of the varieties, etc. should be gathered from farmers. The information on local uses of fruit trees will be important for researchers to select materials for breeding programmes.

Indigenous knowledge can be recorded through a participatory approach by directly involving farmers. Women play an important role in managing plant genetic resources in many communities. More indigenous knowledge can be gathered through interviewing women.

**Reporting on collecting missions**

When a collecting mission is completed, a comprehensive report on the mission should be prepared not only for the purpose of submitting to donors and relevant organizations, but also for use in future. The report should cover the following contents: Introduction, Methods (including sites, routes, sampling methods), Results, Discussion, Suggestions, and References.

**References**


Appendix I: Equipments for a collecting mission

For transportation:
- One or more vehicles according to members of the collecting team
- Spare parts of vehicles, including tires, pump and pressure gauge, tools for repairing, chain or nylon ropes, etc.

For camping
- Tents and accessories
- Tarpaulin and ropes
- Waterproof sleeping-bags
- Mosquito nets
- Camp-beds or air mattresses
- Small folding table and chairs
- Hand torches and enough batteries
- Cooking stove and fuel
- Match boxes
- Cooking pots and utensils, plates, mugs, cutlery etc.
- Candles or lamp for light
- Water containers

Medical supplies
- Water-purifying tablets
- Insect-repellent cream
- Antihistamine cream
- Antiepileptic cream or rampage
- Antibiotic tablets and cream
- Fungal infections remedies
- Antacid tablets
- Anti-diarrhoeal tablets
- Sachets of oral dehydration solution
- Eyewash
- Oil of cloves for toothache
- Lip salve
- Aspirin, paracetamol or other pain-killer
- Anti-malarial tablets for both prophylaxis and treatment
- Snakebite sera
- Disposable hypodermic syringes
- Cotton wool
- Spills
- Bandage and plasters
- Scissors
- Disinfectant solution

For collecting samples
- Measuring instruments — diameter and height measuring instruments
- Global Positional System (GPS) — for locating fruit trees in the field
- Collapsible collaring sheets (e.g. 2 x 3)
- Large, heavy-duty, canvas and nylon tarpaulins for seed and fruit collecting setae
- Large scissors for cutting shoots
- Tree climbing equipment
- Tree ladders
- Safety belt, gloves, etc.
## Appendix II: Collecting Form

### COLLECTING FORM

*General for wild and cultivated species*

**CN Number** (assigned by IPGRI for internal use)

**Expedition**

1. Collector name(s)
2. Collector's number
3. Site number
4. Date (DD/MM/YYYY)
5. Genus
6. Species
7. Subspecies/variety
8. Local species name
10. Country
11. Province
12. Location km from in a Direction
13. Latitude (in degrees and minutes) N/S Longitude (in ° and ′) E/W Elevation (in m)
14. Map name and reference
15. Status of sample
   1. Wild
   2. Weedy
   3. Primitive cultivar/varanana
   4. Breeders line
   5. Advanced cultivar
   6. Other (specify)
16. Collecting source
   1. Wild habitat: forest/woodland
   2. Farm field
   3. Market: town
      - shrubland
      - grasslands
      - desert/semi-arid
      - pasture
   4. Breeders line
   5. Other (specify)
## Plant parts used
1. Stalk/Stalk
2. Branch/twig
3. Leaf
4. Bark
5. Rhizomes
6. Flower/inflorescence
7. Fruit
8. Seed
9. Root
10. Tuber
11. Raphe/seed

## Plant uses
1. Food
2. Medicine
3. Beverage
4. Fibre
5. Timber
6.Cream
7. fodder
8. Building
9. Ornamental/Cultural
10. Other (specify)

## Type of sample
1. Seed
2. Vegetative (tissue)
3. Other (specify)

## Number of plants found
- Per area
- Site size and area (m²)

## Number of plants sampled

## Other samples from the same species group of plants
- Yes
- No

## Photograph number
- Yes
- No

## Herbarium sample
- Yes
- No

### Cultivated species

### Micro-environment
1. Sonkringes
2. Forest margins
3. Water course
4. Forest clearing
5. Houseyard
6. Woodlot
7. Other (specify)

### Cultural methods

#### a) Type
1. Irrigated
2. Interplanted
3. Intercrop
4. Fertilizer (organic)
5. Fertilizer (inorganic)
6. Mechanized

#### b) Division of labour (gender) Male
1. Field preparation
2. Planting
3. Weeding/fertilizer application
4. Plant protection
5. Harvest/field handling

#### c) Land tenure
1. Public lands
2. Own community lands
3. Freehold
4. Tenancy
5. Reserve/sanctuary
6. Other (specify)

### Data: Sowing Transplanting Harvest (dd/mm/yyyy)
29. Distribution of crop sampled in farming cycle — temporal niche
   1. Main crop
   2. Harvest prior to main crop
   3. Harvest after main crop
   4. Alongside main crop
   5. Continuous harvest/gathering

30. Post-harvest handling (gender division of labor)
   Male          Female
   1. Husking/milling
   2. Fermentation
   3. Drying
   4. Seed selection

31. Commercialization
   1. Mostly consumed locally
   2. Mostly for sale — local markets
   3. Mostly sold to buyers outside community
   4. Partly sold

32. Site physiography
   1. Plain
   2. Basin
   3. Valley
   4. Plateau
   5. Upland
   6. Hill
   7. Mountain
   8. Other (specify)

33. Soil drainage
   1. Poor
   2. Moderately poor
   3. Moderately well-drained
   4. Well-drained

34. Slope (°)

35. Slope aspect (direction, N,S,E,W)

36. Soil texture
   1. Clay
   2. Loam
   3. Sandy loam
   4. Fine sand
   5. Coarse sand
   6. Organic
   7. Other (specify)

37. Stoniness
   1. None
   2. Low
   3. Medium
   4. High

38. Method of propagation
   1. Seed
   2. Vegetative
   3. Both

39. Related wild and weedy forms growing nearby

40. Could you note any relevant sociocultural differences in the cultivation and use of the crop?

41. Describe crop rotations in collecting season: (and/or intercropping)

42. Comments on morphological variation, diseases and pests, genetic erosion
   1. Morphological variation
   2. Diseases/pests
   3. Genetic erosion (Major causes and extent at population and variety levels)

43. Other notes/comments
### Wild and Forage Material

<table>
<thead>
<tr>
<th>Site Physiography</th>
<th>Habitat</th>
<th>Micro-environment</th>
<th>Soil Drainage</th>
<th>Slope</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Plain</td>
<td>1. Forest</td>
<td>1. Mountain</td>
<td>1. Very Wet</td>
<td>0. None</td>
</tr>
</tbody>
</table>

### Soil Texture

1. Clay
2. Loam
3. Silt
4. Sandy soil
5. Clay soil
6. Clay
7. Organic

### Soil Chemical Properties

<table>
<thead>
<tr>
<th>Estimate</th>
<th>Field measurement</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH</td>
<td>(pH 2-5)</td>
</tr>
<tr>
<td>Acidic</td>
<td>(pH 6-6.5)</td>
</tr>
<tr>
<td>Neutral</td>
<td>(pH 6.5-7)</td>
</tr>
<tr>
<td>Alkaline</td>
<td>(pH &gt; 7.5)</td>
</tr>
</tbody>
</table>

### Soil Sample

1. Yes
2. No

### Other Notes on Soil (e.g. Colour)

### Rhizobium Sample

1. Yes
2. No

### Human Management of Habitat (land use)

1. Grazed areas
2. Managed forest
3. Regenerating forest
4. Abandoned fields
5. Fallows
6. No human management
<table>
<thead>
<tr>
<th>39. Disturbance factors</th>
</tr>
</thead>
<tbody>
<tr>
<td>a) Describe if an area is regularly used or traversed by large mammals and humans</td>
</tr>
<tr>
<td>b) Key animal species using the habitat</td>
</tr>
<tr>
<td>c) Other factors, e.g. fire, flooding, mining, logging</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>40. Major threats to the population — Genetic erosion</th>
</tr>
</thead>
<tbody>
<tr>
<td>a) What is the natural mode of propagation?</td>
</tr>
<tr>
<td>1. Seed</td>
</tr>
<tr>
<td>2. Vegetative</td>
</tr>
<tr>
<td>3. Seed and vegetative</td>
</tr>
<tr>
<td>4. Apomictic</td>
</tr>
<tr>
<td>b) Give relative importance of mode of propagation</td>
</tr>
<tr>
<td>- Seed</td>
</tr>
<tr>
<td>- Vegetative</td>
</tr>
<tr>
<td>- Obligate outbreeding</td>
</tr>
<tr>
<td>- Facultative outbreeding</td>
</tr>
<tr>
<td>- Apomictic</td>
</tr>
<tr>
<td>- Others (specify)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>42. Is the population well isolated from others?</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Yes</td>
</tr>
<tr>
<td>2. No</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>43. What are the barriers between populations in the area?</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>44. What is the plant population density?</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Few scattered individuals</td>
</tr>
<tr>
<td>2. Very scarce (&lt;1% ground cover)</td>
</tr>
<tr>
<td>3. Scarce (1-5% cover)</td>
</tr>
<tr>
<td>4. Present (&gt;5-25% cover)</td>
</tr>
<tr>
<td>5. High (&gt;25%)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>45. What is the spatial distribution of individual plants in the population?</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Patchy</td>
</tr>
<tr>
<td>2. Uniform/ mixed stand</td>
</tr>
<tr>
<td>3. Pure stand</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>46. What is the dominant plant species?</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>47. What are the associate species?</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>48. Closest meteorological station</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>49. Comments on morphological variation</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>50. Comments on diseases and pests</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>51. Are related cultivated forms grown nearby?</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Yes</td>
</tr>
<tr>
<td>2. No</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>52. Other notes</th>
</tr>
</thead>
</table>
### Additional information for ecogeographical surveys

#### Soil descriptors

1. Soil type (UNESCO/FAO)
2. Soil parental rock
3. Soil depth analysis of soil sample
4. Soil pH
5. Soil physical analysis (Distribution of particle size, etc.)
6. Soil chemical analysis (P, K, Ca, organic carbon content, etc.)

#### Climatic descriptors

7. Annual rainfall (mm)
8. Rainfall seasonality
   - Jan
   - Feb
   - Mar
   - Apr
   - May
   - Jun
   - Jul
   - Aug
   - Sep
   - Oct
   - Nov
   - Dec
9. Mean annual temperature
10. Temperature seasonality
    - Jan
    - Feb
    - Mar
    - Apr
    - May
    - Jun
    - Jul
    - Aug
    - Sep
    - Oct
    - Nov
    - Dec
11. Forests (Occurrence and severity)

#### Site descriptors

12. Successional status of vegetation
    - 1. Recently colonized
    - 2. Pioneer
    - 3. Intermediate
13. Current protection of site (Specify)
14. Is the protection effectively enforced?
    - 1. Yes
    - 2. No
    - 3. Do not know
15. Protected site (in conjunction with local community stewardship or use rights)
16. Suggestions for future protection


Tropical fruit trees: Enhancing germplasm exchange and use

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\textsuperscript{1}Regional Director, \textsuperscript{2}Senior Scientist (Genetic Diversity), and \textsuperscript{3}COGENT Coordinator,
IPGRI Regional Office for Asia, the Pacific and Oceanic, Serdang, Malaysia.

Rationale for germplasm exchange

The continuous evolution of plants for food, medicine, aesthetics and general well-being of human society is dependent on the process of germplasm exchange and use in support of sustainable development. There are many strong reasons for enhancing the exchange and use of plant germplasm (Sajise and Batugal 2000). The strongest rationale for this is that no country possesses sufficient plant genetic resources within its borders to meet all its present and future needs and species of plants do not respect country boundaries and centres of biodiversity often span across the entire region. For example, in 1993, taro blight destroyed 95 per cent of the taro crop in Western Samoa where it is a staple food. The only basis for the recovery of production of this staple crop in Western Samoa was the availability of leaf blight resistant taro varieties from the Philippines and Palau, which they were able to use for their crop production. The historical records are replete with similar examples that belied on important crop plants to illustrate this significant rationale and to emphasize that plant genetic resources are the common heritage of humankind (Lebot 1992; Anon, 1977).

Exchange of plant genetic materials will allow the enhancement of genetic diversity, which is a natural defence mechanism against genetic vulnerability and even environments' risks. Countries which still have a significant amount of genetic diversity and species diversity have a responsibility unto themselves as well as the world at large to conserve them and make them available for use (Ramanatha Rao et al. 1994).

Constraints and opportunities for promoting germplasm exchange and use

Before the 1980s, plant genetic resources were considered as a common good and heritage of mankind and were exchanged freely. The application of intellectual property protection (IPP) was just beginning during this period in a few industrialized countries. The FAO International Undertaking on Plant Genetic Resources (IU) which served as basis for this paradigm was adopted in 1983.

During the past two decades, there had been various forces which changed the existing paradigm on plant genetic resources as a common heritage (Hawtin 1999). Advances in science, especially molecular genetics, resulted in growing interests and investments of private organizations in coming up with new varieties and materials with intellectual property rights protection primarily through patenting. There was also pressure on the national governments to strengthen their Intellectual Property Protection (IPP) legislation, which resulted in rapidly eroding the concept of plant genetic resources as a common heritage of mankind (Hawtin 1999). While this was taking place in the agriculture sector, there was also the growing concern for protecting the environment and biodiversity recognizing the need for a fair and equitable sharing of benefits arising from the use and exploitation of these biological resources. These concerns led to governments negotiating the Convention on Biological Diversity (CBD) which came into force in December 1993. The CBD is a legally binding document which aims to promote the conservation of biodiversity, its sustainable use and the fair and equitable sharing of the benefits arising from their use. It also recognizes biodiversity as a resource that is subject to national sovereignty.

Since plant varieties and other biological products could now be patented and has become a major material to be traded internationally, the World Trade Organization (WTO) has been insisting on the member countries to adhere to trade-related-aspects of intellectual property rights (TRIPS) agreement. TRIPS agreement has also an impact on germplasm exchange and
needs to be considered in developing plans for plant genetic resources conservation and use. Under the TRIPS agreement, the countries are required to have some sort of intellectual property protection (patent, see generic or other forms) to plant materials and its products and processes.

These developments during the past two decades have ceased a distinct paradigm shift with regard to the status of plant genetic resources from a common heritage of mankind to one that was subject to more IPR due to commercialization. Therefore, exchange of germplasm cannot take place freely unless there is mutual consent between parties concerned, including the sharing of benefits and responsibilities for its sustainable use. The FAO Commission on Genetic Resources for Food and Agriculture decided to negotiate the International Undertaking (IU) to bring it in line with the CBD and the new paradigm. This has taken a long time to renegotiate until now, and in the meantime, these international protocols have caused some ambivalence in the position of countries with respect to exchange of plant genetic resources. This is at the expense of a slowdown in the building up of biodiversity buffers for sustainability and at the expense of the poor farmers not being able to access freely good materials to alleviate food insecurity, poverty and environmental risks. However, the opportunity, for sharing and exchanging plant genetic resources still exists as indicated in the CBD as long as the Contracting Parties do it on mutually agreed terms.

Some examples and options for enhancing the sharing of plant genetic resources

There are examples of on-going exchange of plant genetic materials of tropical fruits even after the CBD and TRIPS, which are often seen as constraining conditions at the global level. These exchanges have taken place mostly on a bilateral and mutually accepted terms and conditions of the involved parties. A good example is that of mango in this regard.

The recent economic studies have shown that the genus Mangifera has 69 species, though the number of identified species varies from 36 to 69. The crossing barriers within the genus are not known, and consequently, the structure of the gene pool is largely unknown. However, it appears that several Mangifera species can cross naturally or be crossed artificially. Therefore, the prospects of using wider range of genetic diversity for mango improvement are excellent (Verheij and Cornelis 1991; Liz 1997; Hofman 1998). However, it must be noted that very little hybridization work has taken place in mango in the region with the exception of India, but only through inter-varietal crosses (Ramamuthu Rao and Shag Mai 2000).

The genus Mangifera is of South and Southeast Asian origin. Only one of the species in the genus, M. Geoffroi, has a quite wide distribution from Myanmar to Malaysia and Papua New Guinea. The other species have been divided into two groups: (i) those adapted to monsoon climates (Myanmar, India, Thailand, Indochina and parts of Indonesia), and (ii) the species adapted to the ever-wet tropical rain forests. The common mango, Mangifera indica, was originated from India and Myanmar (Bompard and Schafer 1993). The highest concentration of species is found in western parts of Malaysia (29 species, 1 endemic) Sumatra (14 species), Java (30 species, 2 endemic) and Borneo (36 species, 3 endemic). The concentration of species is relatively low in India (5 species, 2 endemic), China (4 species, 3 endemic), the Philippines (8 species, 2 endemic), Thailand (12 species, 2 endemic) and Myanmar (5 species) (Kostermans and Bompard, 1993). Thus, the distribution of species of Mangifera is quite wide and several countries in the region have some unique species or germplasm that could be used in different locations.

Most of the mango that is grown and consumed belongs to a single species. M. indica, the widest and well-characterized diversity with around 13000 local varieties in India, while in other Asian countries, the reported number of local cultivars varies from 10-30 (Liz 1997). Thus, India would be naturally the country where one can look for a wide genetic diversity in common mango.
A few cultivars in Southeast Asia belong to other species of Magnifera although about 26 are edible (Verheij and Cornel, 1999), often well known locally, with excellent edible fruits claimed to be with better taste than that of M. indica. These species also possess other important characters, such as disease resistance, which is lacking in the currently used germplasm (Bompard and Schaffer, 1993). A concerted action is needed to locate the most useful variations in the entire gene pool, to collect and evaluate efficiently, and to exploit the most useful diversity both through direct use as well as through hybridization (Ramarathna Rao and Bhag Nal, 2000).

The other mango species, such as M. abissina, M. caesia, M. kemanga, M. foetida, M. laurina and M. odorata, could not only be developed into potential crops for large scale cultivation but also for improvement of M. indica.

Given the above scenario, there seems to be a large potential in using Magnifera genetic resources for improvement of existing cultivars and also in developing new varieties. It is also clear from the distribution of mango diversity that no single country has all the diversity and hence exchange is imperative.

Mango species could generally be divided into two categories:

(i) Those that do well in monsoon climate with distinct dry periods, and
(ii) Those that are adapted to wet tropical Zone.

Regional field genebanks may be established at two locations, which could assist regional and international germplasm exchange of Magnifera. These could be India (for species of dry zone, and M. indica) and Java (either in Malaysia or Indonesia). Facilities for safe exchange of germplasm could be established along with other facilities for characterization and evaluation of the material, so that all the partners can benefit from the work at these regional centres. For this, the model of multi-site International Coconut Genebank (ICG) could be adopted (Ramarathna Rao and Batugal, 1998).

**Status and needs of tropical fruit species germplasm exchange**

A survey of the status and needs was carried out in the 10 participating countries and the results from such a survey in four countries, namely, Indonesia, Nepal, the Philippines and Sri Lanka are briefly mentioned below:

<table>
<thead>
<tr>
<th>Species</th>
<th>Quantity</th>
<th>Type of material</th>
<th>Sent to country</th>
<th>Received from country</th>
<th>Years</th>
<th>Usage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mango</td>
<td>5 clones</td>
<td>Bud</td>
<td>India</td>
<td>-</td>
<td>1996</td>
<td>-</td>
</tr>
<tr>
<td>Mango</td>
<td>1 clone</td>
<td>Bud</td>
<td>Australia</td>
<td>1996</td>
<td></td>
<td>Conservation</td>
</tr>
<tr>
<td>Mango</td>
<td>1</td>
<td>Seed</td>
<td>Japan</td>
<td>1997</td>
<td></td>
<td>Conservation</td>
</tr>
<tr>
<td>M. communis (Fuku)</td>
<td>1</td>
<td>Seed</td>
<td>-</td>
<td>-</td>
<td>1998</td>
<td>Conserva_ tion &amp; research</td>
</tr>
<tr>
<td>Banana</td>
<td>21 clones</td>
<td>Plantlet</td>
<td>INIBAP</td>
<td>1999</td>
<td></td>
<td>Testing (Fusarium)</td>
</tr>
<tr>
<td>Papaya</td>
<td>12</td>
<td>Seed</td>
<td>Philippines</td>
<td>-</td>
<td>1996</td>
<td>-</td>
</tr>
<tr>
<td>Papaya</td>
<td>12</td>
<td>Seed</td>
<td>Malaysia</td>
<td>1996</td>
<td></td>
<td>Yield testing</td>
</tr>
<tr>
<td>Citrus</td>
<td>5</td>
<td>Seed</td>
<td>Australia</td>
<td>1998</td>
<td></td>
<td>Roadstock</td>
</tr>
<tr>
<td>Durian</td>
<td>3 varieties</td>
<td>Bud</td>
<td>Thailand</td>
<td>1990s</td>
<td></td>
<td>Conservation; 2 varieties developed</td>
</tr>
<tr>
<td>Banana</td>
<td>Several</td>
<td>Cumm</td>
<td>Philippines</td>
<td>-</td>
<td>1990s</td>
<td>Conservation</td>
</tr>
</tbody>
</table>
Indonesia

(i) Fruit germplasm that was exchanged during the past 5-10 years
(ii) The rate of success of receiving requested material from other countries is in the range of 50-75 per cent, and
(iii) Indonesia would like to receive from the tropical fruit tree (TFT) project member countries, the following material for use in the breeding programmes:

<table>
<thead>
<tr>
<th>No.</th>
<th>Species</th>
<th>Variety</th>
<th>Member Country</th>
<th>Specific Characteristics</th>
<th>Usage</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Mango</td>
<td>Makkia</td>
<td>India</td>
<td>Dwarf</td>
<td>Breeding</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Chausa</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Nesium</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.</td>
<td>Citrus</td>
<td>Several clones</td>
<td>China, Nepal</td>
<td>Seedless; sweet; Trinasa &amp; phytophthora resistance</td>
<td>Breeding</td>
</tr>
<tr>
<td>3.</td>
<td>Jackfruit</td>
<td>Several species</td>
<td>Bangladesh</td>
<td>Dwarf, fruit borer resistance</td>
<td>Breeding</td>
</tr>
<tr>
<td>4.</td>
<td>MangoDeen</td>
<td>G. hamburiana</td>
<td>Malaysia</td>
<td>-</td>
<td>Breeding</td>
</tr>
<tr>
<td></td>
<td></td>
<td>G. malaccensis</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Nepal

(i) Exchange of fruit crop germplasm: Officially or formally, not much of the fruit crop germplasm has been introduced/exchanged during the past 10 years. However, some banana cultivars were introduced during 1998/99 from Caribbean countries. Similarly, Amarpali cultivar of mango was introduced from India about 6-10 years ago.

(ii) Use of germplasm: The main use of the germplasm is for experimental purposes, particularly for the evaluation of cultivars for fruit production in different environmental conditions of Terai area and the hills of Nepal.

(iii) Success rate of the introduced germplasm: In banana, although the evaluation is still going on, it has been noticed that performance of these cultivars is poor. However, in mango, Amarpali cultivar tested in Terai, inter Terai and in low hills gave very promising results. In mid-hills, the evaluation is still going on.

(iv) Germplasm of specific interest: The specific interest of Nepal includes germplasm introduction of papaya from Thailand, Aoxila lime from India, tropical strawberry from Malaysia, banana from any tropical country and guava from Thailand.

(v) Information on germplasm: Germplasm should be introduced from Government research stations and the phytosanitary and safe exchange needs have to be taken care of. Along with the germplasm with desirable traits, technical information related to crop and variety must be made available.

(vi) Germplasm available for supply from Nepal: Germplasm of lime, lemon, mandarin, orange, guava, mango, litchi, jackfruit and pineapple are available for supply to other countries.

Philippines

(i) The Fruits Division of National Plant Germplasm Research Laboratory (NPGRL) received a number of fruit species from individual fruit growers/enthusiasts from overseas through the exchange of materials.

(ii) The materials received, when successfully grown, became part of the collection and are continuously being evaluated for its potential for utilization.
(iii) Germplasm has been exchanged successfully with individual fruit growers.
(iv) Selected accessions of mango and species of *Citrus* and * Garcinia* that are native to
some of the countries need to be introduced.
(v) Germplasm exchange needs to be discussed among network members.

**Sri Lanka**

(i) Sri Lanka has received planting materials of a number of fruit tree species from Australia,
Malaysia, India and Thailand during the last decade. The crops include mango, durian,
grapes, rambutan, avocado, guava, citrus, etc. The planting materials of mango and
grapes were procured in commercial quantities. At the moment, there is an ongoing
programme of fruit tree germplasm exchange between Sri Lanka and India through
Council for Agricultural Research Policy (CARP) - Indian Council of Agricultural
Research (ICAR).

(ii) Upon receipt of germplasm, it is subjected to quarantine inspection. In some instances,
the introduced material will be planted/ multiplied at research centres under the
supervision of plant protection specialists. Thereafter, once cleared, materials will be
propagated and used in varietal evaluation trials. At various research centres, a number
of evaluation trials with exotic fruit germplasm are still being conducted.

(iii) The success rate was generally good, for example, in one mission to Australia in 1993,
all materials needed were procured through Queensland Department of Primary
Industries (QDPI), Queensland.

(iv) Fruit researchers are interested in receiving germplasm of fruit trees with better quality
characteristics and high yield. Sri Lankan researchers are interested in obtaining Carabao
mango from the Philippines and Nam Doc Mai variety from Thailand.

With regard to future germplasm exchange, it was proposed that every country would prepare
a list of available non-restricted fruit varieties together with information regarding special
characteristics of the variety in addition to its general description. Usually, while selecting
varieties for requests, there is tendency to go by just the variety name only. Again, the
authenticity of the cultivar and the planting materials must be certified. This is important due
to the perennial nature of fruit tree species. As is evident, there is a great interest as well as the
need for exchange of germplasm among the TFT project partner countries.

There are two options that can be considered to enhance the plant germplasm exchange and
the use. These options have their own advantages and disadvantages.

**Option 1. Bilateral exchange**

This involves the exchange of germplasm between two countries, which is decided by the
researchers of both the governments. This system is used by some countries and is guided by a
mutually agreed Material Transfer Agreement in some cases. However, negotiating is often
more difficult with several countries which own other germplasm of interest. Access could be
improved if both countries have mutual interest to exchange germplasm but it is very difficult
if only one country is interested and it does not have much valuable germplasm to exchange.
The success depends on the knowledge of the performance of specific germplasm in national
collections. Most of the time, this information is inadequate and often not available. Access to
germplasm is often weak and country requests are often difficult to be met for economic,
technical, quarantine and political reasons. Also, the range of germplasm that can be exchanged
with one country is often limited.

**Option 2. Establishment of regional collection for evaluation and exchange**

This involves the conservation and evaluation of valuable germplasm in a designated host
country and the germplasm collected are conserved, evaluated and exchanged on mutually
agreed terms. Once countries agree to contribute germplasm and share the germplasm conserved
in the regional collections, requests for germplasm will only be made to the host country at the
regional collection. It requires documentation of available national information on performance of specific germplasm and generation of additional data by all member countries; development and use of standard methods of characterization and evaluation by all members of the network; and development and sharing of database which will serve as basis of selecting germplasm of interest for conservation and exchange. It is a system that needs to be established through networking.

**Germplasm exchange under TFT project**

There is an urgent need that the countries participating in the Tropical Fruit Trees Project discuss the possibility of initiating a mutually agreeable process for enhancing the exchange of germplasm of specific interest which came out of the survey conducted by the TFT coordinating body at IPGRI-AFO. The steps involved could cover some of the following points:

(i) Develop, discuss and exchange list of varieties of interest from other member countries, while at the same time list the varieties and materials which have been indicated as of interest by those member countries;

(ii) Discuss mutually agreeable terms for the exchange which could be covered by a Material Transfer Agreement and select the most appropriate options or arrangements. Basic to the second step is the agreement for exchange of the identified varieties and materials as indicated by the member countries in exchange for germplasm materials from the members of the network;

(iii) Agree on the safe procedure for transfer of these materials regardless of whether the agreement is for Option 1 or 2.

(iv) Provide a mutually agreeable time frame for these processes to take place.

It is expected that the training and setting-up of a readily exchangeable database of the national collections of the fruit species involved in the network would be utilized as basis for the selection of these materials of mutual interest to the member countries. While the basic work is being done for locating, characterizing and evaluating fruit species genetic diversity in the Project, it will be advantageous to initiate a process that will promote mutually agreeable exchange of what is available. In addition, it would be extremely useful to link it with crop improvement, agronomic and, in general, the production objectives of this project. This is because the expectation is that eventually it will contribute to the basic goal of alleviating poverty, maintaining through increased income and food security of farmers in Asia, the Pacific and Oceanic region.

**References**


Workshop on Genetic Resources. Root and Tuber Crops, 15-17 March, 1994, Tsukuba, Japan, MAPP, Tsukuba.
Information and documentation action plan for tropical fruit tree collections

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Introduction

The collaborative project on conservation and use of tropical fruit tree species is being implemented by the International Plant Genetic Resources Institute (IPGRI) and the national programmes in 19 countries in South Asia (India, Nepal, Bangladesh and Sri Lanka), East Asia (China) and Southeast Asia (Indonesia, Thailand, Vietnam, the Philippines and Malaysia). The project involves the activities in collecting, characterization and evaluation, conservation, documentation and use of tropical fruit tree species. Training for national programme staff is also an important activity of this project. A Regional Training Course on Strengthening National Capacity to Manage Information on Tropical Fruit Tree Genetic Resources was organized at the Philippines from 9 - 20 October 2000. The documentation local staff from all the member countries, except China, participated in it. The relevant technologies and software for data management were demonstrated during the course. Practical exercises on relevant software were provided to all the participants. Based on overall work plan of the project, the participants developed an action plan for documentation activities. It was agreed that all participants would use the re-entry plan developed during the training course for all the documentation-related work on tropical fruit tree collections after the training in collaboration with other staff. This paper deals with the roles, components and implementing aspects of the documentation action plan.

Roles of information and documentation activity

Documentation is an important activity planned in the Asian Development Bank (ADB) supported project, “Conservation and Use of Native Tropical Fruit Species Biodiversity in Asia”. This activity has a supporting role in the activities on collecting and locating diversity, characterization, evaluation and conservation as well as use of tropical fruit tree species. The well-managed information not only can help researchers to share experiences, setting up priorities and planning the activities, but also can fill gaps in knowledge, avoid duplication of efforts, and identify useful materials for conservation and use with the limited resources.

The relevant components

Following are the major components of the documentation activities:

- Producing germplasm catalogues and directories
- Developing information network
- Publishing fruit trees descriptors
- Carrying out data analysis and synthesis of information
- Publishing status reports
- Raising public awareness

Action plan

It was agreed that the action plan be developed for overall documentation activity with focus on the year 2001. The national coordinators were requested to backup and supervise the documentation activities in different institutes involved with the project in each country. IPGRI documentation staff will provide technical support wherever possible. The necessary
equipments such as computers, Global Positioning System (GPS), etc. should be provided according to the needs of documentation work in each institute. IPGRI-APO will provide the relevant software including GIS software (e.g. FloraMap and DIVA) to each partner for documentation and data analysis work. The action plan along with a timeframe for documentation activities developed during the Regional Training Course on TGT documentation at Los Baños, the Philippines from 9-20 October 2000 is given in Table 1.

**Computerizing passport data**

The passport data of germplasm collections of 6 tropical fruit tree species will be computerized according to IPGRI/FAO multicrop passport descriptor lists (Appendix D). The file format can be MS Excel, MS Access, Foxbase, DBase, Data Interchange Protocol (DIP) or simple text files or MS Word tables. The passport data from all countries will be compiled into a single database and will be shared by all partners through internet or other traditional/electronic media. While compiling the passport data, particular attention should be given to the geo-referenced data, i.e. latitude and longitude. As most of the accessions collected in the past do not have geo-referenced data, the efforts will be made by national documentation staff to obtain this information. There are two ways to find this information:

1) Use of more detailed local maps to locate the specific site from where the sample was collected in the past. Once the location is determined, the latitude and longitude of the site can be identified through the coordinates at that point using the reference map(s); or

2) Use of Global Gazette database which contains geo-referenced information of localities in each country. Through the index of this database, the name of the site can be located and with it the respective latitude and longitude information can be recorded. The Global Gazette database will be provided by IPGRI.

Though the first method is accurate, it will be very tedious and time consuming to get the respective geo-reference information if the collections are very large. On the other hand, obtaining information from the Global Gazette is easy and information is equally precise. This database has been tested for the information available from India and it was found that the information provided in these databases can safely be used for plant genetic resources (PGR) related activities.

**Computerizing characterization and evaluation data**

The characterization and evaluation data can be placed in any format mentioned in the section on computerizing passport data. The sharing of characterization and evaluation data among the partners is very important. It is suggested that all the countries should follow IPGRI descriptor lists if available. Currently, the descriptor lists developed by IPGRI are available for citrus, mango and jackfruit. The descriptor lists for litchi, rambutan and mangosteen need to be developed. The partners are also encouraged to develop the descriptor lists for those species, which are not yet published by IPGRI.

**Developing descriptor lists**

Leading institutes will be identified to prepare the draft for each crop. IPGRI-APO will coordinate this work. In order to facilitate uniform and easy data recording and developing database, it is also proposed to develop electronic copies of these descriptor lists using Macro in MS Excel, as was done for tree descriptors by IPGRI-APO. Participants of the TGT documentation course were exposed to this kind of approach, which was appreciated. There is a need to discuss and identify the countries that will take lead in helping IPGRI-APO for the finalization of these electronic descriptors.
Setting up homepages for tropical fruit tree species
A website for the tropical fruits will be set up as a node to link all partners and to share information among national programmes in the region. It will also serve as a platform for conducting e-conferences for the scientists working on tropical fruit tree species. The website is considered as one major activity in information networking for tropical fruit tree species. The relevant issues, which need to be discussed for developing the website, are given in Appendix II.

Publishing status reports and monographs
Status reports and monographs on tropical fruit trees provide extremely useful information for understanding the status of the research and development of tropical fruit trees in different countries. Twenty-two status reports on priority fruit species are available. Monographs on mango and citrus are being developed. They are important sources of information for priority setting and decision-making activities. Status report on mangosteen and monographs on durian and rambutan will be prepared and published. The relevant expertise available in the region will be used in preparing the status reports and monographs and IPGRI-APO will play the coordinating role.

Assisting in data analysis
IPGRI-APO will assist in data analysis and using the data of relevant tropical fruit tree collections. GIS software such as Flora Map and DIVA will be used to locate diversity, identify gaps in existing collections and plan collecting activities. Copies of these software will be provided to all member countries along with the geo-reference data. Training for the use of these software was provided during the Regional Training Course on Tropical Fruit Trees (TFT) Documentation organized in the Philippines. IPGRI documentation staff will follow up on the use of these geo-reference data and the use of GIS software so that these tools can be used more efficiently.

The other statistical tools such as cluster analysis, principal component analysis, multivariate analysis, etc. could be used to assess the genetic diversity and to establish relationships between different attributes of tropical fruit tree species. Such analysis could also be used for the rationalization/developing core collection for some of the large collections held by partners, IPGRI-APO documentation staff will work closely with the relevant national staff to carry out analysis of available data.

Public awareness
It was recognized that the public awareness is an important activity for this project. Hence, there will be some activities that will focus on popularizing tropical fruit species throughout the region and providing information to donors. All members of the project are encouraged to write relevant articles and papers for newsletters, web pages, etc. It was suggested that relevant calendar and postcards should be produced in 2001.
<table>
<thead>
<tr>
<th>Activity</th>
<th>Resources available</th>
<th>Person responsible</th>
<th>Time frame</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Synthesis of existing information:</strong></td>
<td>NPs within each country holding germplasm for these tropical fruit species</td>
<td>Country Coordinator and documentation specialist for TFT</td>
<td>January 2001 (depending on size of accessions)</td>
</tr>
<tr>
<td>Compiling of the existing characterization data into e-catalogues</td>
<td>(no ceiling on no. of accessions and descriptors available)</td>
<td></td>
<td>March 2001</td>
</tr>
<tr>
<td>Assisting in mapping diversity collected and identifying gaps in collection using Flora Map and DIVA</td>
<td>Flora Map/DIVA and other GIS software available</td>
<td>Documentation specialist for TFT and IPGRI staff</td>
<td>February 2001 (time is flexible depending on country needs and resources)</td>
</tr>
<tr>
<td>Preparation of all available data in DIP format for exchange</td>
<td>DIP Manual and DIPVIEW software</td>
<td>Documentation specialist for TFT and IPGRI staff</td>
<td>April 2001</td>
</tr>
<tr>
<td><strong>Public awareness:</strong></td>
<td>Activity reports</td>
<td>Country Coordinator and IPGRI staff</td>
<td>December 2001</td>
</tr>
<tr>
<td>Newspapers, Newsletters, Magazines; Posters, calendar and postcards (TFT messages on letterheads)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Information networking:</strong></td>
<td>All members of project</td>
<td>NBPGR is willing to host the website</td>
<td>Domain name to be ready by March 2001; First draft for comments by August 2001</td>
</tr>
<tr>
<td>To set-up web site for TFT</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Documenting new information:</strong></td>
<td>FlorasMap, DIVA and other GIS softwares available</td>
<td>Country Coordinator in consultation with documentation specialist for TFT and IPGRI staff</td>
<td>March 2001</td>
</tr>
<tr>
<td>To assist in predicting potential sites for collecting by identifying gaps in germplasm collected and planning collecting missions</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Contd.
<table>
<thead>
<tr>
<th>Activity</th>
<th>Resources available</th>
<th>Person responsible</th>
<th>Time frame</th>
</tr>
</thead>
<tbody>
<tr>
<td>Documenting data on newly collected germplasm</td>
<td>NPS staff and availability of GPS</td>
<td>Documentation and collecting staff</td>
<td>December 2001 (depending on germplasm collecting season in the respective countries)</td>
</tr>
<tr>
<td>Assisting in planning of germplasm characterization for both in situ and in field genebank</td>
<td>Need for manuals both for in situ and ex situ characterization</td>
<td>NPS and IFGRI staff</td>
<td>Refer to the time frame of overall plan activities of this project</td>
</tr>
<tr>
<td>Standardization of management and characterization descriptors and agreement on list of minimum descriptors</td>
<td>Various crop descriptors lists</td>
<td>Country Coordinator, documentation specialist for TFT from NPS and IFGRI staff</td>
<td>Drafts to be initiated during 2007</td>
</tr>
<tr>
<td>To maintain and update the data on passport and characterization for all collections</td>
<td>Software available</td>
<td>Documentation specialist for TFT and IFGRI staff</td>
<td>To be organized into a system during 2001</td>
</tr>
</tbody>
</table>
Appendix I. Multi-crop passport descriptors

IPGRI/FAO multi-crop passport descriptor list contains following information:

1. Institute code (INSTITUTE)
   This is the code of the institute where the accession is maintained. The code consists of the 3-letter ISO 3166 country code of the country where the institute is located plus number or an acronym as specified in the Institute database that will be made available by FAO. Preliminary codes (i.e. codes not yet incorporated in the FAO Institute database) start with an asterisk followed by a 3-letter ISO 3166 country code and an acronym.

2. Accession number (ACCNUM)
   This number serves as unique identifier for accessions and is assigned when an accession is entered into the collection. Once assigned, this number should never be reassigned to another accession in the collection. Even if an accession is lost, its assigned number should never be reused. Letters should be used before the number to identify the genebank or national system (e.g. IDG indicates an accession that come from the genebank at Bari, Italy; CGN indicates an accession from the genebank at Wageningen; The Netherlands; PI indicates an accession within the USA system).

3. Collecting number (CCLNUM)
   Original number assigned by the collector(s) of the sample, normally composed of the name or initials of the collector(s) followed by a number. This item is essential for identifying duplicates held in different collections. It should be unique and always accompany sub-samples wherever they are sent.

4. Coccus (GENUS)
   Genus name for taxon, Initial Uppercase letter required.

5. Species (SPECIES)
   Specific epithet portion of the scientific name in lowercase letters plus authority. The following abbreviation is allowed: "sp."

6. Subtaxa (SUBTAXA)
   Subtaxa can be used to store any additional taxonomic identifier plus authority. Following abbreviations are allowed: "ssp." (for subspecies); "var." (for variety); "convar." (for conservariet); "f." (for form).

7. Accession name (ACCCNAME)
   Either a registered or other formal designation given to the accession. First letter upper case. Multiple names separated with semicolon.

8. Country of origin (ORIGCCT)
   Name of the country in which the sample was originally collected or derived. Use the ISO 3166 extended codes (i.e. current and old 3 letter ISO 3166 country codes).

9. Location of collecting site (COLLSITE)
   Location information below the county level that describes where the accession was collected starting with the most detailed information. Might include the distance in kilometres and direction from the nearest town, village or map grid reference point (e.g. CURITIBA 7S, PARANA means 7 km south of Curitiba in the state of Parana).

10. Latitude of collecting site (LATITUDE)
    Decimal format DD.MNNN. Positive and negative degrees are used where a positive is North and Negative value is South of the Equator.

11. Longitude of collecting site (LONGITUDE)
    Decimal format DD.MNNN. Positive and negative degrees are used to indicate hemispheres. Positive values are used for the eastern hemisphere and negative values for the western hemisphere.

\(^1\)Authority is only provided at the most detailed taxonomic level
12. Elevation of collecting site [masl] (ELEVATION)
Elevation of collecting site to be expressed in meters above sea level. Negative values allowed.

13. Collecting date of original sample [YYYY/MM/DD] (COLLDATE)
Collecting date of the original sample where YYYY is the year, MM is the month and DD is the day.

14. Status of sample (SAMPSTAT)
1) Wild
2) Weedy
3) Traditional cultivar/ landrace
4) Breeding/ research material
4.1) Breeder's line
4.1.1) Synthetic population
4.1.2) Hybrids
4.1.3) Founder stock/ base population
4.1.4) Inbred lines (parents of hybrid cultivars)
4.1.5) Segregating populations

4.2) Mutant/ genetic stock
5) Advanced/ improved cultivar
99) Other (Elaborate in REMARKS field)

15. Collecting source (COLLSRC)
The coding scheme proposed can be used at 3 different levels of detail: Either by using the global codes such as 1, 2, 3, 4 or by using the more detailed coding such as 1.1, 1.2, etc.

1) Wild habitat
2) Farm
3) Marriet or shop
6) Weedy,
1.1) Forest/woodland
1.2) Shrubland
1.3) Grassland
1.4) Desert/ tundra
1.5) Aquatic habitat
2) Field
2.1) Field
2.2) Orchard
2.3) Backyard,
2.4) Threshing floor
2.5) Pasture
2.6) Farm store
3.1) Town
3.3) Village
3.3.3) City
kitchen or
urban, peri-urban
or rural
station, research
org.
5) Seed company
5.1) Family
5.2) Large-scale
6) Roadside
6.1) Roadside
6.2) Field margin
6.3) Fallow land
99) Other

(Elaborate in REMARKS field)

16. Donor institute code (DONORCODE)
It is the code for the donor institute. The code consists of the 3-letter ISO 3166 country code of the country where the institute is located plus number or an acronym as specified in the Institute database that will be made available by FAO. Preliminary codes (i.e. codes not yet incorporated in the FAO Institute database) start with an asterisk followed by a 3-letter ISO 3166 country code and an acronym.

17. Donor number (DONORNUMB)
Number assigned to an accession by the donor. Letters should be used before the number to identify the genebank or national system (e.g. IDG indicates an accession that comes from the genebank at Bari, Italy; CGN indicates from the genebank at Wageningen, The Netherlands; PI indicates an accession within the USA system).

18. Other number(s) associated with the accession (OTHERNUMB)
Any other identification number known to exist in other collections for this accession. Letters should be used before the number to identify the genebank or national system (e.g. IDG indicates an accession that comes from the genebank at Bari, Italy; CGN indicates from the genebank at Wageningen, The Netherlands; PI indicates an accession within the USA system). Multiple numbers can be added and should be separated with a semicolon.
19. Plant uses (PLANTUSE)

1) Food
2) Food additive
3) Animal food
4) Bee plant
5) Invertebrate food
6) Materials
7) Fuels
8) Social uses
9) Vertebrate poisons
10) Non-vertebrate
11) Medicines
12) Environmental uses
13) Gene sources

20. Plant part used (PLANTPART)

1) Entire plant
2) Unspecified aerial parts
3) Seedlings/germinated seeds
4) Galls
5) Stems
6) Bark
7) Leaves
8) Inflorescence
9) Infructescences
10) Seeds
11) Roots
12) Exudates

21. Remarks (REMARKS)

The remarks field is used to aid notes or to elaborate on descriptors with value "99" (=Other).
Prefix remarks with the field name they refer to and a colon (e.g. COLLSRC: roadside).
Separate remarks referring to different fields are separated by semicolons.
Appendix II. Proposed web site for tropical fruit trees project

1. Owner of the web pages: ADB-TFT project partners
2. Hosted by: Central Institute of Subtropical Horticulture (CISH), Lucknow, India
3. Publication committee: Regional Director, Project Coordinator and national coordinators
4. Editors: IPGRI documentation staff
5. Contributions: All members of the project
6. Page designer: Relevant staff at CISH and IPGRI
7. Domain name: http://www.tropicalfruit.net
   The name selected was based on name with a life-span beyond the project. There are several alternatives for selection:
   - http://www.adbtftgr.net
   - http://www.adb-tftgr.net
   - http://www.tropfruits.net
   - http://www.adbfruits.net
   - http://www.ipgri-adb.net
   Any other suggestions???

8. Functions:
   - Information sharing
   - Linkages with other relevant sites
   - Platform for e-conference and e-mail exchange

9. Major contents:
   - Introduction to TFT project
   - Annual progress reports
   - Descriptor lists of TFT
   - Training materials
   - Germplasm catalogues and directories of TFT
   - Conservation directories of TFT
   - Publications of TFT including proceedings of meetings
   - Information on on-going meetings and training courses
   - Linkages to relevant WebPages
In situ conservation of tropical fruit trees in Southeast Asia

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Introduction
In situ conservation is concerned with maintaining tropical fruit tree populations in the habitats in which they occur. In situ conservation of cultivated species, sometimes referred to as on-farm conservation, is primarily concerned with supporting the conservation of traditional crop and fruit tree genetic resources in the production system in which they have evolved and continue to evolve and maintained. On-farm conservation concerns the entire eco-systems including underutilized tropical fruit tree species.

In this paper, 5 main areas are discussed: (i) why in situ conservation on-farm is important and to whom, (ii) what information is necessary to support on-farm conservation of tropical fruit trees genetic resources, (iii) the importance of ad methods for linking different disciplines and formal and informal institutions and sectors including community sensitisation and farmer involvement, (iv) methods for collection and analysis of the needed information, and (v) using this information for social, economic and genetic benefits for farmers and the society.

Why in situ conservation of tropical fruit trees?
Understanding why we want to conserve tropical fruit trees on-farm is important because it can help to identify the specific needs of an on-farm conservation programme. In addition to preserving tropical fruit tree genetic resources, on-farm conservation has other major benefits that make it unique among the options available to conservationists. These benefits not only relate to genetic diversity but also to ecosystem and human well-being.

The conservation of agrobiodiversity at all levels within the local environments helps ensure that the ongoing process of evolution and adaptation of fruit species to their environments are maintained within farming systems (Oldfield and Alcorn 1987; Attié and Merrick 1987; Brush 1991). This benefit is central to in situ conservation, as it is based on conserving not only existing germplasm but also the conditions that allow for the development of new germplasm.

In the maintenance of farming systems, on-farm conservation applies the principle of conservation to all the three levels of bio-diversity: ecosystem, species, and genetic diversity (Frenkel et al. 1995; Humphries 1995; IPCRI 1996). In conserving the structure of the agroecosystem, with its different niches and the interactions among them the evolutionary process and environmental pressures that affect genetic diversity are maintained.

Farmers are likely to know the nature and extent of local fruit tree species better than anyone else through their daily interactions with diversity in their fields. Given their expertise, incorporating farmers into the National Plant Genetic Resource (NPGP) system can help create productive partnerships for all involved. This integration can happen in several ways, including: developing systems to generate material more easily accessible to farmers; seeing farmers as partners in the maintenance of selected germplasm; establishing a national dialogue on biodiversity conservation; sustainable use and equitable benefit sharing between farmers, genebanks and other partners, assisting the exchange of information with and among farmers from different sites and projects.

On-farm conservation may also be an important way to maintain the local tree management systems for agro-ecosystem sustainability by ensuring soil formation process; reducing chemical pollution and other waste emissions from farms, and restricting the spread of plant disease (Goodland 1995; Vandermeer 1995; Costanza et al. 1997; Finck and Wolfe 1997).

In situ conservation programmes also have significant potential to improve the livelihoods of farmers at the local level. On-farm conservation programmes can be combined with local infrastructure development or the increased access for farmers to useful germplasm held in...
national genebanks. Farmers will benefit from the continued agricultural diversity and ecosystem health that on-farm conservation supports. Local crop resources can be the basis for initiatives to increase crop production or secure new marketing opportunities. By building development efforts on local resources and through the empowerment of farming communities, they can lead to sustainable livelihood improvement. Resource-poor farmers, in particular, may benefit if development initiatives are not based on external inputs that may be costly or inappropriate for marginal agro-ecosystems.

On-farm conservation also serves to empower farmers to control the genetic resources in their fields (van Oosterhout 1997; Mshaka 1993; Taredo and Hauen 1993; Vazzana 1996, Bellon 1996 a,b). On-farm conservation recognizes farmers and communities as the curators of local genetic diversity and the indigenous knowledge to which it is linked. In turn, farmers are more likely to reap the benefits that arise from the genetic material they have conserved.

The importance of conservation of agrobiodiversity for the future of global food security lies in its potential to supply crop breeders' and other users' future needs for germplasm. On-farm conservation will allow the processes of evocation and adaptation to continue in crop plants, ensuring that new germplasm is generated over time, rather than limiting conservation to a finite set of genetic resources conserved in genebanks. In addition to these, "public" genetic benefits, on-farm conservation can also provide other benefits to society and to the farmers who maintain crop diversity. Society can benefit from the agro-ecosystem stability and decreased use of chemicals in agriculture promoted by the use of diverse local varieties. Socio-economic benefits might include the empowerment of rural communities. For farmers, on-farm conservation could serve to support cultural traditions, fit household labour and budget constraints, mitigate pests, diseases and other environmental stresses, and provide an insurance of new genetic material in the face of future environmental or economic change.

Creating a framework for project implementation

Before implementing an in situ conservation programme, a thorough understanding of the factors that influence the level of crop genetic diversity on-farm is needed. While ex situ conservation is primarily a technical issue of how best to preserve germplasm, the conservation or erosion of genetic diversity in farmers' fields is shaped by a complex range of factors over time. These range from farmers' decision-making to local environmental change to interactions between and within crop populations. The combinations of these factors require research to answer the following key questions:

(i) What is the amount of genetic diversity maintained by farmers over time and space and how it is distributed?
(ii) What processes are used to maintain this genetic diversity on farm?
(iii) Who maintains this diversity on-farm (men, women, young, old, rich, poor, certain ethnic groups)?
(iv) What factors influence farmers' decision-making to maintain diversity on-farm?

Social, cultural, economic, environmental and biological factors influence a farmer's decision of whether to select or maintain a particular crop variety at any given time (Brush 1991; Bellon 1996 a,b). Farmers, in turn, make decisions in the processes of planting, managing, and harvesting their crops. Over time they may modify the genetic structure of the crop population.

A challenge undertaken by on-farm conservation research is to quantify the effects of social, cultural and economic factors on farmers' actions with regard to the maintenance of crop genetic diversity. Understanding these relationships will provide insights into the conditions fostering landrace conservation and better enable the design of formal in situ conservation strategies.

Social research investigates how people group together in institutions and organizations for collective action. Cultural research focuses on the customs and values through which a society or group defines itself. The economics deals with the decisions people make regarding the allocation and use of resources, based on their market and non-market values.
Key questions to ask are:

(i) What social, cultural and economic forces influence varietal choice?

(ii) What are the opportunity costs of conserving agrobiodiversity?

(iii) What are the appropriate social or economic categories or data disaggregation? (gender, age, ethnicity?)

The basic unit to be sampled should be centered on the farmers' management unit. For social, cultural and economic information, this is normally the household. Some major social, cultural and economic factors that could influence farmers' choice of varieties and how they manage these varieties are listed above.

In addition, to social, cultural and economic factors, environmental and biological factors such as soil type, water availability, pests and diseases, may also influence a farmer's choice of variety that he or she may plant and manage.

In addition, the level and structure of crop genetic diversity in the farmer's field is a result of a number of actions and external influences extending beyond the farmer's choice of how many and which varieties to plant. Farmers exert influence on the genetic diversity of their crops through a range of actions, while the agro-ecosystem and the biology of the crop also affect the outcome in ways the farmer cannot always control.

The local practices of agro-ecological management, including seed preparation, irrigation, plant management, and use of inputs, create microenvironments favouring certain adaptations. Farmers' seed selecting decisions are based on the range of agro-morphological characteristics that their crops exhibit. These qualities include the phenology or morphological characteristics of the plant, unique aspects of its adaptation, or particular uses of the plant parts. These characteristics help farmers, as well as scientists in identifying landraces. Farmers influence the population structure of a crop, by determining the proximity of the crop population to potential breeding partners, and thus how genetic material is exchanged between and within fields. New genetic material may be introduced through the system of seed flows, in which seeds are acquired from a variety of channels or stored on-farm for later use.

Farmers like all humans, easily recognize many or the phenotypic features of fruit trees and use those features to identify and select their fruit varieties. These agro-morphological criteria may take a wide range of forms and are usually linked to the genetic diversity of fruit trees. These criteria are used by farmers to distinguish and name crop varieties and they are commonly the basis for farmers' selection of planting seed. Because of this, we can say that species' agro-morphological characteristics are the link between farmers and the crop genetic diversity in their fields.

It is important for us to understand how farmers make use of their observations on agro-morphological characteristics of fruit trees they grow in these different capacities. First, agro-morphological traits are used by farmers to identify or distinguish varieties; these identifying characteristics are often the basis for the names farmers give to varieties. Second, some of these traits are preferred, or valued, by the farmer; that is, the farmer chooses to plant a particular variety because certain of its distinguishing characteristics are desirable. Third, farmers select among the trees in the fruit population to maintain these desirable characteristics and to increase the prevalence of other valued traits in the population over time. For instance, a farmer may identify a named variety of durian by its colour, leaf shape, and region of origin, value it for its eating quality, and select for higher yielding trees to increase the yield potential of the variety.

Agro-ecosystems are comprised of the non-living (abiotic) and living (biotic) components in a human-managed, agricultural system. Agroecosystems provide the arena in which tree evolution occurs, presenting stresses, but also opportunities, to which fruit trees must adapt in order to thrive. Abiotic components of agroecosystems include temperature, soil, water, relative humidity, light and wind. Biotic factors include parasitic and herbivorous pests, competition from other trees, and favorable (syntrophic) relationships with other organisms. The farmers who manage these factors in terms of irrigation, nutrient input, pest control, land preparation,
mixed/relay cropping and other practices are also abiotic components of agro-ecosystems. These factors vary over time, with seasonal, annual, and stochastic changes, and in space, from the micro-environmental to the eco-regional scale; as a result, local landraces adapt to the particular conditions of their immediate ecogeographic setting. These adaptations to local environmental stresses are likely to be reflected in landraces' genetic composition over time.

Since we are dealing here with perennial species, the time over which this could happen would be much longer than that for annual species and more than one generation of growers would be involved. Thus, history of cultivation of perennial fruit species is one great importance in on-farm conservation of fruit genetic resources.

Plant population genetics is a branch of plant population biology with three aims. These are: (i) to describe the genetic diversity within and between the populations of a plant species, (ii) to estimate the strength of evolutionary forces that shape these patterns of diversity, and (iii) to develop theoretical models that predict the stability and change in these patterns. Thus, population genetics is one of the basic disciplines underpinning the scientific basis of on-farm conservation, providing a framework, and procedures for monitoring diversity. The breeding systems of crop plants help determine how genetic diversity will be patterned within and between their populations, and also how new genetic diversity can arise in individual species.

Farmers' decisions regarding the size and relative placement of their fields impact significantly on local crop diversity. Fields may be large or small, close together or widely separated, or it may be one or several trees in a home garden. Depending on the reproductive biology of the crops in question, this structuring can have a range of effects on the genetic diversity of fruit trees.

The simplest basis for measuring the population genetic structure is conservation in situ, the distinct landrace or farmer-managed unit of the species. (i) the number of different landraces in a particular sample or area or field; (ii) the genotype diversity index, being the probability that two randomly drawn individuals from the sample will belong to different landraces. Further two measures of pattern of occurrence in the region apply to each specific landrace within the study, (i) the average population or field size of a specific landrace and hence the distribution of field sizes (mean and variance) within and between landraces, and (ii) the number of fields in the study region in which a landrace is grown.

These two measures classify each landrace according to whether or not it is widespread (occurs in more than a few fields) versus localized (restricted to a few fields), and secondly whether it is common (here defined as grown at least on some farms in large numbers in above average field sizes) versus rare (in small fields only).

Genetic diversity is ideally measured by screening a sample of individuals for genetic differences (as different alleles) at marker loci. The more important variables are listed above. These data measure the average diversity of a field, the differences in allele frequencies among different populations, and the differences in levels of polymorphism among population. Important also is the time dimension - Is the genetic diversity of a population changing over time?

Given the seasonality of long-lived species such as fruit trees, the only opportunity for a farmer to select fruit varieties is at the time of planting which may occur every 10-15 years. This creates a very limited window of opportunity for seed/propagule selection to meet the unique challenge for conservation.

The processes used for maintaining and managing long-lived species

In each planting season, the farmer decides how much seed to plant and where that seed comes from. In addition to the seed or propagating material selected and stored from his or her own fruits, the farmer may procure new seed from markets, local nurseries or other farmers. By planting seeds from sources beyond his or her own fields, the farmer makes a conscious decision to introduce new germplasm into the agro-ecosystem. Studying the seed flows will
enable a better understanding of the processes by which seed is stored and exchanged and the associated impact on the distribution of genetic diversity.

There are significant biases in the way the varieties are developed and released, such that resource-poor farmers are less likely to be able to benefit from the products. Seed certification and distribution regulations often hinder farmers' access to seed and cultivars that would be beneficial to them. Information on the farmers seed system can aid the formulation of appropriate policies.

In addition to the genetic constitution of a variety and its effective population size being influenced by seed exchange between farmers, villages or regions, and by the extent to which farmers mix exchanged seeds, or their progeny either deliberately or accidentally, seed and seedling survival ensuring storage, germination and emergence will also have significant effects on the genetic constitution of the next generation. Seed storage and post-harvest pests may also be a limiting factor in farmer's variety production.

Often, the amount of genetic diversity of tropical fruits in homegardens is higher than the commercialized orchard; it is important to understand why the compositions of fruit tree species are different within various ecosystems. What are the criteria by which farmers chose to conserve certain fruit species? How do farmers manage, propagate and exchange this genetic diversity within the community? Understanding such process may be crucial for on-farm conservation of fruit trees. The challenge is to understand the methods farmers used to maintain fruit diversity and find ways and means to encourage farmers to select and maintain species of their choice.

Creating a framework for project implementation
The first step in the establishment of a national framework for on-farm conservation is the identification of partners and the creation of linkages between them, including diverse disciplines, institutions, and formal and informal sector organizations (Solms 1998, Broek et al. 1996; Hardon and deBoedt 1993). Other important aspects of creating a national framework for long-term sustainable research and implementation of on-farm conservation include training and equity.

Enhancing national expertise through training male and female personnel in plant population biology, ecology, biogeography, conservation biology, economics, sociology and anthropology will create a foundation for sustainable research and conservation programmes. Training should target both farmers and project personnel and when possible should serve to strengthen the collaboration between them, such as training on participatory approaches to research.

On-farm conservation initiatives should also promote equity at all project levels, from farmer participation to research to project management and decision-making. Gender awareness is one important facet of national on-farm conservation projects, not only in the collection of gender-disaggregated data and the participation of women farmers in the project, but also in the involvement of women and men as members of research and management teams. Increased participation of women, minority community and farmer in decision-making is essential to ensure that diverse perspectives are incorporated into the project objectives and that all stakeholders feel ownership in the project.

Methods for collecting and analysis of needed information
Research for on-farm conservation should be implemented with a participatory approach at all stages of the process. Participatory research refers to techniques that emphasize researchers and participants learning together, rather than the extraction of information by researchers from participants. The use of participatory methods can serve to include farmers in the research process and to incorporate their knowledge on local socio-economic and agroecological conditions, their fruit tree and seed management practices, and the characteristics and origins of their varieties into project data. An exploratory approach—one which is not based on
Preliminary hypotheses are initially useful because they do not presuppose or assume the different categories or reasons underlying farmers' knowledge and enables farmers to employ their own values and standards of measurement. Techniques are structured to allow for the collection of quantitative data, or semi- or unstructured to elicit qualitative data.

Empirical data can confirm a farmer's perception of his or her surrounding system. Empirical data also should add information that may be invisible to the farmer or may be outside the farmer's expertise, or may be at a height spatial or temporal level than the farmer household or community (R. Salazar, pers. comm., 1997).

Survey questionnaires, completed by a personal interview, are a means of gathering quantitative data directly from informants. They function as an "interpersonal role" situation in which an interviewer asks respondents questions designed to elicit answers pertinent to the research hypotheses. When these data have been collected, farmers' decisions can be analyzed in the context of microeconomic theory of variety choice. This theory has been applied using econometric models. An econometric model is one in which economic theory is used to postulate causal relationships and test them with multiple regression analysis.

Agroecosystem data might document dozens of factors (abiotic, biotic and management), and it is impossible for the mind to simultaneously contemplate the dimensions of such a data set. It is necessary to simplify the data set by determining which dimensions are most important to describe the overall variation within the data. Two common statistical techniques for reducing the dimensionality of complex data sets are: classification and ordination. These multivariate methods can be used to explore the relationships not only among study sites or fields based on their multiple-abiotic, biotic and management characteristics, but also the relationships among fruit tree samples based on morphological traits and/or genetic markers and among households based on social and economic characteristics.

The procedures for collecting data on agromorphological traits are standard whether the data is used for measurements of genetic diversity or farmers' traits. It entails taking physical measurements of various aspects of a plant's morphology or agronomy under different experimental conditions or treatments. Plant morphological traits, such as seed size or colour, can be measured. The agronomic traits include characteristics that refer to a tree's growth and performance, such as time of flowering or yield.

In addition to field evaluations, laboratory and greenhouse evaluations may also be necessary to distinguish different degrees of adaptive and quality traits that farmers may have identified. The nutrition value, shelf life, etc. are traits that can be analysed using laboratory techniques to quantify differences between farmer-named varieties. Some agronomic traits such as disease resistance and tolerance to abiotic stresses (drought, salinity, etc.) can be easily evaluated using specific laboratory or greenhouse screening techniques for better characterization of the genotype differences among landraces.

In addition to agromorphological characters, biochemical and molecular markers can also be used to reflect genetic differences between trees. These differences are measured in the form of differences in the amino acid sequences of proteins and by differences in the nucleotide base sequences in DNA. By looking directly at such variations, molecular markers allow us to avoid the complications of environmental effects acting upon characters that are problematic when studying morphological characters.

Appropriate sampling is important to ensure that adequate representation of the situation or site is reflected in the information collected. Regardless of the approach chosen, some part of the diversity in human, environmental and genetic diversity factors will not be sampled. Sampling strategies must consider resource constraints along with scientific needs.

How many subsamples of households, plots, and trees are necessary to have a representative sample of the site or population in question? The objective is to determine the smallest number of samples to adequately characterize the region in question. Sampling size will depend on the amount of variation among samples. A larger sample size will give more information on the
variation between samples than with a smaller sample. Thus, the more homogenous the population, be it in terms of household characteristics, field soil types, or variety populations, the less the need will be for larger sample sets. This concept of trend in the decrease in new information as more and more, or larger and larger, samples are included is often used to determine the minimum size and number of samples that will be representative of a population.

The information to study these topics comes from different levels and disciplines. The different sources and levels of information include the variety, the crop, the parcel or plot, the household, the village or community, the landscape or region. Likewise, information from one aspect may be useful to answer more than one question. What is important is that the information collected at the level of the household or farmer’s plot may not be the appropriate scale for analysis of for crop diversity conservation, but may have other uses. So, such information needs to be treated with caution.

**Using information for ecological, genetic, social and economic benefits**

Effective management and conservation of genetic resources on-farm takes place where the resources are valued to meet the needs of local communities. In order for local orchard systems to be maintained by farmers, resources must have some value and/or be competitive to other options a farmer might have. The benefits may be social, cultural, economic, ecological and genetic and may be for farmers, communities and society (Table 1).

### Table 1. Example of possible benefits of on-farm conservation of intraspecific crop diversity to the farm households and the society.

<table>
<thead>
<tr>
<th>Economic and socio-cultural benefits</th>
<th>Ecological benefits</th>
<th>Genetic benefits</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Farmer households</strong></td>
<td><strong>Some examples:</strong></td>
<td><strong>Some examples:</strong></td>
</tr>
<tr>
<td>• manage risk and uncertainty</td>
<td>• reduction in chemical pollution</td>
<td>• insurance against environmental and socio-economic change</td>
</tr>
<tr>
<td>• fit different budget constraints</td>
<td>• soil amelioration, nitrogen fixation</td>
<td></td>
</tr>
<tr>
<td>• avoid or minimise labour bottlenecks</td>
<td>• pest control</td>
<td></td>
</tr>
<tr>
<td>• manage pests and disease</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• fulfill rituals or forge social ties</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Society</strong></td>
<td><strong>Some examples:</strong></td>
<td><strong>Some examples:</strong></td>
</tr>
<tr>
<td>• food security</td>
<td>• greenhouse gas regulation</td>
<td>• future insurance against environmental change, diseases and pests</td>
</tr>
<tr>
<td>• empowerment of local communities</td>
<td>• reduction of chemical pollution</td>
<td>use for the agricultural industry</td>
</tr>
<tr>
<td>• social sustainability</td>
<td>• soil formation processes</td>
<td></td>
</tr>
<tr>
<td>• nutritional</td>
<td>• regulation of hydrological flows</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• restrict plant diseases</td>
<td></td>
</tr>
</tbody>
</table>
When on-farm conservation research has identified genetically important tropical fruit tree populations and farming systems that are priorities for conservation, it may be appropriate to assess different options for "adding value" to these populations, or in other words, increasing the benefits to farmers from growing diverse local fruit tree resources in a given social, economic, and ecological context. When we refer to "enhancing the benefits" to farmers of local crop diversity, we mean the net benefits (benefits minus costs), as there may also be costs to farmers associated with participation in these options.

Increasing farmers' access to diverse crop genetic resources, as well as information about these resources, could serve to broaden farmers' options regarding choice of variety while fostering diversity conservation. Access to new and diverse varieties can be improved through community-based genebanks and community biodiversity registers, strengthened seed exchange networks, and the incorporation of landraces into national extension programmes, while information regarding these resources can be disseminated through community-level public awareness activities like 'Diversity Theatres' and 'Diversity Fairs'.

If diversity can be more highly valued in the market place through the creation of consumer demand for certain products, and farmers can access those markets, this would motivate farmers to maintain diversity. Strategies to increase consumer demand for diverse crop resources include improved processing, packaging, and marketing of landrace products, public awareness initiatives to educate consumers about the value of agrobiodiversity, and linking with other types of products in demand, such as organic produce.

Training extension personnel in the value of local crop genetic resources and the importance of landrace conservation could be an important step in creating extension programmes that support, rather than hinder, maintenance of diverse crop resources on farm. This training could be incorporated into the curriculum of extension workers at a national level or offered as in-service training to the experienced extension workers. If extension personnel recognize the importance of local landraces for conservation and local livelihoods, their work could act as a means of spreading local fruit tree diversity and knowledge while strengthening the relationship between farming communities and national PGR systems.

The general ethos of respect for the environment has gained prominence in much of the developing world through the widespread association with indigenous people and traditional ways of life. This has been achieved largely through public awareness campaigns, which use the media to disseminate messages about the potential success of ecologically sound environmental management practices. Although they have played a relatively small part in such media campaigns to date, local agricultural systems could figure prominently in these types of messages, disseminating information about the processes and implications of genetic erosion, as well as the importance of on-farm conservation.

Particular agroecological management practices may also serve to support the production of crop diversity. Low chemical input or organic farming with local varieties can serve to promote agro-ecosystem stability and health. Such improvement strategies must necessarily be local in order to be used for a diversity of landrace materials.

Improving diverse fruit tree populations or the production systems in which they are grown is one possible means of increasing benefits to the farmers who grow them. Plant breeding strategies have been developed to improve varieties locally and according to farmers' interests, like participatory plant breeding and seed cleaning treatments. In addition, seed storage practices could be strengthened to prevent losses due to diseases, pests and deterioration.

Many fruit species are known to grow, though not at their best, on marginal lands. This is especially true with respect to locally adapted fruit species. Promoting fruit production on available marginal lands not only will help in conserving the genetic diversity but also in income generation of rural poor. Appropriate land tenure reforms and policies and social forestry would play a major role in this effort.
The role that national economic and agricultural policies play in the support, or lack thereof, of farming systems maintaining fruit tree diversity remains to be investigated. If market failures are identified that prevent the farmer from capturing the full benefits of the market's valuation of diverse landraces, policy changes can serve to correct these market failures. Current national policies may serve to deter the maintenance of landraces. Farmer varietal classification systems often do not use the criteria of uniformity required for seed certification through national systems, which may hinder local-level seed innovations. In addition, linkages are weak between public agricultural research and commercial seed providers, limiting distribution of farmer varieties. The support of farmer seed marketing may be necessary for landraces to become widely available beyond the local level. However, the effects of specific policies on farmers' choice of varieties are not fully understood. For example, an extension programme promoting an agronomic package of modern varieties, fertilizers and pesticides and credits may discourage landrace cultivation. On the other hand, even if farmers adopt these packages, the increased income that may result could enable farmers to continue to maintain the preferred varieties on smaller land areas. These aspects need further investigation.

Studies of diversity management have shown that local cultivars are highly varied in their genetic structure, while different cultures and communities approach the naming and management of local cultivars in different ways (IPGRI 2000). It will be essential that the development of strategies effectively integrate this local information. It will also be essential to identify regional and national actions that will have a positive effect on fruit tree diversity maintenance. This will include recognizing the importance of maintaining local cultivars' supply system, which national genebanks might be able to strengthen and support this supply. In developing and strengthening a programme of work for in situ conservation of fruit tree genetic resources, it will be important to act in ways that recognize the farmer and communities thousands of years of input in domesticating and maintaining fruit tree diversity for sustainable production.

References


Cryopreservation of citrus and other tropical fruits - Recent research results

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Introduction
Southeast Asia is known to be the centre of diversity and distribution of Citrus, especially of the subfamily: Aurantioidae. Among the aurantioids, Citrus medydooraf is a widely grown species within this region and is commonly known as lime, sour lime or common lime. The fruit is used mainly as flavour food, as a drink and a source of medicine. At present the crop is mainly cultivated in the field, as the seeds are partially sensitive to desiccation. For such recalcitrant and semi-recalcitrant seeds, cryopreservation in liquid nitrogen (LN) is an important and practical alternative for their germplasm conservation.

The vitrification technique is relatively new and was reported to be successful for a number of recalcitrant species (Sakai 1993, 1997; Takagi et al. 1998). However, there were many reports which emphasized the importance of pre-growth and pre-conditioning for increased survival of tissues during vitrification (Matsumoto et al. 1995, 1998; Paris et al. 1996). Pre-growth refers to a short period of culture before excision to enable the tissue to stabilize in culture media for many tissues of tropical plants such as taro, banana and coffee meristems, incorporation of sucrose into the pre-growth medium can enhance freezing tolerance and improve survival in LN (Mari et al. 1995; Matsumoto et al. 1995; Paris et al. 1996; Takagi et al. 1998; Thinh, H. 1997; Hirai et al. 1998). Pre-condition on the other hand is a short period of growth of culture material in various cryoprotectants so predispose the plant to withstand subsequent desiccation and freezing.

Although many cryoprotectants such as ascorbic acid (Eberhardt and Wegmann 1989), sorbitol and dimethyl sulfoxide (DMSO) were reported to be effective, many reports confirmed the effectiveness of sucrose also for pretreatment of many tissues (Mizun et al. 1988, 1993; Yamada et al. 1991; Radhames and Chandey 1992; Kohmura et al. 1994; Matsumoto et al. 1995, 1998; Nishio 1996; Takagi et al. 1998; Gonzalez-Arumio et al. 1996, 1998; Donnet et al. 1997; Hirai et al. 1998).

Citrus seeds were considered recalcitrant for many years. Efforts made to investigate the response of seeds of citrus species and related genera to desiccation indicated that different species show different responses, ranging from high desiccation tolerance as in kumquat to high sensitivity as in Poncirus trifoliata.

Direct immersion and storage in LN after partial desiccation using air-drying and silica gel drying, without any treatment by cryoprotectant, successfully cryopreserved seeds that are tolerant to desiccation such as those of Citrus lemon, C. aurantium and C. aurantifolia. However, seeds partially tolerant to desiccation such as those of sweet orange, C. clementina, Seville citrange and C. hystrix require careful monitoring of drying to avoid desiccation beyond a critical value, which varies among species, to achieve acceptable survival. In the case of species whose seeds are sensitive to desiccation such as trifoliata orange and C. hystrix, no survival after cryopreservation has yet been achieved.

Attempts have been made to investigate the tolerance to desiccation and suitability for cryopreservation of embryonic axes excised from citrus seeds. The limited information available indicates that, as observed with most recalcitrant and intermediate species, citrus embryonic axes were more tolerant to desiccation than the whole seeds and that could also be cryopreserved by direct immersion in LN after drying. Embryonic axes of P. trifoliata, C. hystrix, C. hystrix and Mexican lime were tolerant to partially tolerant to desiccation. Survival after cryopreservation of embryos was high in P. trifoliata and Mexican lime, and intermediate in C. hystrix and C. hystrix.
Cryopreservation of *Citrus madurensis*

A study was conducted to evaluate the effects of various pre-growth and pre-conditioning treatments on subsequent survival of excised embryos of *Citrus madurensis* during vitrification in liquid nitrogen.

**Materials and methods**

Seeds of *C. madurensis* were extracted from freshly harvested fruits and surface sterilized in 20% commercial Clorox for 20 min followed by 70% ethanol for 5 min. The seeds were then rinsed 3 times in sterile water and then axes excised aseptically before being used for four experiments to establish the optimum pretreatment for successful vitrification in liquid nitrogen (LN).

In the first experiment, the effects of pre-growth duration on survival were evaluated. Freshly excised embryos were pregrown for 0, 3, 5, 7, 9, and 11 days on solidified Murashige and Skoog (MS) medium supplemented with 0.1 mg L\(^{-1}\) BAP, NAA and GA3. The embryos were then pre-cultured on MS basal agar supplemented with 0.3M sucrose for 1 day before being vitrified.

In the second experiment, the optimum sucrose concentration for pre-culture was assessed using the optimum pre-growth period established in the first experiment. The embryos were pre-cultured in 0.1, 0.3, 0.4, 0.5, 0.6, and 0.7M sucrose for 1 day before being vitrified and their survival measured.

The third experiment evaluated the inclusion of various concentrations of glycerol with the optimum concentration of sucrose in the pre-culture medium established in the second experiment. Glycerol at 0, 0.1, 0.3, 0.5, and 1.0M were incorporated and evaluated as before.

The optimum sucrose-glycerol pre-culture medium was compared with other reported pre-culture media used successfully for vitrification. Two pre-culture durations of 4 h and 1 day were also evaluated.

The vitrification processes in all experiments were similar. The pre-grown and pre-cultured embryos were exposed to loading solution (0.4M sucrose + 2M glycerol) for 20 min at 25°C before being dehydrated in PVS2 vitrification cocktail for 20 min at 25°C. Dehydrated tissues were re-immersed in fresh PVS2 and either cultured directly without plunging it in LN or plunged into LN for 16 h. When required, the frozen tissues were thawed at 40°C, unloaded in 1.2M sucrose and cultured on MS medium supplemented with 0.1 mg L\(^{-1}\) BAP, NAA and GA3 to assess their survival after four weeks incubation. All experiments were carried out with four replications.

**Results and discussion**

Highly significant effects of pre-growth were observed on survival of *C. madurensis* embryos in LN (Table 1) with 3 days being the optimum duration. With increasing duration in LN, survival of frozen embryos gradually decreased until 11 days when survival was as low as no pre-growth. Non-frozen embryos maintained high survival of above 85%, suggesting that the preculture, loading and desiccation in PVS2 were not injurious to the embryos.

**Table 1. Percentage survival of *C. madurensis* embryos after various durations of pre-growth; followed by vitrification in PVS2 in liquid nitrogen.**

<table>
<thead>
<tr>
<th>Cooling</th>
<th>0 day</th>
<th>3 days</th>
<th>5 days</th>
<th>7 days</th>
<th>9 days</th>
<th>11 days</th>
</tr>
</thead>
<tbody>
<tr>
<td>LN</td>
<td>90.00</td>
<td>87.50</td>
<td>92.50</td>
<td>92.50</td>
<td>85.00</td>
<td>92.50</td>
</tr>
<tr>
<td>+LN</td>
<td>15.00</td>
<td>72.00</td>
<td>62.50</td>
<td>47.50</td>
<td>30.00</td>
<td>12.50</td>
</tr>
</tbody>
</table>

Standard deviation of individual was less than 10%.

(LN = no freezing, +LN = freezing in LN)
Using 3 days pre-growth, the best sucrose concentration for subsequent pre-culture was found to be 0.3M at which a high (70%) survival was obtained with embryos subjected to vitrification in LN (Table 2). Higher or lower sucrose concentrations were less suitable as they resulted in much lower survival. High concentrations of sucrose above 0.5M were in fact found to be injurious as it resulted in decreased survival (>50%) even in the absence of exposure to LN.

Table 2. Percentage survival of *C. madurensis* embryos following pre-culture in various concentrations of sucrose followed by vitrification in PVS2 in liquid nitrogen.

<table>
<thead>
<tr>
<th>Cooling</th>
<th>Concentration of sucrose followed by vitrification in PVS2 in liquid nitrogen</th>
</tr>
</thead>
<tbody>
<tr>
<td>-LN</td>
<td></td>
</tr>
<tr>
<td>0.1M</td>
<td>97.50 95.00 85.00 82.50 50.00 40.00</td>
</tr>
<tr>
<td>+LN</td>
<td>32.50 70.00 52.50 40.00 27.50 15.00</td>
</tr>
</tbody>
</table>

*Standard deviation of individual mean was less than 10%.

Incorporation of glycerol into the pre-culture medium containing 0.3M sucrose was advantageous as it resulted in higher survival after vitrification in LN while optimum concentration of glycerol to be incorporated was 0.5M (Table 3). The sucrose-glycerol combination was also less injurious as high survival of over 92% was maintained in all non-frozen (-LN) embryos.

Table 3. Percentage survival of *C. madurensis* embryos after pre-culture in 0.3M sucrose incorporated with various concentrations of glycerol followed by vitrification in PVS2 in liquid nitrogen.

<table>
<thead>
<tr>
<th>Cooling</th>
<th>Concentration of incorporated glycerol followed by vitrification in PVS2 in liquid nitrogen</th>
</tr>
</thead>
<tbody>
<tr>
<td>-LN</td>
<td></td>
</tr>
<tr>
<td>0M</td>
<td>92.50 96.00 95.00 96.00 92.50</td>
</tr>
<tr>
<td>+LN</td>
<td>67.50 75.00 75.00 82.50 72.50</td>
</tr>
</tbody>
</table>

*Standard deviation of individual mean was less than 10%.

The sucrose-glycerol pre-culture medium was superior to other types of medium as a relatively high survival of 92.5% was obtained after 1 day pre-culture followed by vitrification in LN (Table 4). The highest survival obtained by other pre-culture media was only 52.5%. Shorter duration of pre-culture (4 h) was relatively ineffective for all media suggesting that there was insufficient penetration of the cryoprotectants into the embryo to effect protection.

Table 4. Percentage survival of *C. madurensis* embryos after exposure to various pre-culture media for 4 h and 1 day followed by vitrification in PVS2 in liquid nitrogen.

<table>
<thead>
<tr>
<th>Cryoprotectants</th>
<th>Pre-culture duration and LN exposure</th>
<th>4 h pre-culture</th>
<th>1 day pre-culture</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>-LN</td>
<td>+LN</td>
<td>-LN</td>
</tr>
<tr>
<td>0.3 M suc + 0.5M EG</td>
<td>92.5</td>
<td>10.0</td>
<td>90.0</td>
</tr>
<tr>
<td>0.3 M suc + 0.5M DMSO</td>
<td>75.0</td>
<td>25.0</td>
<td>60.0</td>
</tr>
<tr>
<td>0.2 M suc + 0.5M Gly</td>
<td>95.0</td>
<td>37.5</td>
<td>92.5</td>
</tr>
<tr>
<td>0.3 M suc + 0.5M Gly + 0.5M DMSO</td>
<td>82.5</td>
<td>32.5</td>
<td>77.5</td>
</tr>
</tbody>
</table>

*Standard deviation of individual mean was less than 10%.
The pre-growth influenced the survival of *C. madurensis* embryos in LN strongly (Table 1) with 3 days being the optimum duration. This duration was perhaps the optimum period for active cell division in the apices to be completed for cryopreservation. Pre-growth beyond 3 days may result initiation of germination as evident from the elongation of the root and shoot apices, which could pre-dispose the tissues to increased damage during vitrification.

During pre-culture, the best sucrose concentration for survival in LN was found to be 0.3M. This is similar to many reports in the literature using meristem tissues and apices. These include on tao (Thinh '97), pineapple (Gonzalez-Armol et al. 1998), yam (Kyesu '98), and *Cymbidium* (Thinh '99). However, the period of pre-culture was different for different species and could range from 16-48 hours. The results also suggested that pre-culture in sucrose concentration higher than 0.3M could be inhibitory as survival of *C. madurensis* embryos was reduced to low levels both before and after LN exposure.

Incorporation of glycerol into 0.3M sucrose during pre-culture of *C. madurensis* appears to be synergistic as in most cases there was increased survival both before and after vitrification. This was also reported by Matsumoto (1998) for wasabi and could be due to improved penetration of sucrose into the tissues in the presence of glycerol. Alternately, the presence of glycerol might provide additional cryoprotection to the tissues during vitrification.

Incorporation of 0.5M glycerol into 0.3M sucrose was superior to that of 0.5M BG and 0.5M DMSO, suggesting that both these chemicals were less synergistic to sucrose than was glycerol. Dimethyl sulfoxide and BG might also be more toxic to *C. madurensis* embryos than glycerol or they may be relatively less effective as cryoprotectants. The toxicity of DMSO was in fact confirmed by the decreased survival of the tissues when 0.5M DMSO was added to the relatively effective combination of 0.3M sucrose and 0.5M glycerol.

The results also established that pre-culture for 24 hours was more effective than that of 4 hours, suggesting that 4 hours pre-culture was insufficient for effective penetration of the cryoprotectants into the tissues.

Overall, the study confirmed that pre-growth and pre-culture are vital for successful vitrification of *C. madurensis* embryos for germplasm conservation. As the survival obtained (>82%) is above the minimum level of 80% recommended by IFPRI (PAO/IFPRI 1994; IBFGR 1965b), the present technique can be utilised for routine conservation of germplasm of *C. madurensis* using excised embryos.

**Cryopreservation of *C. medica* and *C. aurantifolia***

**Materials and methods**

In this study, an attempt was made to desiccate the seeds and embryonic axes of *C. medica* and *C. aurantifolia* as a means to long-term conservation of genetic resources. Freshly harvested fruits of *C. medica* and *C. aurantifolia* were collected from germplasm field in UKM and MARDI. The seeds of *C. medica* (60-90 seeds per fruit) and *C. aurantifolia* (15-25 seeds per fruit) were extracted.

**Seed and embryo moisture content (MC) determination**

Seed MC was determined initially for 20 seeds individually and also for 4 replicates of 20 seeds each, using the oven-dry method (103 °C for 24h). Each seed was cut into 3-5 pieces. Seed MC taking 4 replicates of 20 seeds each was also determined at different times during desiccation days. But MC of seeds without tests and embryos was determined for 10 seeds and embryos only. Embryo MC was determined initially for 10 embryos individually and also for 4 replicates of 10 embryos each, using the oven-dry method (103 °C for 24h).

**Seed survival test with and without tests**

Seed survival was tested soon after desiccation and cooling of seeds by planting them in sand pots in the green house. Four replicates of 20 seeds each were tested under the natural
temperature and light from the first of May 1999 to the end of October 1999 in UKM, Bangi. Observations were made twice a week during the first four weeks and later on once a week up to eight weeks. Seeds emerging from the growing media were considered germinated. Data were analyzed by SAS programme in Korea.

**Culture medium**
A basal MS medium was supplemented with 30 g L⁻¹ sucrose, 7g L⁻¹ Difco agar and 0.3 mg L⁻¹ BAP. The pH was adjusted to 5.7 before autoclaving.

**Pre-culture medium**
A basal MS medium supplemented with 7g L⁻¹ Difco agar and three different sucrose concentrations (0.2M, 0.5M, 0.7M) were employed. The pH was the same as that of culture medium.

**Size of excised embryos and establishment of cultures**
Seeds were surface sterilized with absolute ethanol for 2 minutes followed by 20% commercial Clorox with a few drops of Tween 20 for 30 min with shaking. The seeds were then rinsed with distilled water 3-5 times. Embryonic axes (1-2 mm) were excised aseptically from these seeds by removing the testa and separating the axes from the cotyledons with a scalpel blade. Axes were then cultured on the described pre-culture medium for 1 day. After each 1 h, 2 h and 3 h desiccation, the axes were cultured on the culture medium in a growth cabinet. The embryos cooled in LN for 24 h were cultured on the same media.

**Desiccation**
The seeds of *C. medica* and *C. aurantifolia* with testa (sample of 100 seeds) were desiccated with silica gel under laminar flow and on the lab bench under ambient conditions for different periods. *C. aurantifolia* seeds without testa (sample of 100 seeds) were desiccated under similar conditions (silica gel, laminar flow and lab bench). Desiccation periods with silica gel were 0, 1, 2, 4, 8 and 16 days, those in laminar flow 0, 1, 2 and 3 days, and those on the lab bench were 0, 2, 4, 6 and 8 days.

Excised embryonic axes were desiccated in batches of 40 for 0, 1, 2 and 3 hours in the sterile airflow of a laminar flow cabinet. At the end of each desiccation period, 20 seeds with testa, 10 seeds without testa and 10 axes, respectively, were used for determining MC using a low constant temperature oven method (103 °C for 24 h) and then calculated on a fresh weight basis. 20 seeds with testa, 10 seeds without testa and 10 axes, respectively, were germinated and cultured as controls for each desiccation period.

Another group of 20 seeds with testa, 10 seeds without testa and 10 embryonic axes, respectively, were wrapped in aluminium foil and immersed directly in LN for 24 hours. The seeds and axes were then removed from the cryo-tank, thawed in a water bath (40 °C) and tested for germination. This experiment was repeated four times. Seeds, which produced a morphologically normal seedlings, were considered viable. Embryonic axes were recorded as surviving when a fully developed seedling with shoot and root was obtained.

**Cooling and cryopreservation**
The seeds of *C. medica* and *C. aurantifolia* with testa and without testa were cooled to 5 °C, -18 °C and Liquid Nitrogen for 1 day. We tested to 5 °C and -18 °C for checking of survival rate, because 5 °C represents the temperature for short-term storage of germplasm, and -18 °C represents the temperature for long-term storage of germplasm, which are routinely employed in genebanks. The embryos of *C. medica* and *C. aurantifolia* were cooled at LN only for 1 h.
Thawing and plating
After cooling to -18 °C and LN for 1 day (only 1 h for embryos), the seeds with testa and without testa were rewarmed at 40 °C for 5 min. Then, the seeds and embryos were plated on MS medium with 0.3M for 1 day.

Protocol for cryopreservation of seed
The seeds were extracted from fruits, and desiccated. After desiccation, the seeds were cooled to different temperatures (5 °C, -18 °C and LN). Then, the seeds and embryos thawed at 40 °C for a few min were plated on MS medium with 0.3M sucrose for 1 day. After 1 day, the seeds and embryos were transferred on MS medium with 0.1M sucrose.

Results and discussion
Tables 1, 2, 3 and 4 already given. The percentage germination of C. medica seeds with testa following cryopreservation at various MCs are given in Tables 5-7. The germination of C. medica seeds with testa was not much affected when the whole seeds were desiccated from 47% to 2.88% moisture content. After four days of desiccation with silica gel, at MC below 6.17%, C. medica seeds with testa survived in the range of 20-40% after cryopreservation. A further increase in survival was obtained after cryopreservation. But the germination of those seeds with testa in laminar flow was 50-73% after cryopreservation at MC below 12.49%. The germination of those desiccated on lab bench was 76-95% after cryopreservation at MC below 8.81%.

Table 5. Effect of desiccation period on silica gel on the survival (%) of C. medica seeds with testa after cooling to different temperatures.

<table>
<thead>
<tr>
<th>Days</th>
<th>Moisture content (%)</th>
<th>Control</th>
<th>+5°C</th>
<th>-18°C</th>
<th>-196°C</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>46.96±4.6</td>
<td>95.00±5.0</td>
<td>96.66±2.9</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>1</td>
<td>18.36±1.8</td>
<td>91.66±2.9</td>
<td>90.00±5.0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>2</td>
<td>14.45±1.2</td>
<td>91.66±2.9</td>
<td>96.66±2.9</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>4</td>
<td>6.17±2.0</td>
<td>81.66±2.9</td>
<td>80.00±0.0</td>
<td>40.00±5.0</td>
<td>20.00±5.0</td>
</tr>
<tr>
<td>8</td>
<td>3.16±0.4</td>
<td>85.00±5.0</td>
<td>83.33±5.8</td>
<td>76.66±15.3</td>
<td>43.33±1.6</td>
</tr>
<tr>
<td>16</td>
<td>2.88±0.3</td>
<td>81.66±2.9</td>
<td>80.00±7.5</td>
<td>33.33±5.8</td>
<td>28.33±16.4</td>
</tr>
</tbody>
</table>

Table 6. Effect of desiccation period on laminar flow on the survival (%) of C. medica seeds with testa after cooling to different temperatures.

<table>
<thead>
<tr>
<th>Days</th>
<th>Moisture content (%)</th>
<th>Control</th>
<th>+5°C</th>
<th>-18°C</th>
<th>-196°C</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>46.32±1.4</td>
<td>86.66±2.9</td>
<td>83.33±5.8</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>1</td>
<td>18.11±2.3</td>
<td>86.66±5.8</td>
<td>93.33±5.8</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>2</td>
<td>12.49±0.7</td>
<td>85.00±5.0</td>
<td>85.00±5.0</td>
<td>66.66±10.4</td>
<td>50.00±10.0</td>
</tr>
<tr>
<td>3</td>
<td>9.36±1.1</td>
<td>85.00±5.0</td>
<td>88.33±2.9</td>
<td>73.33±12.6</td>
<td>63.00±5.0</td>
</tr>
</tbody>
</table>

The percentage germination of C. australitolia seeds with testa following cryopreservation at various MCs are given in Tables 8-10. The germination rate of C. australitolia seeds with testa was not affected when the whole seeds were desiccated from 53.12% to 15.51% moisture content. After two days of desiccation in silica gel, at MC below 15.51%, C. australitolia seeds with testa two days after desiccation survived it; the range of 15-25% after cryopreservation.
But survival of seeds desiccated under the laminar flow for two days was 33-41% after cryopreservation (Table 9) and that of seeds desiccated on the lab bench for two days was 20-44% after cryopreservation (Table 10).

Table 7. Effect of desiccation period on lab bench on the survival (%) of *C. medica* seeds with testa after cooling to different temperatures.

<table>
<thead>
<tr>
<th>Days</th>
<th>Moisture content (%)</th>
<th>Control</th>
<th>+5°C</th>
<th>-18°C</th>
<th>-196°C</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>46.7±4.0</td>
<td>53.3±2.9</td>
<td>91.3±2.9</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>2</td>
<td>7.7±0.9</td>
<td>9.0±0.8</td>
<td>93.3±2.9</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>4</td>
<td>8.8±0.9</td>
<td>83.3±2.9</td>
<td>86.6±5.5</td>
<td>86.6±2.9</td>
<td>81.6±2.9</td>
</tr>
<tr>
<td>6</td>
<td>7.7±0.2</td>
<td>85.0±5.9</td>
<td>90.0±6.0</td>
<td>95.0±5.0</td>
<td>81.6±2.9</td>
</tr>
<tr>
<td>8</td>
<td>6.5±1.1</td>
<td>83.3±5.8</td>
<td>91.6±5.0</td>
<td>86.5±1.0</td>
<td>78.3±2.9</td>
</tr>
</tbody>
</table>

Table 8. Effect of desiccation period on silica gel on the survival (%) of *C. aurantifolia* seeds with testa after cooling to different temperatures.

<table>
<thead>
<tr>
<th>Days</th>
<th>Moisture content (%)</th>
<th>Control</th>
<th>+5°C</th>
<th>-18°C</th>
<th>-196°C</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>53.0±2.6</td>
<td>82.5±2.9</td>
<td>87.5±5.0</td>
<td>6</td>
<td>0</td>
</tr>
<tr>
<td>2</td>
<td>29.8±2.6</td>
<td>90.0±4.1</td>
<td>92.5±2.9</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>4</td>
<td>15.1±2.4</td>
<td>65.0±4.1</td>
<td>55.6±12.9</td>
<td>25.0±10.8</td>
<td>16.5±8.5</td>
</tr>
<tr>
<td>8</td>
<td>3.8±0.4</td>
<td>31.5±8.5</td>
<td>32.5±6.5</td>
<td>25.0±5.1</td>
<td>18.7±9.5</td>
</tr>
<tr>
<td>8</td>
<td>3.9±0.9</td>
<td>21.5±2.5</td>
<td>22.5±2.9</td>
<td>21.5±9.3</td>
<td>15.0±14.1</td>
</tr>
</tbody>
</table>

Table 9. Effect of desiccation period on laminar flow on the survival (%) of *C. aurantifolia* seeds with testa after cooling to different temperatures.

<table>
<thead>
<tr>
<th>Days</th>
<th>Moisture content (%)</th>
<th>Control</th>
<th>+5°C</th>
<th>-18°C</th>
<th>-196°C</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>53.7±7.1</td>
<td>88.7±7.5</td>
<td>86.0±7.6</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>2</td>
<td>28.7±2.8</td>
<td>87.5±2.9</td>
<td>87.0±6.5</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>4</td>
<td>15.7±2.8</td>
<td>73.7±8.5</td>
<td>72.5±7.8</td>
<td>41.2±6.3</td>
<td>36.2±5.3</td>
</tr>
<tr>
<td>3</td>
<td>7.8±0.4</td>
<td>45.0±4.1</td>
<td>48.7±6.2</td>
<td>36.2±7.5</td>
<td>32.7±9.6</td>
</tr>
</tbody>
</table>

Table 10. Effect of desiccation period on lab bench on the survival (%) of *C. aurantifolia* seeds with testa after cooling to different temperatures.

<table>
<thead>
<tr>
<th>Days</th>
<th>Moisture content (%)</th>
<th>Control</th>
<th>+5°C</th>
<th>-18°C</th>
<th>-196°C</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>53.9±5.5</td>
<td>91.2±2.5</td>
<td>91.2±2.5</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>1</td>
<td>16.7±3.8</td>
<td>81.2±15.5</td>
<td>61.2±14.4</td>
<td>22.5±11.9</td>
<td>20.0±14.7</td>
</tr>
<tr>
<td>2</td>
<td>8.2±0.4</td>
<td>60.0±7.1</td>
<td>48.7±8.8</td>
<td>43.7±12.5</td>
<td>40.6±11.1</td>
</tr>
<tr>
<td>4</td>
<td>7.3±1.0</td>
<td>53.7±16.0</td>
<td>46.2±11.1</td>
<td>40.0±10.8</td>
<td>41.2±11.8</td>
</tr>
<tr>
<td>8</td>
<td>0.1±1.1</td>
<td>25.0±9.1</td>
<td>31.2±6.3</td>
<td>25.0±10.8</td>
<td>22.7±10.4</td>
</tr>
</tbody>
</table>
The percentage germination of *C. aurantiifolia* seeds without tests following cryopreservation at various moisture contents are given in Tables 11-13. The germination of seeds without tests was not affected when seeds were desiccated from 43.3% to 21.7% moisture content. After desiccation for one day with silica gel, at MC below 21.7%, survival of *C. aurantiifolia* seeds without tests was between 33-72% after cryopreservation (Table 12). But the germination after 2 days of desiccation under the laminar flow and on the lab bench, at MC below 7%, was 73-88% after cryopreservation (Table 13).

The percentage germination of *C. aurantiifolia* embryos following cryopreservation at various moisture contents after pre-culture on different media is shown in Table 14. The germination of embryos after cooling (-196 °C) was 70-100% after 1 h desiccation. The pre-cultured embryonic axes survived in the range of 70-80% after cryopreservation following pre-culture with 0.7M sucrose.

**Table 11. Effect of desiccation period on silica gel on the survival (%) of *C. aurantiifolia* seeds after cooling to different temperatures.**

<table>
<thead>
<tr>
<th>Days</th>
<th>Moisture content (%)</th>
<th>Survival (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Control +5°C -18°C -196°C</td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>43.3±6.7</td>
<td>92.5±5.0</td>
</tr>
<tr>
<td>1</td>
<td>21.7±5.0</td>
<td>87.5±9.6</td>
</tr>
<tr>
<td>2</td>
<td>7.6±1.8</td>
<td>85.0±5.8</td>
</tr>
<tr>
<td>4</td>
<td>3.3±0.3</td>
<td>72.5±5.0</td>
</tr>
<tr>
<td>8</td>
<td>2.3±0.3</td>
<td>57.5±5.0</td>
</tr>
</tbody>
</table>

**Table 12. Effect of desiccation period on laminar flow on the survival (%) of *C. aurantiifolia* seeds after cooling to different temperatures.**

<table>
<thead>
<tr>
<th>Days</th>
<th>Moisture content (%)</th>
<th>Survival (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Control +5°C -18°C -196°C</td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>41.5±3.5</td>
<td>92.5±9.6</td>
</tr>
<tr>
<td>1</td>
<td>15.5±3.1</td>
<td>90.0±8.2</td>
</tr>
<tr>
<td>2</td>
<td>7.1±1.0</td>
<td>87.5±5.0</td>
</tr>
<tr>
<td>3</td>
<td>6.4±1.3</td>
<td>87.5±5.0</td>
</tr>
</tbody>
</table>

**Table 13. Effect of desiccation period on lab bench on the survival (%) of *C. aurantiifolia* seeds after cooling to different temperatures.**

<table>
<thead>
<tr>
<th>Days</th>
<th>Moisture content (%)</th>
<th>Survival (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Control +5°C -18°C -196°C</td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>41.1±3.7</td>
<td>97.5±5.0</td>
</tr>
<tr>
<td>2</td>
<td>7.2±0.5</td>
<td>85.0±5.0</td>
</tr>
<tr>
<td>4</td>
<td>5.3±1.1</td>
<td>82.5±5.0</td>
</tr>
<tr>
<td>6</td>
<td>5.0±2.3</td>
<td>87.5±5.0</td>
</tr>
<tr>
<td>8</td>
<td>4.4±2.1</td>
<td>82.5±5.0</td>
</tr>
</tbody>
</table>
### Table 14. Effect of pre-culture media and desiccation period on laminar flow on the survival (%) of *C. surintfolia* embryos after cooling.

<table>
<thead>
<tr>
<th>Pre-culture media (sucrose)</th>
<th>Desiccation period (h)</th>
<th>Moisture content (%)</th>
<th>Survival (%) Before LN</th>
<th>Survival (%) After LN</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>MS+0.1M</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>33.0±2.4</td>
<td>97.50±5.0</td>
<td>7.50±6.6</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>14.4±2.6</td>
<td>90.00±5.0</td>
<td>90.00±5.2</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>7.2±1.2</td>
<td>92.2±6.0</td>
<td>92.5±5.0</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>5.3±2.6</td>
<td>87.5±5.6</td>
<td>82.0±5.6</td>
<td></td>
</tr>
<tr>
<td><strong>MS+0.3M</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>34.9±4.1</td>
<td>97.50±5.0</td>
<td>25.0±17.3</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>14.5±2.1</td>
<td>90.00±8.2</td>
<td>85.0±5.6</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>8.2±1.4</td>
<td>86.0±5.8</td>
<td>80.0±5.0</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>6.6±1.5</td>
<td>85.5±5.8</td>
<td>82.5±5.0</td>
<td></td>
</tr>
<tr>
<td><strong>MS+0.5M</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>34.3±2.0</td>
<td>97.5±5.0</td>
<td>35.0±23.8</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>17.3±1.9</td>
<td>90.0±8.2</td>
<td>87.5±5.0</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>7.1±0.6</td>
<td>82.5±5.0</td>
<td>80.0±5.0</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>5.5±1.1</td>
<td>80.0±8.2</td>
<td>75.0±5.8</td>
<td></td>
</tr>
<tr>
<td><strong>MS+0.7M</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>27.6±4.8</td>
<td>95.0±10.0</td>
<td>77.5±5.0</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>13.7±2.1</td>
<td>90.0±8.2</td>
<td>82.5±15.0</td>
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</tr>
<tr>
<td>2</td>
<td>4.79±2.0</td>
<td>92.5±9.6</td>
<td>82.5±5.0</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>3.86±1.4</td>
<td>90.0±8.2</td>
<td>77.5±5.0</td>
<td></td>
</tr>
</tbody>
</table>

The percentage germination of *C. medica* embryos following cryopreservation at various moisture contents after pre-culture on different media is shown in Table 15. The germination of the embryos after 90% after cryopreservation after pre-culture with 0.3M sucrose and 2-3 h desiccation.

### Table 15. Effect of pre-culture media and desiccation period on laminar flow on the survival (%) of *C. medica* embryos after cooling.

<table>
<thead>
<tr>
<th>Pre-culture media (sucrose)</th>
<th>Desiccation period (h)</th>
<th>Moisture content (%)</th>
<th>Survival (%) Before LN</th>
<th>Survival (%) After LN</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>MS+0.1M</strong></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>0</td>
<td>30.3±4.0</td>
<td>87.8±6.9</td>
<td>90.0±0.0</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>10.3±1.7</td>
<td>95.0±6.9</td>
<td>91.2±2.5</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>5.8±1.8</td>
<td>100.0±3.0</td>
<td>91.4±2.5</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>6.0±0.5</td>
<td>90.0±4.1</td>
<td>63.7±2.5</td>
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</tr>
<tr>
<td><strong>MS+0.3M</strong></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>33.3±3.9</td>
<td>100.0±0.0</td>
<td>90.0±0.0</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>73.0±4.1</td>
<td>90.0±4.1</td>
<td>90.0±8.2</td>
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</tr>
<tr>
<td>2</td>
<td>6.6±0.8</td>
<td>90.0±8.2</td>
<td>39.0±8.2</td>
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</tr>
<tr>
<td>3</td>
<td>5.5±0.6</td>
<td>90.0±8.2</td>
<td>39.0±8.2</td>
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<tr>
<td><strong>MS+0.5M</strong></td>
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<tr>
<td>0</td>
<td>28.5±7.9</td>
<td>100.0±3.0</td>
<td>90.0±0.0</td>
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</tr>
<tr>
<td>1</td>
<td>16.6±1.2</td>
<td>71.4±2.5</td>
<td>50.0±4.1</td>
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</tr>
<tr>
<td>2</td>
<td>10.3±1.7</td>
<td>70.0±4.1</td>
<td>70.0±8.2</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>6.2±0.6</td>
<td>50.0±8.2</td>
<td>50.0±8.2</td>
<td></td>
</tr>
<tr>
<td><strong>MS+0.7M</strong></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>30.3±2.2</td>
<td>100.0±0.0</td>
<td>20.0±11.6</td>
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<tr>
<td>1</td>
<td>11.5±0.5</td>
<td>80.0±8.2</td>
<td>50.0±11.6</td>
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<td>2</td>
<td>8.0±0.4</td>
<td>90.0±8.2</td>
<td>40.0±8.2</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>4.0±0.6</td>
<td>60.0±8.2</td>
<td>90.0±14.1</td>
<td></td>
</tr>
</tbody>
</table>
It has been reported that lemon and sour orange seeds showed high survival rates after desiccation and cooling in liquid nitrogen, but Mexican lime, sweet orange, common mandarin and Troyer citrange seeds showed medium survival rates after cryopreservation (King et al., 1980; Mumford et al., 1979; Normah et al., 1995; Duran-Vila 1997). They also reported that C. hystrix and P. trifoliata seeds were very sensitive for desiccation and cooling in liquid nitrogen. The results of cryopreservation of embryonic axes reported by Radhanani and Chandel (1992) and Normah et al. (1995) showed that embryonic axes of C. hystrix, P. trifoliata and Mexican lime were highly tolerant to desiccation and cooling in LN. The embryonic axes of C. hallii (Duran-Vila 1997) only were medium tolerant after desiccation and cooling in LN. Also, many scientists have reported that calusus and cell suspensions of sweet orange, common mandarin, mandarin hybrids, sour orange, lemon, Mexican lime, F. hindsii, P. brasiliensis, Glycosmis pentaphylla and Microcirus papiusa (Duran-Vila 1997) showed high survival rates after cryopreservation in LN.

These reports confirmed that the tolerance of embryonic axes after cooling in LN was higher than seeds of many Citrus spp. Our study also confirms that the high survival rate of embryonic axes in C. medica and C. sinensis is higher than that of seeds with seed coat and without seed coat after cooling in LN. These results can be used for long-term conservation of citrus germplasm.

References
FAO network activities on tropical fruit species

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Introduction
Official concern regarding the need for conservation of plant genetic resources started only in the 1930s, and international efforts through Food and Agriculture Organization of the United Nations (FAO) to promote conservation, exchange and utilization are even more recent. However, from the first FAO Newsletter on plant genetic resources, published in 1957, for the establishment of the FAO Global System on the Conservation and Sustainable Use of Plant Genetic Resources for Food and Agriculture (PGRFA), FAO, alone or in cooperation with other international agencies and institutions has provided a unique forum to develop the international strategy to stop the accelerated rate of loss of genetic diversity.

During the Fourth International Technical Conference that took place in Leipzig, Germany in 1996, 150 countries adopted a rolling Global Plan of Action (GPA) for the conservation and sustainable utilization of PGRFA with programmes and activities aimed at filling gaps, overcoming constraints and facing emergency situations, which were detected in the first report on the State of the World’s Plant Genetic Resources. The Leipzig Conference decided that the GPA should be implemented with the participation of all stakeholders.

The GPA is based on the assumption that countries are fundamentally interdependent with respect to plant genetic resources for food and agriculture and that substantial international cooperation would be necessary to meet the aims of the Plan effectively and efficiently.

Strong linkages need to be established with national and regional crop networks and with the users of plant genetic resources for food and agriculture (breeders and farmers) in order to direct and prioritize the entire conservation process.

By establishing links between those involved in the conservation, management, development and utilization of plant genetic resources for food and agriculture, networks can promote the exchange of materials on the basis of mutually agreed terms and enhance the utilization of germplasm. In addition, they can also serve to help set priorities for action, develop policy, and provide means whereby crop-specific and regional views can be conveyed to various organizations and institutions.

FAO's initiatives on tropical fruit species
The establishment of networks for the conservation and utilization of tropical fruits is considered as one of the priorities in FAO's strategy of conservation of plant genetic resources for food and agriculture. FAO established in 1997 a Global Network on Tropical and Subtropical Fruit Germplasm Conservation and Utilization, REMUFRUT (the Spanish acronym for Red Mundial de Frutales Tropicales). Thirteen countries are currently members of this network, including Malaysia and Vietnam. The network was established to coordinate activities on the identification of genetic variability, evaluation and characterization of tropical fruit genetic resources, conservation activities, documentation and information. It has recently brought together an inventory of more than 60 experts worldwide working on tropical fruits, and is still gathering information about germplasm ex situ collections worldwide.

At the regional level, RELAFRUT, the Latin American Network on Tropical Fruits, was established in Havana, Cuba in 1998. It concentrates on the activities on avocado (Persea americana M.), mango (Mangifera indica L.), pineapple (Ananas concinosus M.), papaya (Carica papaya L.), guava (Psidium guajava L.), passiflora, native fruits of the American continent and also exotic fruits. This network coordinates the overall activities of its several subnetworks which involve activities on genetic resources conservation, fruit production, phytosanitary
FAO NETWORK ACTIVITIES ON TROPICAL FRUIT SPECIES

protection, post-harvest fruit trade and transfer of technology. Eight Latin American countries, namely, Brazil, Colombia, Costa Rica, Cuba, Dominican Republic, Guatemala, Honduras, Martinique, Mexico, Panama, Peru and Venezuela, are members of the network.

In the Mediterranean region, FAO established the Mediterranean Selected Fruit Inter-country Network (MISFIN) in 1993. Eight Mediterranean countries, namely, Cyprus, Greece, Italy, Portugal, Spain, Syria, Tunisia, and Turkey, are members of this network. The scope of this network is wider than tropical fruits as there are activities to analyse the status of temperate fruits in the region. The network started activities to analyse the status of tropical fruits collections in the region and has promoted joint programmes to collect technical information on the performance and potential of genotypes, particularly under varying climatic conditions. The network has been particularly active in providing capacity building to its members on specific aspects of ex situ conservation of fruit germplasm.

Recently, FAO has supported the establishment of the West African Fruits Network, WAFNET, in which seven West African countries, namely, Burkina Faso, Cameroon, Cote d'Ivoire, Ghana, Mali, Nigeria and Senegal collaborate. The scope of the network is the conservation and use of tropical and subtropical fruit trees in West African countries. However, the lack of funding resources has not allowed for the development of specific activities as agreed by its participants.

FAO has established citrus germplasm networks for the Mediterranean region (MECINET), the Latin America region (IACNET) and at a global level Global Citrus Germplasm Network (GGCN). The Mediterranean Citrus Network (MECINET) was established in 1993 by fourteen countries as a joint effort to coordinate activities on citrus production and improvement in the Mediterranean region. Currently, seventeen countries are members of this network. It has recently published a report on the status of ex situ citrus genetic resources in American countries.

A project proposal is being developed with the objective to enhance the citrus production by sustainable utilization of healthy citrus genetic resources in order to meet the industry needs, to protect the environment and to promote the free exchange of these resources among Mediterranean countries. The draft proposal also includes the following important aspects:

- Harmonization of protocols for germplasm characterization, pathogens detection and sanitation and conservation;
- Introduction of new and reliable low cost technologies, easy to be applied;
- Establishment and the harmonization of the certification programmes, and
- Capacity building for the upgrading of technical skills.

This project proposal is being developed jointly with The Mediterranean Network on Citrus Certification (MNCC) which is a subnetwork of the Plant Protection and Quarantine Network (PPQ) promoted by the Centre International de Hautes Etudes Agronomiques méditerranéennes (CHEADAM), coordinated by the Mediterranean Agronomic Institute of Bari, Italy (IAMB).

MECINET is strongly linked with the Inter-American Citrus Network, IACNET (RIAC is its acronym in Spanish). This network that covers most citrus producing countries in Latin America and also includes the United States, is currently developing a project with the objective to check the impact of diseases threatening the sustainability of citrus production in the region. It includes three main elements: a) the establishment or strengthening of national certification programmes, b) the establishment of programmes for sanitization and production of basic propagation material, and c) programmes for diagnosis, surveing and integrated pest management. The project has received funding from the Common Fund for Commodities, to cover these countries in an initial phase, Guatemala, Mexico and Cuba and a formulation mission took place at the end of last year to refine its main elements.

The Global Citrus Germplasm Network was established in 1997 in Acireale, Sicily, Italy, with the objective to promote cooperative activities on citrus genetic resources at global level, it is closely linked with MECINET and IACNET. It held its last meeting in Orlando, in December 2000. Among the several activities agreed, participants requested for the FAO support
for the establishment of a citrus network in the Asia-Pacific region, and it was agreed to start contacting relevant authorities to explore real needs and opportunities for cooperative action.

Additionally, FAO has been supporting the Underutilized Tropical Fruit Trees in Asia Network (UFTANET) which was established in 1994 with the aim of promoting the conservation, utilization and improvement of fruit production in Asia. Twelve national programmes, International Centre for Underutilized Crops (ICUC), FAO and International Plant Genetic Resources Institute (IPGRI) are collaborating in this network.

Other subregional and crop-specific networks in Asia-Pacific region

The four subregional plant genetic resources networks for Southeast Asia, South Asia, East Asia and the Pacific are at various stages of development. The most developed is the Regional Committee in Southeast Asia on Plant Genetic Resources (RECSEA-PGR), formally established in 1993. Its members are: Indonesia, Malaysia, Papua New Guinea, the Philippines, Thailand and Vietnam. RECSEA-PGR has identified the establishment of a subregional network on information system, and on-farm conservation as its priority areas, for which greater financial support is needed. Other networks in Southeast Asia include the following:

- The Plant Resources of South East Asia (PROSEA) in which Indonesia, Malaysia, Papua New Guinea, the Philippines, Thailand, Vietnam and the Netherlands collaborate in order to collate and document the wealth of existing information on updated 22-volume handbook on the plant resources of Southeast Asia, and to build a database of plant publications;
- The Southeast Asian Programme for Potato Research and Development (SAPPRAD) which coordinates training, crop improvement and varietal testing for potato and sweet potato; and
- The User’s Perspective with Agricultural Research and Development (UFWARD) programme which aims to collect the wide range of sweet potato germplasm and associated indigenous knowledge in the subregion.

The National Coordinators of South Asian countries met in 1990, 1992, 1995, 1998 and 2000 to stimulate collaboration in the sub-region. A plant genetic resources network for East Asia is now formally established. The formation of plant genetic resources network for East Asia was strongly recommended by the subregion’s National Coordinators at their meeting in 1994. A plant genetic resources network for the Pacific sub-region is also being initiated with support from IPGRI, the South Pacific Regional Environmental Programme, the Secretariat of the Pacific Community, and the University of the South Pacific. A number of plant genetic resources activities are already being carried out within other collaborative programmes. Examples are:

- The Pacific Agricultural Research Programme, which includes the establishment of a collection of sweet potato germplasm and the selection, evaluation and distribution of superior genotypes to member countries;
- The South Pacific Regional Environment Programme (SPREP) which coordinates research on conservation and the sustainable use of biodiversity, especially forest species; and
- Secretariat of the Pacific Community (SFC) which, through its Agriculture Division, has been active in collaborating with member countries in the collection and conservation of root crop genetic resources.

Other countries in the subregion have collaborative programmes with the International Agriculture Research Centres (IARCs) as well as the Australian Centre for International Agricultural Research (ACIAR).

The nine plant genetic resource centres that support national programmes and contribute to international plant improvement programmes are linked in a network through the Australian and New Zealand Network of Plant Genetic Resources Centres (ANZNPGR). This has a coordinating function for promoting linkage among the centres.
The subregional meetings in the region recommended stronger collaboration between subregions and the establishment of regional network within which the subregional network would operate.

Also at the regional level, FAO has established the Asia and Pacific Seed Association (APSA), which has 150 private and public sector seed programme members. Finally, FAO is in the process of establishing a sub-network on mushroom genetic resources for the Asia-Pacific region in the framework of the FAO Global Network on Mushrooms.

Collaboration among stakeholders
A recent survey made by IPGRI-APO to assess the gaps and opportunities in the existing networks showed interesting results. It was pointed out that networks need to enhance their sustainability through greater resource generation; they need an effective monitoring and evaluation system, for which effective mechanisms need to be developed for exchanging information, technology and germplasm materials on mutually agreed terms and conditions.

The results of this survey triggered discussions among some of the stakeholders in the region, that is FAO, APAARI and IPGRI, and in a follow-up meeting discussed the possibility of initiating a collaborative assessment, through a case study approach, of some plant genetic resources networks in the region.

This is particularly relevant in the field of tropical fruits, including citrus. In this context, it is relevant to raise the issue to avoid unnecessary duplication of efforts of international agencies.

References
Activities of TFNet in Asia Pacific region and prospects for collaboration with IPGRI

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Introduction
The establishment of the International Tropical Fruits Network (TFNet) as an independent and self-financing international organization to promote the global development of tropical fruits is the outcome of a series of intergovernmental consultations and meetings by FAO member countries on tropical fruits over a period of five years, starting from 1998. The first General Assembly of TFNet held in Kuala Lumpur, Malaysia from July 27-29, 2000 endorsed TFNet’s constitution and rules of procedure, membership structure and fees as well as programme of work and budget for three years and set the stage for the implementation of projects to encourage the production and export of tropical fruits.

Why tropical fruits?
The tropical fruits sector is yet to be fully explored and developed and, therefore, provides many opportunities and challenges to both producing and consuming countries. The current production of tropical fruits mainly serves the domestic market. According to FAO, the export in 1999 was limited to slightly more than 3% of the world production of fruits (excluding banana and citrus) of 57.5 million tonnes. The per capita consumption of fruits in producing countries is still relatively low and with increasing population the demand should increase.

Secondly, there is increasing attention given by governments to diversify agriculture and to optimise land use by intercropping fruits with other traditional primary commodities such as rubber, oil palm and coconut. With falling market prices of these commodities, millions of hectares of land under these crops will be made available for fruit growing. In addition, with the introduction of new varieties and technologies, the geographical distribution of tropical and subtropical fruits has expanded beyond their traditional agro-ecological zones.

Thirdly, the potential contribution of tropical fruits to medicinal and nutraceutical products are yet to be realised. With growing interest in research and development, to evaluate and identify phytochemical content of tropical fruits, the economic value of tropical fruits especially the underutilized species will be increased. The successful marketing of the Tahitian Noni Juice (Meloidea citrifolia) in Southeast Asia with an estimated sales of US$ 134 millions in 1999 and a growth rate potential of 10% per annum is very good example of the potential contribution of tropical fruit species.

Given this optimism on the economic potential of the tropical fruits sector and its important contribution to addressing food security and human health issues in the new millennium, an agenda for tropical fruits research and development and human resource development needs to be developed. In this regard, to participate in this global yet equally focused set of projects, TFNet seeks strategic alliance and smart partnership with international and regional organizations to implement integrated projects at the grassroots levels so as to ensure adequate, safe and affordable fruits to the consumers.

Areas of collaboration
The first general assembly endorsed four programme areas and eight projects (Table 1) based on the recommendations by earlier fora on tropical fruits related to the production, processing, marketing and international trade. One of the top priorities of TFNet is to develop a comprehensive and integrated information system on tropical fruits that will cater to the needs
Table 1. Programmes and projects of TFNet

<table>
<thead>
<tr>
<th>Programme</th>
<th>Project</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>1</td>
<td>Improving the international information system on tropical fruits. Establishing an information system for tropical fruits.</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>Supporting research and development in production, processing and marketing of tropical fruits. Alternative to methyl bromide treatment for tropical fruit infestation.</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>Disease resistance of tropical fruits through genetic engineering.</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>Extension of the shelf-life of selected tropical fruits through genetic engineering.</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>Technology transfer process of in-field handling and transportation systems for tropical fruits.</td>
</tr>
<tr>
<td>III</td>
<td>6</td>
<td>Tropical fruits market development and trade promotion. Strengthening capacity for WTO and other trade negotiations on agricultural trade liberalization with special reference to market distortions, sanitary and phytosanitary requirements and technical barriers to trade of tropical fruits.</td>
</tr>
<tr>
<td></td>
<td>7</td>
<td>International tropical fruit exposition.</td>
</tr>
<tr>
<td>IV</td>
<td>8</td>
<td>Strengthening financing and investment flows for tropical fruits. Study on financing and credit in the tropical fruits industry with special reference to the export sub-sector.</td>
</tr>
</tbody>
</table>

of its members and clients. Another area of focus is to support research and technology transfer activities so as to increase production and productivity as well as adding value to tropical fruits.

TFNet would like to associate itself to capacity building in developing countries, especially in areas of international trade and compliance to international agreements related to the export of tropical fruits.

Conclusion
Advances in information and communication technology (ICT) have affected the organizational behaviour and work culture, at the national, regional and international levels. Accessibility and sharing of information and ideas are made easier through networking and collaborative projects. The synergistic value of such relationship cannot be underestimated and cost-saving efficiency has been achieved in this way through many international undertakings in the agriculture and food sector.
UTFANET/ICUC collaboration with IPGRI for tropical fruit trees project

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Introduction

Asia is the centre of diversity for tropical fruits that provide vast potential benefits to the local communities. Fruits are very important for small holders in the Asia-Pacific region as these can provide excellent nutritional and economic benefits both to humans and animals, as well as can improve the environment. In Asia alone, local communities have been growing/domesticating a wide array of tropical fruits either in marginal lands or in their own homesteads for livelihood sustenance. Non-food products such as timber, fuel, fodder, medicinal, and other industrial products can be derived by processing of the fruit crops (Arons., 1998).

Local fruits grown by small holders or collected from the wild areas provide valuable source of additional income. Major constraints confronting this condition include low yields owing to poor planting materials, non-availability of recommended propagation and production packages, and post-harvest losses. The lack of government support from the region likewise contributes to very poor market structure that is tantamount to substantial crop wastage.

In the recent years when crop diversification has been given emphasis by many less developed and developing nations, fruit crops have played a vital role, particularly in terms of their economic and environmental importance.

As an offshoot of the workshop held in Dhaka, Bangladesh in July 1992, the Commonwealth Science Council (CSC), U.K. and the International Centre for Underutilized Crops (ICUC) Southampton, U.K., agreed that both Commonwealth and non-Commonwealth countries should spearhead and get involved in a regional research and development fruit network in Asia. Then, ICUC and the International Plant Genetic Resources Institute (IPGRI) collaborated on assessing the respective Asian countries' priority fruit crop species potential for crop diversification in the region, as well as those that can provide additional income from traditional horticultural gardens and small plantations. Environmental concerns and local and international market demands were also considered. The proposed fruit network in the Asia-Pacific was aimed at facilitating a common research and development programme while utilizing and maintaining the available fruit/crop database/information already developed by ICUC. All the participating member countries, namely Bangladesh, India, Indonesia, Nepal, Pakistan, Sri Lanka, Thailand, and Vietnam, were expected to play active role in germplasm and information exchange and in determining markets for their produce. With this in view, the Underutilized Tropical Fruits in Asia Network (UTFANET) which is governed by a Steering Committee (SC) and whose membership emanates from member countries, was formed in 1995. The financial support for UTFANET comes from various sources such as Asia-Pacific Association for Agricultural Research Institutions (APARI), Commonwealth Science Council (CSC), Department for International Development (DFID), UK, Food and Agriculture Organization of the United Nations (FAO), the International Plant Genetic Resources Institute (IPGRI), National Lottery Charities Board (NLCB), UK. and the participating member countries.

ICUC-UTFANET

The International Centre for Underutilized Crops (ICUC) is a coordinating centre for networks of member countries from the Asia-Pacific, Western, Eastern, and Southern Africa, the Caribbean and Latin America. ICUC's mission is to: "Contribute to food security, improved nutrition and human well-being through sustainable and increased economic production of food and industrial
raw materials which can be achieved through the development and utilization of untapped biological diversity of underutilized plant species."

UTFANET is a programme of ICUC, and it was endorsed by the Asia Pacific Association of Agricultural Research Institutions (APAARI). It is operationalized by various stakeholders that presently constitute the donor institutions and the participating member countries as implementers/collaborators in Asia. These stakeholders include the respective countries' governments and private entities/individuals such the R&D institutions, extension agencies, the small holders (fruit growers and nursery operators), farmers, traders, food processors and the policy-makers. UTFANET's mission is "Improving the economic and social development in the region through increased production and utilization of underutilized tropical fruits which can also be achieved through enhanced R&D activities". The activities focus on the following:

- Conservation and sustainable use of genetic resources (UTFANET collaborates with IPGRI on this aspect taking care of avoiding duplication);
- Improvement in propagation, production, and management;
- Assemblage, dissemination, and exchange of relevant information; and
- Strengthening local, regional and international capabilities through appropriate training activities.

Objectives

The seven specific objectives of UTFANET are:

- To develop an effective network which facilitates collaborative partnerships among countries in the region for biodiversity conservation, efficient use of genetic resources, expertise, and technologies;
- To assemble, collate and distribute relevant information on selected tropical fruit species for dissemination to scientists, fruit growers, and policy makers;
- To improve propagation, production and management practices of tropical fruits;
- To reduce post-harvest losses and enhance quality through improved post-production technologies;
- To facilitate rural development through efficient farming system research and extension services and improved nutrition, particularly for women and children;
- To strengthen the capabilities of local and national institutions through appropriate training; and
- To assist the respective national governments in developing appropriate policies for promoting tropical fruits.

Activities

At the first SC meeting of UTFANET, priority species for research and development work were determined. These included jackfruit, pummelo/mandarin, mangosteen, ber, guava, line, sourp, embik, salak, carambola and durian. Later on, for the first three initial years of the network, in order to have some focus on the development of identified priority species, the list was narrowed down to three species, namely, jackfruit, mangosteen, and pummelo/mandarin. Likewise, during the last SC meeting of UTFANET, R&D work on product development and marketing for the three identified priority species (jackfruit, pummelo/mandarin, mangosteen) and also guava, annon and durian was approved and a proposal on this was developed and subsequently submitted to a donor organization for funding.

The major activities under UTFANET are given below:

- Collecting information (including market information) through farmers' participatory survey
- Exploration, collecting, conservation, characterization, evaluation, documentation, exchange and safe movement of germplasm
- Developing appropriate propagation and production methods, supply of quality planting materials, testing of promising rootstocks and cultivars
- Developing fruit-based cropping systems for different agro-ecological and socio-economic settings
- Improving post-production handling, processing and transportation
- Promoting collaborative research on agreed topics with individual countries taking lead roles in areas where they have comparative advantages
- Organizing training, workshops, meetings and exchange of technical visits for technology transfer
- Establishing and strengthening of links with other networks and programmes and organizations working on tropical fruits

Achievements
The progress vis-à-vis major achievements are highlighted below:

i) A decade’s existence of ICUC enabled UTFANET, with support from various organizations and institutions, to make several important achievements that involved priority setting, R&D work including product development, knowledge-based information and dissemination, and human resource development/capacity building.

ii) Priority setting on fruit species that includes underutilized fruit crops was carried out in collaboration with IPGRI. The activity was guided by farmers/fruit growers as well as fruit and market experts. It determined the priority species in the region, which became the basis for a more comprehensive R&D work on underutilized fruit crops in the region. It is, however, considered by ICUC, UTFANET and the collaborating partners that priority setting should be a continuing activity because priorities change over time in any geographic location.

iii) Germplasm collecting and evaluation of jackfruit, pummelo, and mangosteen have been carried out in some member countries and germplasm collecting is in progress in other countries. Bangladeshi and Nepal studied the diversity of jackfruit and pummelo and both vegetative and in vitro propagation methods have been established in these two species.

iv) All the information gathered through the collaborative work of ICUC with IPGRI in 1993-94 for an information synthesis on genetic resources diversity and priority setting based on a survey involving 15 countries was carefully databased. A report based on the information was published and distributed by IPGRI. The database provides a directory of resource institutions and R&D key scientists working on tropical fruits in the region.

v) At the second SC meeting of UTFANET held at FAO-RAPA in Bangkok in 1994 with representation from IPGRI and FAO, it was agreed that UTFANET will initially concentrate on three underutilized fruit crops, namely, jackfruit, mangosteen, and pummelo. IPGRI and FAO were identified to lead the work on genetic resources. During the Leipzig Conference in June 1996, IPGRI and UTFANET agreed to work on the development and joint publication of descriptors list for pummelo, mangosteen and jackfruit. At subsequent meetings of UTFANET with IPGRI as an associate member of the network it was further agreed that an R&D collaborative work with IPGRI by UTFANET on the initial three priority underutilized crops identified by nine NARS in South and Southeast Asia would be pursued.

vi) For data/information gathering which includes market information through farmers’ participatory survey, the information is sourced out not only from farmers/fruit growers but also from individuals and organizations around the world who are working on underutilized crops, and it is being added to the existing databases, which are published and disseminated. For example, ICUC-UTFANET has come out with a publication on
"Annotated Bibliography of Jackfruit, Pummelo and Mangosteen" (Anon 1997), which is a comprehensive and very useful reference material for scientists and others working on these crops. Other examples are newsletters, fact sheets (on 9 initial priority species) with a theme "Fruits for the Future", flyers and various books, journals and proceedings of symposia/workshops, extension/training manuals for farmers' use, and posters. Extension materials highlight information on appropriate production technologies starting from the selection of good quality planting materials, propagation, distribution up to product development and establishment of market pathways.

vii) ICUC provided support to Bangladesh Council for Scientific and Industrial Research (BCSIR) for a study on jackfruit product development. Several jackfruit products that include toffees, biscuits, jackfruit juice/drink and dry pulp in syrup were successfully produced and these enabled local entrepreneurs to venture and become successful in marketing these products. There was a high level of product acceptability particularly among the children.

viii) ICUC-UTFANET has published several books, journals and proceedings of various trainings/workshops/conferences that provide an excellent source of quality information/knowledge on underutilized crop species. UTFANET was also instrumental in jointly developing the descriptors for jackfruit, which IPRGI has published. UTFANET also conducted a product exhibition on jackfruit, which was organized in Dhaka, Bangladesh.

ix) Two Ph.D. students from Bangladesh and Nepal were supported. Study visit to Fruit Growing Areas in the Philippines was also supported by IPRGI. The following training programmes in collaboration with ICUC-UTFANET partners were also supported:

- Training on Crop Improvement in Malaysia
- Practical Training on the Production Management of Tropical Fruits in Thailand
- Regional Training Course on the Conservation and Use of Tropical Fruits in Asia organized in collaboration with IPRGI in India
- Training Course on Propagation Methods of Jackfruit and Pummelo in Bangladesh
- Regional Training Course on Mangosteen Propagation in the Philippines

x) UTFANET has developed close links with Plant Resources of Southeast Asia (PROSEA), IPRGI and International Centre for Research on Agroforestry (ICRAF). PROSEA has contributed articles for UTFANET newsletter. ICRAF collaborates with UTFANET for 'Fruits of the Future' which deals with Tamarind, Ziziphus and Annona spp. UTFANET collaborates with IPRGI on genetic resources and conservation strategies and will focus on the distribution of quality planting materials, crop improvement, production and post-harvest technology, documentation and database development.

Current activities

ICUC's strong efforts for several years and perseverance to promote UTFANET, paved the way to boost the interest of UK's National Lottery Charities Board (NLCB) to support the activities of the network. UTFANET's Secretariat based in the Philippines is now in operation with a full-time Regional Coordinator. There are currently nine participating member countries. In addition, China and Malaysia have also indicated their interests to participate that have agreed on an initial 3-year work plan for the development of 3 identified priority underutilized fruit crops, jackfruit, and pummelo. The 3-year work plan refers to the following activities:

- Farmers' participatory surveys including production, utilization/uses, processing and marketing of priority species.
- Characterization of jackfruit, pummelo and mangosteen
- Propagation and distribution of planting materials particularly through private fruit growers and nurseries
• Identification of water and nutrient requirements for pummelo and jackfruit
• Training in propagation for the scientists and growers
• Documentation/database development
• Publication and distribution (Newsletter, flyers, fact sheets, and training/extension/information materials on jackfruit, mangosteen, and pummelo).

Future perspectives
There lies a big challenge for the development of the fruit crops sector, especially on the maximization of the potential of underutilized fruit species. Several past and recent events provide a wholesome scenario for underutilized fruit crops. The Consultative Group on International Agricultural Research (CGIAR) recommended the widening of the food security basket by including underutilized crops, which are considered essential for both ecological and sustainable food and nutrition security. The potential contribution of the underutilized crops to poverty reduction, improved human health, biodiversity conservation and natural resources management, empowerment of women and disadvantaged members of the society, and raising the food production to feed the world was recognized by the meeting of the Global Forum on Agricultural Research (GFAR). At this meeting in Dresden, GFAR recommended that the activities on underutilized crops should be focused on regional basis. It also recommended the establishment of a Global Fertilization Task Force involving ICUC and IPGRI. In 1999, an international consultation meeting was organized by CGIAR in Chennai, India, which recommended the establishment of global network on underutilized crops. The Global Plan of Action (GPA) also recommended the promotion and commercialization of underutilized crops (Agenda 12 of Leipzig Declaration) and ICUC, in partnership with FAO and IPGRI, has been implementing programmes to fulfill these recommendations.

With the full operationalization of UTPANET and the positive indications of identified donors to support the network, UTPANET together with its partners shall pursue short and long-term plans that complement the activities of other regional networks on underutilized fruit crops, avoiding any duplication.

In the meantime, the short-term work plan of UTPANET includes a Regional Workshop on the theme: "Products and Marketing and the 5th UTPANET Steering Committee Meeting" to be held in Bangkok, Thailand in June 2001. A collaborative work plan with PROSEA is likewise envisioned and will be pursued upon negotiation with PROSEA officials.

During the next three years, ICUC will, in general, focus on the following activities:
• Strengthening national and regional R&D efforts through existing programmes and projects in the region with particular reference to agricultural and agroforestry systems
• Promoting community entrepreneurship for promotion and marketing of information (following Fruits for the Future)
• Capacity building, particularly organizing training workshops for extension workers and farmers for technology transfer
• Strengthening linkage/collaboration of stakeholders, from producers to researchers and users
• ICUC along with its partners (stakeholders, such as, IPGRI, FAO) will promote policy dialogue for underutilized crops and will assist in formulation of national policies and plans

Conclusion
It is important to note, "The pursuit of any endeavour will not always be that perfect if it is done by one, but rather by many, not duplicating, but rather complementing." UTPANET will always be there to initiate and complement. UTPANET is committed to work in close cooperation
with emerging institutions/networks and the NARS partners in an all-out effort and support for the development of underutilized crops.

References

Prospects of CIRAD’s collaboration with IPGRI for tropical fruit trees project

Philippe Cao-Van
CIRAD-Fihor Vietnam, C/o SOFRI, PO Box 203, My THO, Tin Ginag, Vietnam.

Need for conservation of Citrus species

Citrus, unlike any other tropical fruit species, is affected by debilitating diseases, caused by virus, viroid, or mycoplasma, with economic effects including stunting, decrease in yield, size, quality and decline of the tree. In Asia, one of the most severe diseases affecting Citrus is ‘Huanglongbing’, a debilitating disease caused by *Candidatus Liberibacter asiaticus* and is transmitted through budwood or an insect vector, the psylla *Diaphorina citri*. All the information available shows that this disease occurs everywhere in Asia. For this reason and due to the severe effects of the disease on the tree (undeveloped and lopsided fruits, decline of the tree), *in situ* conservation should be considered with these risks involved, which make such an effort limited. *Ex situ* conservation for *Citrus* should always be done with disease-free plants (involving indexing and sanitation) to make its utilization possible for propagation and to guarantee the varietal authenticity, the phytosanitary status and the horticultural performance. Analysis of fruits should also be done on samples collected from disease-free trees. For grafted (or budded) trees, evaluation should be done with reference to the rootstock, as it would influence the behaviour of the trees.

Prospects of CIRAD’s collaboration with IPGRI-TFT project

For the evaluation of *Citrus*, the IPGRI’s *Citrus* descriptors list was considered important by the participants. To make easier the management of the data, CIRAD offers the possibility to use the EGRID software. This software was developed for the computerized germplasm management based on the IPGRI’s descriptors. It will be provided free of charge to the TFT project members. This software works inside a network, which allows exchange of information. Each registered member (see subscription form) can manage its own database for the varieties already recognized by the programme (enter, correct, delete data) while users can only read data. New cultivars are subjected first to a validation by the Maser Computer before being accessible through the software. This just means to provide for each cultivar the following information: (local name, current identification number (if available), genus and species, sanitary conditions (virus free / not guaranteed) and availability status (available / restricted). Exchange of information with the Master Computer should be done by mail or e-mail and general update of information, is automatically done through time-to-time internet connection with the Master Computer. An EGRID subscription form is attached to this document (please ignore the cost mentioned).

In an other field, CIRAD has also developed some tools for the analysis of the biodiversity of the germplasm (mainly for *Citrus* in the fruit sector) using molecular markers (nuclear and chloroplast microsatellites and mitochondrial RFLP). Proposals have recently been made to develop cooperation with Asian countries through a call for a French Project. Discussion is on going with IPGRI Headquarters in Rome to make the connection with the Asian partners. Such a project should offer the possibility for some Asian researchers to go to France and work in CIRAD’s laboratory. This proposal, if agreed, should help the IPGRI-TFT project in the transfer of new technologies. Other possibilities such as postdoctoral fellowships and bilateral projects should also be found to strengthen the collaboration in this field between Asian and French (CIRAD and INRA) teams.
### ADB funded Project on Conservation and Use of Native Tropical Fruit Species Biodiversity in Asia

**Work plan for 2001**

#### Bangladesh

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<thead>
<tr>
<th>Task/activity</th>
<th>Jackfruit</th>
<th>Mango</th>
<th>Citrus</th>
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<tbody>
<tr>
<td>1. Locating and collecting diversity</td>
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<tr>
<td>1.1 Conducting ecogeographic studies</td>
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<tr>
<td>1.2 Preparation of distribution maps</td>
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<tr>
<td>1.3 Collection and estimation of genetic diversity from different mango growing areas</td>
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<td>2. Germplasm evaluation, characterization and utilization</td>
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<td>2.1 Passport data and morphological characterization at the collecting site</td>
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<td>2.2 Identification of germplasm having high yield and good quality with regular bearing habit</td>
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<tr>
<td>3. In situ conservation</td>
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<tr>
<td>3.1 Improvement of field gene bank (FGB) management practices</td>
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<tr>
<td>4. Ex situ conservation</td>
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<tr>
<td>4.1 Seedling raising and grafting in the nursery</td>
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<td>4.2 Planting of the accessions in the field</td>
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<td>4.3 Maintenance and improvement of FGB at 3 locations</td>
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<tr>
<td>5 Information and documentation</td>
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<tr>
<td>5.1 Updating existing database</td>
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<tr>
<td>5.2 Documentation of collected germplasm accessions</td>
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<td>5.3 Documentation of indigenous knowledge</td>
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<tr>
<td>6 Socio-economic studies</td>
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<tr>
<td>6.1 Survey of orchards, homesteads and fresh fruit markets for constraint analysis</td>
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<tr>
<td>7 HRD and capacity building*</td>
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<tr>
<td>7.1 Human resource development: Training courses, study visits and workshops</td>
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<td>7.2 Improving the existing laboratories (equipment, etc.)</td>
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<tr>
<td>7.3 Improving field and other genebank management facilities</td>
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#### China

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<tr>
<th>Task/activity</th>
<th>Mango</th>
<th>Citrus</th>
<th>Litchi</th>
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<tbody>
<tr>
<td>1. Locating and collecting diversity</td>
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<tr>
<td>1.1 Conducting ecogeographic studies</td>
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<tr>
<td>1.2 Preparation of distribution maps</td>
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<tr>
<td>1.3 Exploration and collecting genetic diversity</td>
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<tr>
<td>1.4 Estimate genetic diversity in collected germplasm using molecular methods</td>
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<td>2. Germplasm evaluation, characterization and utilization</td>
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<tr>
<td>2.1 Assess, evaluate and characterize genetic resources</td>
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<td>2.2 Identify germplasm with valuable traits</td>
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<tr>
<td>2.3 Carry out evaluation studies for identification of better rootstocks and scions</td>
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</tbody>
</table>
### 3. Ex situ conservation
- 3.1. Develop complementary conservation strategies
- 3.2. Improve field genebank management practices
- 3.3. Standardize cryopreservation techniques

### 4. Information and documentation
- 4.1. Documentation of existing information
- 4.2. Updating existing databases

### 5. Human resource development (HRD) and capacity building
- 5.1. Human resource development: Training courses, study visits and workshops
- 5.2. Improving facilities for germplasm identification evaluation and utilization

### India

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<thead>
<tr>
<th>Task/activity</th>
<th>Mango</th>
<th>Citrus</th>
<th>Litchi</th>
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<tbody>
<tr>
<td><strong>1. Locating and collecting diversity</strong></td>
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<tr>
<td>1.1. Conducting eco-geographic studies to locate and document genetic diversity</td>
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<tr>
<td>1.2. Prepare distribution maps</td>
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<tr>
<td>1.3. Explore and collecting genetic diversity</td>
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<tr>
<td>1.4. Estimate genetic diversity in collected materials</td>
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<tr>
<td><strong>2. Germplasm evaluation, characterization and utilization</strong></td>
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<tr>
<td>2.1. Assess, evaluate and characterize existing collections</td>
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<tr>
<td>2.2. Identity germplasm with valuable traits (rootstock, scion, biotic stress tolerance, fruit quality)</td>
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<td>2.3. Carry out evaluation for identification of desirable clones and potential breeding stocks</td>
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<tr>
<td>2.4. Assess genetic diversity in material with communities and home gardens using indigenous knowledge</td>
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<td><strong>3. Develop guidelines for in situ conservation</strong></td>
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<tr>
<td>3.1. Identify sites for in situ conservation and develop guidelines for their monitoring</td>
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<tr>
<td>3.2. Identify links with in situ conservation sites</td>
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<tr>
<td>3.3. Complementary conservation strategies at national level</td>
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<tr>
<td>3.4. Develop guidelines and undertake community-based conservation</td>
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<td><strong>4. Ex situ conservation</strong></td>
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<tr>
<td>4.1. Undertake specific research to develop/improve conservation methods (seeo conservation, in vitro conservation, cryopreservation)</td>
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<td>4.2. Conserve existing and collected germplasm in genebanks</td>
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<td>4.3. Improve field and in vitro genebank management practices</td>
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<td><strong>5. Information and documentation</strong></td>
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<td>5.1. Documentation of existing information</td>
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<td>5.2. Updating existing databases</td>
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<td>5.3. Preparing and publication of catalogues</td>
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<td>5.4. Documentation of indigenous knowledge</td>
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<tr>
<td><strong>6. Socio-economic studies</strong></td>
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<tr>
<td>6.1. Surveys of grower and consumer preferences and market opportunities for use as a fresh fruit</td>
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<tr>
<td>6.2. Surveys of grower and consumer preferences and market opportunities for processed products</td>
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### Indonesia

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<th>Task/activity</th>
<th>Rambutan</th>
<th>Mingosteen</th>
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<tr>
<td>1 Locating and collecting diversity</td>
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<tr>
<td>1.1 Conducting ecogeographic studies</td>
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<td>1.2 Exploitation and collecting genetic diversity</td>
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<td>2 Germplasm evaluation, characterization and utilization</td>
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<td>2.1 Assess, evaluate and characterize genetic resources</td>
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<td>2.2 Identify germplasm with valuable traits</td>
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<td>3 Ex situ conservation</td>
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<td>3.1 Establish field genebanks</td>
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<td>4 Information and documentation</td>
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<td>4.1 Updating existing databases</td>
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<td>4.2 Preparing and publishing catalogues</td>
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<td>5 Socio-economic studies</td>
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<tr>
<td>5.1 Surveys of grower and market opportunities</td>
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<td>6 HRD and capacity building*</td>
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<tr>
<td>6.1 Human resource development: Training courses, study visits and workshops</td>
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<td>6.2 Improving field and laboratory facilities</td>
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### Malaysia

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<tr>
<th>Task/activity</th>
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<tbody>
<tr>
<td>1 Locating and collecting diversity</td>
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<tr>
<td>1.1 Conducting ecogeographic surveys</td>
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<td>1.2 Preparing distribution maps</td>
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<td>1.3 Exploration and collecting genetic diversity</td>
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<tr>
<td>2 Germplasm evaluation, characterization and utilization</td>
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<tr>
<td>2.1 Passport data and morphological characterization of the accessions at the collecting site</td>
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<td>2.2 Identification of potential accessions for budwood collections</td>
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<tr>
<td>3 Ex situ conservation</td>
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<tr>
<td>3.1 Raising of seedlings in the nursery</td>
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<tr>
<td>3.2 Collection of budwood from selected accessions</td>
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<td>3.3 Establishment of budded/grafted planting materials from selected accessions</td>
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<td>4 Information and documentation</td>
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<td>4.1 Updating existing database</td>
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<td>4.2 Documentation of the passport data and characterization data</td>
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<tr>
<td>5 Socio-economic studies</td>
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<tr>
<td>5.1 Gathering of secondary data on the status of cultivation</td>
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<td>5.2 Primary survey of households involved in the cultivation, constraints in the production and marketing of fruits</td>
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<tr>
<td>6 HRD and capacity building*</td>
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<tr>
<td>6.1 Human resource development: Training courses, study visits and workshops</td>
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<tr>
<td>6.2 Improving field and laboratory facilities</td>
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### Nepal

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<tr>
<th>Task/activity</th>
<th>Mango</th>
<th>Citrus</th>
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<tbody>
<tr>
<td>1. Locating and collecting diversity</td>
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<tr>
<td>1.1 Conducting ecogeographic studies to locate genetic diversity</td>
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<td>1.2 Preparation of distribution maps</td>
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<td>1.3 Exploration and collecting of genetic diversity</td>
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<tr>
<td>2. Germplasm evaluation, characterization and utilization</td>
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<tr>
<td>2.1 Evaluate and characterize existing genetic diversity</td>
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<tr>
<td>2.2 Assess, evaluate and characterize collected genetic diversity</td>
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<tr>
<td>2.3 Identification of germplasm with valuable traits (e.g. fruit quality)</td>
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<tr>
<td>3. In situ conservation</td>
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<tr>
<td>3.1 Identification of sites for in situ conservation</td>
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<tr>
<td>3.2 Develop guidelines and establish in situ sites</td>
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<tr>
<td>3.3 Develop guidelines for community-based conservation and complementary conservation strategies *</td>
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<tr>
<td>4. Ex situ conservation</td>
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<tr>
<td>4.1 Gathering and compiling information on current practices and conservation methods</td>
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<tr>
<td>4.2 Identify potential sites for ex situ conservation</td>
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<tr>
<td>4.3 Collection of elite germplasts in FGB sites</td>
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<td>5. Information and documentation</td>
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<tr>
<td>5.1 Documentation of existing information on genetic resources</td>
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<td>5.2 Updating existing database</td>
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<tr>
<td>5.3 Preparing and publication of catalogues</td>
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<tr>
<td>5.4 Exchanging of information and germplasm</td>
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<td>6. Social-economic studies</td>
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<td></td>
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<tr>
<td>6.1 Carry out surveys for production constraints</td>
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<td>7. HRD and capacity building*</td>
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<tr>
<td>7.1 Improve human resources capabilities in PGR conservation and use through training courses, study visits</td>
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<tr>
<td>7.2 Improving existing laboratory facilities (Equipments, fruit quality analysis)</td>
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### Philippines

<table>
<thead>
<tr>
<th>Task/activity</th>
<th>Mango</th>
<th>Citrus</th>
<th>Garcinia spp</th>
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<tbody>
<tr>
<td>1. Locating and collecting diversity</td>
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</tr>
<tr>
<td>1.1 Germplasm collecting will be focused in Regions I to X</td>
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<tr>
<td>2. Germplasm evaluation, characterization and utilization</td>
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<tr>
<td>2.1 Morphological characterization of the existing germplasm. In addition, initial characterization will be done on site using a limited number of characters to serve as benchmark in formation of the newly collected germplasm</td>
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<tr>
<td>3. Ex situ conservation</td>
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<tr>
<td>3.1 The newly-collected germplasm will be grafted on previously established rootstocks and maintained in the nursery prior to establishment in the field gene bank</td>
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<tr>
<td>4. Information documentation</td>
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<tr>
<td>4.1 Updating the existing database</td>
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<tr>
<td>4.2 Documentation of passport and characterization data of the newly collected germplasm</td>
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</table>
5 HRD and capacity building*

5.1 Human resource development: training courses, study visits and workshops

5.2 Improving field and laboratory facilities

### Sri Lanka

<table>
<thead>
<tr>
<th>Task/activity</th>
<th>Jackfruit</th>
<th>Mango</th>
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<tbody>
<tr>
<td>1 Locating and collecting diversity</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.1 Locating diversity through eco geographic surveys</td>
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<td></td>
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<tr>
<td>1.2 Preparing distribution maps</td>
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<tr>
<td>1.3 Carry out targeted collecting of germplasm</td>
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<tr>
<td>2 Germplasm evaluation, characterization and utilization</td>
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<tr>
<td>2.1 Assess, evaluate and characterize existing collections</td>
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<tr>
<td>2.2 Identify germplasm with valuable traits</td>
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<tr>
<td>2.3 Assessment of genetic diversity of indigenous knowledge</td>
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<tr>
<td>3 <em>Ex situ conservation</em></td>
<td></td>
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<tr>
<td>3.1 Conserve existing and collected germplasm in gene banks</td>
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<tr>
<td>3.2 Improved field gene bank management practices</td>
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<tr>
<td>4 Information and documentation</td>
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<tr>
<td>4.1 Updating existing databases</td>
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<tr>
<td>4.2 Preparation and publication of catalogues</td>
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<tr>
<td>5 Socio-economic studies</td>
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<tr>
<td>5.1 Survey of growers and consumers preferences and market opportunities</td>
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<tr>
<td>6 HRD and capacity building*</td>
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<tr>
<td>6.1 Human resource development: training courses, study visits and workshops</td>
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<td>6.2 Improving field and laboratory facilities</td>
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### Thailand

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<tr>
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<th>Rambutan</th>
<th>Mango</th>
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<tbody>
<tr>
<td>1 Locating and collecting diversity</td>
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<tr>
<td>1.1 Conducting eco geographic studies</td>
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<td>1.2 Preparing distribution maps</td>
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<td>2.2 Identify germplasm with valuable traits</td>
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<tr>
<td>3 <em>Ex situ conservation</em></td>
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<tr>
<td>3.1 Establish field gene banks</td>
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<td>4 Information and documentation</td>
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<td>5.2 Improving field and laboratory facilities</td>
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### Vietnam

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<tr>
<th>Task/activity</th>
<th>Citrus</th>
<th>Litchi</th>
<th>Mango</th>
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<tbody>
<tr>
<td>1 Locating and collecting diversity</td>
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<tr>
<td>1.1 Ecogeographic studies</td>
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<tr>
<td>1.2 Prepare distribution maps</td>
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<tr>
<td>1.3 Exploration and collecting genetic diversity</td>
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</table>
2. Germplasm evaluation, characterization and utilization
   2.1 Assess, evaluate and characterize genetic resources
   2.2 Identify germplasm with valuable traits

3. *Ex situ* conservation
   3.1 Improve gene bank management practices
   3.2 Maintenance of newly collected materials in field genebanks, *in vitro*, or in greenhouse
   3.3 Develop guidelines for FGB management and facilitate implementation

4. Information and documentation
   4.1 Gathering existing information from different research institutes and data analysis
   4.2 Updating existing databases
   4.3 Preparing and publishing catalogues

5. Socio-economic study
   5.1 Carry out surveys of grower and consumer preferences
   5.2 Carry out market surveys

6. HRD and capacity building*
   6.1 Human resource development: training courses, study visits and workshops
   6.2 Improving field and laboratory facilities

* To be organized by IPGRI
Minutes of the Second Meeting of the Steering Committee of the Project on Conservation and Use of Native Tropical Fruit Species Biodiversity in Asia held at Pattaya, Thailand on 9 February 2001

The second meeting of the Steering Committee (SC) of ADB funded Project on Conservation and Use of Native Tropical Fruit Species Biodiversity in Asia was held at Ambassador City Jomtien Hotel, Pattaya, Thailand on 9 February 2001. The meeting was chaired by Dr Felipe S. dela Cruz, current Vice Chairperson of the SC, since Dr S. P. Ghosh, the Chairperson, could not participate in the meeting due to his retirement. The meeting was called to order at 0830 A.M.

The following Country Coordinators/representatives from participating countries and staff of IPGRI (APO and South Asia) attended the meeting:

1. Dr Felipe S. dela Cruz, Jr. Philippines Chair
   2. Dr R.N. Pal India Member
   3. Dr Attab Uddin Ahmed Bangladesh Member
   4. Prof. Chen Zhixiang China Member
   5. Dr Surachmat Kusumoto Indonesia Member
   6. Dr Mohd. Senawi Malaysia Member
   7. Dr Kedar Radathoki Nepal Member
   8. Dr Shantha Peris Sri Lanka Member
   9. Dr Songgul Somari Thailand Member
   10. Dr Nguyen Thi Ngoc Hue Vietnam Member
   11. Dr Percy E. Sajise IPGRI-APO, Malaysia Special Invitee
   12. Dr C. Ramanathra Rao IPGRI-APO, Malaysia Ex-officio Member
   13. Dr Bhag Mal IPGRI, New Delhi Member

Ms Ramamani Yadur Suryanarayanan (Scientific Assistant, IPGRI South Asia) and Dr Margaret C. Yoovatana (Plan and Policy Analyst, Department of Agriculture, Thailand) were requested to record the minutes of the meeting.

The Steering Committee deliberated on several important issues based on agreed agenda items and the following decisions/major points emerged:

**Agenda 1: Adoption of the proposed agenda**
The items of agenda were discussed and approved, with addition of an item on equipment.

**Agenda 2: Approval of the minutes of the first meeting**
The minutes of the first meeting of the Steering Committee held at Selangor, Malaysia, on 18 February 2000 were approved without any amendments.

**Agenda 3: Matters arising out of the first meeting**

(i) Database of existing germplasm can be developed using the programme already being used by the national programmes but it should be compatible and accessible. This was agreed upon among the participants during the documentation training held in the Philippines in October, 2000.

(ii) There was a suggestion for identifying permanent alternatives to represent the Country Coordinators but the suggestion was not agreed by most of the members and hence dropped. The need for continuity of Country Coordinators during the project period was stressed. There is a need to check with Sri Lanka in this regard.
(iii) The Country Coordinator from Malaysia reiterated his request for a replacement because of his impending retirement. It was suggested that a formal letter of request signed by the authority that appointed the Country Coordinator should be sent to the Member Secretary of the Steering Committee to make this change official.

(iv) A suitable name for the network, as well as an acronym, was deliberated. After considering several names suggested by the members and finally, AFGRN, Asian Fruit Genetic Resources Network, was agreed. It was also agreed that this would be used in all future references to the group, as well as on the web.

**Agenda 4: Objectives of the project**

The SC looked closely at the project objectives as given in the original project document and agreed that they were sound and the activities being done were in the right direction and noted the following additional points:

(i) There is a need to look into the issues relating to threatened species genetic resources and to make efforts to determine the extent of the threat. IPGRI has agreed to facilitate the evaluation of threat related to particular threatened species.

(ii) It was suggested to add indicators to evaluate activities and assess accomplishments and impact of activities. IPORI agreed to provide help in this regard and to develop a set of indicators for all the expected outputs.

**Agenda 5: Release of Funds**

(i) Dr Shag Mal, Technical Coordinator of the project, will be the focal point for all communications relating to this project.

(ii) It was agreed that the starting date for implementation of the project is January 2000 (although funds from ADB were received in May and distributed later). The six-monthly reports for January-June should be submitted latest by first week of June and for July-December, latest by first week of December. IPGRI can make payments only after both technical and financial reports are submitted.

(iii) IPGRI will provide a copy of LoAs to Country Coordinators who will follow the schedules/requirements mentioned therein.

(iv) Country Coordinators need to play a pro-active role to facilitate release of funds from the concerned institution/organization which receive the funds from IPGRI.

(v) IPGRI will look into the possibility of a multi-year LoA to avoid a lot of paper work and facilitate the implementation of the project. However, this will depend on existing regulations within IPGRI.

**Agenda 6: Development of database of available characterization data**

(i) Database of available characterization data needs to be developed as soon as possible.

(ii) The persons from the different countries trained for documentation in the Philippines should be designated as the focal points to coordinate the work at the national level in the respective countries. There should be greater interaction among focal persons as well as between focal persons and Country Coordinators.

(iii) The action plan was prepared and the time frame was set. It was agreed that the action plan will be followed by the countries and the target to complete the work is 6 months.

(iv) Complete documentation including passport data and characterization data needs to be done. Passport data need to be compiled in e-catalogue and the Country Coordinators agreed to follow-up on this matter with information focal points.

**Agenda 7: Germplasm exchange and establishment of a regional genebank**

(i) The participants agreed in principle on the need for exchange of germplasm but it was noted that any exchange should be in line with the existing national legislation and
regulations in this regard. The Country Coordinators agreed to look into the respective national policies and determine which material can be exchanged and a response from countries in this regard is expected within 6 months.

(ii) The development of mechanism for exchange of material, such as Material Transfer Agreement (MTA) can be facilitated/ provided by IPGRI.

(iii) Bilateral exchanges can be effected by the concerned countries with mutual understanding and consent. There was a suggestion for establishing regional genebank but was not fully discussed in the meeting.

(iv) All Country Coordinators agreed to continue to discuss the issue of germplasm exchange and SC will make efforts on follow up in this matter.

Agenda 8: Training Needs

(i) Two training programmes were agreed to be organized during 2001. The training course on Characterization, Evaluation and Conservation will be organized in India in May/June 2001. The Country Coordinator for India agreed to develop a training proposal to IPGRI at the earliest possible time.

(ii) The training on Molecular Characterization and DNA Fingerprinting will be conducted in China in October 2001. A training proposal will be developed by the Country Coordinator of China to be forwarded to IPGRI-APU as early as possible.

(iii) It was also agreed that training should be need-based (not necessarily all the 10 countries be represented at each of the training course) and only the most suitable candidates will be sent to these training courses. Country Coordinators will make sure that the skills acquired at the training courses will be put to use within the project framework.

(iv) Additional needs for training was noted in the case of field genebank management and screening for biotic and abiotic stresses. In the case of former, IPGRI will supply the countries the field genebank management guide that is under development and the need for further training will be determined after evaluating the guide.

Agenda 9: Development of descriptors

(i) It was decided to develop descriptors for mangosteen, itchi and rambutan as early as possible. The focal persons identified for the these are:

- Dr S. Kusuma (Indonesia) for mangosteen,
- Dr (Ms) Nguyen Thi Ngoc Hue (Vietnam) for itchi
- Dr (Ms) Salma Idris (Malaysia) for rambutan

(ii) The draft descriptors will be developed independently by 2-3 experts identified by the focal persons and IPGRI will harmonize these in IPGRI format and process these for publication after a wider consultation.

Agenda 16: Proposals for submission to funding institutions

(i) The committee was informed about the progress relating to Australian Centre for International Agriculture Research (ACIAR) proposal. The second phase of the proposal development is under process.

(ii) Funding proposals need to be developed by countries in the areas which are complementary to ADR-TFT project activities and be sent to Dr B irgend Mal, Technical Coordinator of the project.

(iii) A need was expressed to look into the continuity of the project at the end of 2001 to develop proposal for the second phase of current project.

Agenda 11: Update on website and publication of in-house newsletter

(i) Dr Rajan who is the focal person needs to be consulted regarding the cost of developing website.
(ii) The details regarding copyrights and editorial committee, etc. will be looked into.
(iii) Quality control of contents needs to be taken care by the respective Country Coordinators who will pass on information to the website focal person. Dr Paul Quek, Dr Rajan and Dr Bhag Mal will look into the question of necessary resources required to sustain the website.

**Agenda 12: Format and submission of revised annual report**

(i) IPCRI secretariat will provide assistance in the preparation of the annual report. SC also agreed that the proceedings of the meeting should be published after due editing and IPCRI should take lead in this matter.

**Agenda 13: Election of Chairperson and Vice-Chairperson of the Committee**

(i) Dr Felipe S. dela Cruz, Jr. (Philippines) and Dr Songprl Somari (Thailand) were elected as Chairperson and Vice-Chairperson of the Steering Committee, respectively

**Agenda 14: Venue of next meeting**

The next meeting of the Steering Committee will be held at Bogor, Indonesia, preferably in February 2002.

**Agenda 15: Equipment**

(i) Country Coordinators need to be proactive in equipment procurement. IPCRI and the Country Coordinators should look into the possibility of change of equipments and also procurement of accessories.
(ii) Possibility of procurement of additional equipments within the budget allocated to the individual countries needs to be explored by IPCRI.
First Annual Meeting of the Project on ‘Conservation and Use of Native Tropical Fruit Species Biodiversity in Asia’, held at Pattaya, Thailand

6-9 February 2001

Technical Programme

6 February 2001

0830 - 0900  Registration

0900 - 1000  Inaugural Session

0900 - 0910  Welcome address  Bhag Mal
0910 - 0930  Chairperson’s remarks  Percy E. Sajise
0930 - 0955  Inaugural address by Chief Guest  N. Sennarong.
0955 - 1000  Vote of thanks  Songpol Somstri

[Tot: 1000 – 1030 ]

Technical Session I: Review of Progress and Outputs - Country Reports

Chairperson: Percy E. Sajise
Co-Chairperson: Chen Zhusheng

1030 – 1100  Project overview and summary of outputs  Bhag Mal
1100 – 1120  Bangladesh  Aftab Uddin Ahmed
1120 – 1140  China  Chen Zhusheng
1140 – 1200  India  R.N. Pal
1200 – 1215  Discussion

Technical Session I (Contd)

Chairperson: R.N. Pal
Co-Chairperson: Aftab Uddin Ahmed

1215 – 1235  Indonesia  S. Kusumo
1235 – 1255  Malaysia  M. Senawi
1255 – 1315  Nepal  K. Budathoki
1315 – 1330  Discussion

1330 – 1430  [Lunch : 1330 – 1430 ]


Technical Session I (Contd)
Chairperson: S. Kusumo
Co-Chairperson: S. Somsri

1430 – 1450 Philippines
1450 – 1510 Sri Lanka
1510 – 1530 Thailand
1530 – 1550 Vietnam
1550 – 1610 Discussion

[Tea: 1610 – 1630]

Technical Session II: Thematic Activities
Chairperson: V. Ramanatha Rao
Co-Chairperson: M. Senawi

1630 – 1650 Locating genetic diversity of tropical fruit tree species
1650 – 17:0 In situ conservation of tropical fruit species in Asia
1710 – 1730 Tropical fruits trees: Enhancing germplasm exchange and use
1730 – 1750 Information and documentation action plan for tropical fruit tree collections
1750 – 1815 Discussion

7 February 2001
Field trip/Lab visit

8 February 2001

Technical Session II (Contd)
Chairperson: M.K. Papademetriou
Co-Chairperson: K.M. Tahir

0830 – 0930 Cryopreservation of citrus and some other tropical fruits: Recent research results
Discussion

Technical Session III: International/Regional Collaboration and Linkage
Chairperson: Nuria Urquia
Co-Chairperson: K.M. Tahir

0930 – 1000 FAO network activities on tropical fruit species
1000 – 1030 Activities of TFNet in Asia Pacific region and prospects for collaboration with IPGRI
1030 – 1100 UUTFANET/ICUC collaboration with IPGR-TFT project
1100 – 1130 Prospects of CIORD’s collaboration with IPGR-TFT project
1130 – 1230 Discussion

(Lunch: 1230 – 1330)

Technical Session IV: Developing Work plan for 2001

Species:
- 2330 – 1500 Mango
- 1500 – 1600 Citrus

Conveners:
- Chen Zhuosheng
- S. Asamura

[Tea: 1600 – 1630]

Technical Session IV (Contd)

- 1630 – 1715 Rambutan
- 1715 – 1800 Jackfruit
- 1800 – 1830 Garcinia
- 1830 – 1900 Litchi

M. Sengwil
Aftab Uddin Ahmed
Felipe S. dela Cruz
Nguyen Thi Ngoc Hue

9 February 2001

0830 – 1030 Steering Committee Meeting

[Tea: 1030 – 1100]

1100 – 1300 Steering Committee Meeting (Contd)

[Tea: 1300 – 1400]

1400 – 1500 Plenary Session

Chairperson: Percy E. Sajise
Co-Chairperson: Bhag Mal

Presentation of work plan
Presentation of Steering Committee
Meeting’s recommendations
Chairperson’s remarks
Closing remarks
Vote of thanks

Group Conveners:
Felipe S. dela Cruz
Percy E. Sajise
V. Ramakrishna Rao
S. Somshri
First Annual Meeting of the Project on 'Conservation and Use of Native Tropical Fruit Species Biodiversity in Asia' held at Pattaya, Thailand

6-9 February 2001

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Project Planning Meeting of the Project on Conservation and Use of Native Tropical Fruit Species Biodiversity in Asia held at Mines Beach Resort & SPA, Selangor, Malaysia, 15-18 February 2000

Summary of proceedings

A Project Planning Meeting of the ADB funded TTF Project on conservation and use of the native tropical fruit species biodiversity in Asia, approved under technical assistance agreement between the Asian Development Bank (ADB) and the International Plant Genetic Resources Institute (IPGRI), was organized at The Mines Beach Resort and Spa, Selangor, Malaysia from 15-18 February 2000. The objectives of this meeting were: (i) to apprise the Country Coordinators from 10 collaborating countries, about the logistic arrangements regarding administrative and financial aspects, (ii) to interact and understand the ongoing research activities in their respective countries, (iii) to explain them the project implementation arrangements, and (iv) to discuss and finalize the workplan for 3 years. The meeting was organized in five technical sessions, namely, (i) Logistic arrangements, (ii) Current status of work, (iii) Developing workplans, (iv) International/Regional collaboration, and (v) Finalization of workplans and budget. Twenty participants comprising Country Coordinators from 10 countries, representatives from international/regional organizations, IPGRI staff and observers attended the Meeting. The salient points and highlights of the Meeting are as under:

1. Dr V. Ramanatha Rao, Project Coordinator, welcomed the participants and presented a brief background of the project. Dr Percy Sejise, Regional Director, IPGRI-AP region, made the opening remarks and underlined the importance of tropical fruit species in Asia and the urgent need to conserve and use this diversity. Dr Bhag Mal, Coordinator for South Asia, who is the Technical Coordinator of this project, extended vote of thanks and appreciated the good support provided by ADB and also the commitment made by the national governments of the collaborating countries for joint efforts in collaboration with IPGRI for conservation and use of native tropical fruit species diversity in the region.

2. The Meeting was organized in five technical sessions. Technical Session I dealt with logistic arrangements and was basically aimed at providing the partners with the details regarding the administrative, financial and technical aspects and the implementation arrangements for effective functioning of the project. The administrative and financial aspects will be co-ordinated from APO, Serdang, Malaysia by Dr V. Ramanatha Rao, who is the Project Coordinator and Dr Bhag Mal, who is the Technical Coordinator of this project, will deal with technical aspects from IPGRI South Asia Office, New Delhi, India.

3. Dr V. Ramanatha Rao explained that the project activities would be implemented through the Letters of Agreement (LoA’s) between IPGRI and the concerned countries. The proposals on specific activities on different crops as agreed in the workplan will be submitted by the Country Coordinators, which will be examined by IPGRI and funds will be released for approved proposals and activities. The reporting system will include six monthly and annual progress reports as well as financial reports. The monitoring of project expenditure will be done through project track system presented and demonstrated by Dr Paul Quek, Documentation Specialist. Dr Bhag Mal explained that for effective and efficient implementation of the project, the activities envisaged to be undertaken have been regrouped into different tasks which have been assigned to IPGRI Professional Staff who have the expertise in the relevant field and will be working as Task Managers.
4. The presentations by Country Coordinators reflected very clearly that efforts on tropical fruits are not well organized and that very little work has been done in the area of fruit genetic resources. It was pointed out that there was a great need for concerted efforts on germplasm collecting, evaluation, characterization and utilization, database development, and developing appropriate conservation techniques. The Country Coordinators appreciated the initiative taken by IPGRI and the funding support by ADB for research on PGR related activities on selected priority fruit species gene pools, namely, mango, citrus, rambutan and jackfruit and in addition 1-2 locally important potential species.

5. The Country Coordinators clearly expressed that the funds available under the project are not commensurate with the outputs expected and it is not possible to undertake all activities in all the 4 crop gene pools in all the 10 countries. Hence, it was decided to concentrate on a few specific activities only on two priority crops in each country. Based on this criterion, the crop groups identified were mango (9 countries), citrus (6 countries), rambutan (3 countries), jackfruit (3 countries), litchi (3 countries) and C. cinnamomum (3 countries). However, the exercise was very useful and it was felt that the activities proposed by each country are important and can be handled through separate funding proposals, which can be developed subsequently. Intensive deliberations for two days jointly and in groups resulted in finalization of an agreed plan of activities for 3 years and also for the year 2000.

6. In view of the training needs of all the countries, it was felt that human resource development aspect for training, study visits, etc. should be coordinated by IPGRI with the budget earmarked for that activity. The common areas of training identified were: (i) Germplasm collecting, evaluation, characterization, documentation and conservation, (ii) Molecular characterization and DNA fingerprinting, (iii) In vitro conservation and cryopreservation, and (iv) Database development. Besides this, need for field genebank management training for technicians was also expressed. Database development was considered as a high priority activity by all the 10 national programmes. It was stressed that a format may be developed by IPGRI and provided to the collaborators for developing databases in different countries on a uniform pattern. For studies on constraint analysis, a questionnaire needs to be developed and provided to the partners.

7. It was also decided that the PGR activities being supported under UTFANET and other funding sources should not be taken up under this project. Instead, the resources be utilized for those activities on which not much work has been done. This will help in rational use of funds coming from different sources and there will be a greater degree of complementarity between different programmes.

8. The presentations made by the representatives of International/Regional organizations were very useful. Dr Nazmul Haq, Director, International Centre for Underutilized Crops, Southampton, U.K., who represented UTFANET, explained about UTFANET’s activities which are being supported in 8 out of 10 participating countries and expressed interest in further collaboration. Dr Philippe Cao-Van highlighted CIRAD’s activities supporting tropical fruit work in Asia and indicated the CIRAD’s data documentation software could be very useful for this project also. He also briefly summarized the work being done on tropical fruits in America and mentioned the need for clear linkage. An interesting presentation was made by Dr Koke wai Hong, Regional Representative on the role of CAB International in promoting the conservation and use of tropical fruit species through information dissemination. On behalf of Dr Saharan Anang, Dr Mohamad M. Salleh made a presentation highlighting the objectives, role, area of operation and the focused activities of Tropical Fruits Network (TFNET) which will be formally launched in March 2000.
9. The Steering Committee (SC) for the ADB project was constituted which will have the responsibility for monitoring the activities, providing direction and developing funding proposals. All the Country Coordinators will be the members of SC. The Project Coordinator and the Technical Coordinator from IPGRI will be the Ex-Officio members. The Technical Coordinator will also act as the Member Secretary of Steering Committee. The Country Coordinators elected, by consensus, Dr S.P. Ghosh (India) as the Chairperson and Dr Felipe S. della Cruz (Philippines) as the Vice-Chairperson for a two-year term. IPGRI staff opted out during the election process so as to give the Country Coordinators a free hand.

10. The first meeting of the Steering Committee was also organized and the Chairperson explained the roles and responsibilities of Steering Committee and asked the SC members to make it fully effective. The SC discussed the workplan for 3 years and identified the major activities in each crop on which the thrust is to be given during the year 2000.

11. A visit to the Field Genebank at the Malaysian Agricultural Research and Development Institute (MARDI), Serdang, was organized. The Scientist Incharge of Tropical Fruits at MARDI apprised the participants about the research and development of activities on tropical fruit tree species being undertaken at MARDI. During discussions that ensued, a strong need was expressed for exchange of useful germplasm of different fruit species between the participating countries.

12. In the plenary session, the Country Coordinators presented the final work plans for 3 years as well as for the first year. It was emphasized that the financial support being provided by ADB for specific agreed activities will supplement the national efforts on tropical fruit tree species. The session ended with the concluding remarks by Dr Percy Sajise, who mentioned that working on tropical fruit tree species was a challenging area and with a firm commitment and support from the Governments of respective countries, these joint collaborative efforts in partnership mode would certainly bring spectacular success in achieving the expected project outputs.
## Staff recruited under Tropical Fruit Genetic Resources Project

<table>
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<tr>
<th>Sl. No.</th>
<th>Name of the staff</th>
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</tbody>
</table>
ACRONYMS

ACIAR  Australian Centre of International Agriculture Research
ADB  Asian Development Bank
AFO  Asia, the Pacific and Oceania
BAP  6, Benzyl Amino Purine
CBD  Convention on Biological Diversity
CEO  Chief Executive Officer
CHES Central Horticultural Experiment Station
CIAT  International Centre for Tropical Agriculture
CIF  International Potato Centre
CIRAD  Centre de Cooperation Internationale en Recherche Agronomique pour le Development
COGENT  International Coconut Genetic Resources Network
DIP  Data Interchange Protocol
DMSO  Dimethyl Sulphoxide
EG  Ethylene Glycol
FAO  Food and Agriculture Organization of the United Nations
GA3  Gibberellic Acid 3
GGCN  Global Citrus Germplasm Network
GIS  Geographic Information System
GPA  Global Plan of Action
GPS  Global Positioning System
ICAR  Indian Council of Agricultural Research
ICG  International Coconut Genebank
ICUC  International Centre for Underutilized Crops
IIHR  Indian Institute of Horticultural Research
IPB  Institute of Plant Breeding
IPGRI  International Plant Genetic Resources Institute
IPP  Intellectual Property Protection
IU  International Undertaking for Plant Genetic Resources
LN  Liquid Nitrogen
MC  Moisture Content
MUCINET  Mediterranean Citrus Network
MS medium Murashige & Skoog's medium
MT  Murashige & Tucker
NAA  Naphthalene Acetic Acid
NARS  National Agricultural Research System
NATP  National Agriculture Technology Project
PCA  Principal Component Analysis
PGR Plant Genetic Resources
PGRFA  Plant Genetic Resources for Food and Agriculture
PVS2  Plant Virification Solution 2
QDPI  Queensland Department of Primary Industries
RECSEA-PGR Regional Cooperation for Southeast Asia - Plant Genetic Resources
RELAFRUT Latin American Network on Tropical Fruits
REMUFRT Red Mundisí de Frutales Tropicales (Global Network on Tropical and Subtropical Fruit Germplasm Conservation and Utilization)
RH Relative Humidity
TAROGEN Taro Genetic Resources Network
TFNet International Tropical Fruits Network
TFT Tropical Fruit Trees
TRIPS Trade-Related Aspects of Intellectual Property Rights
UPLB University of the Philippines, Los Banos
UTFANET Underutilized Tropical Fruits in Asia Network
VASI Vietnam Agriculture Science Institute
WAFNET West African Fruits Network
WTO World Trade Organization