ADVANCING BANANA AND PLANTAIN R&D IN ASIA AND THE PACIFIC

Proceedings of the 6th BAPNET Steering Committee meeting in Tiruchirapalli, Tamil Nadu, India 22-25 October 2008

AB Molina, MLJ Baroña, VGO Sinohin, JD Generoso, editors



ADVANCING BANANA AND PLANTAIN R&D IN ASIA AND THE PACIFIC

Proceedings of the 6th BAPNET Steering Committee meeting in Tiruchirapalli, Tamil Nadu, India 22-25 October 2008

AB Molina, MLJ Baroña, VGO Sinohin, JD Generoso, editors

Bioversity International is an independent international scientific organization that seeks to improve the well-being of present and future generations of people by enhancing conservation and the deployment of agricultural biodiversity on farms and in forests. It is one of 15 centres supported by the Consultative Group on International Agricultural Research (CGIAR), an association of public and private members who support efforts to mobilize cutting-edge science to reduce hunger and poverty, improve human nutrition and health, and protect the environment. Bioversity has its headquarters in Maccarese, near Rome, Italy, with offices in more than 20 other countries worldwide. The Institute operates through four programmes: Diversity for Livelihoods, Understanding and Managing Biodiversity, Global Partnerships, and Commodities for Livelihoods.

The international status of Bioversity is conferred under an Establishment Agreement which, by January 2008, had been signed by the Governments of Algeria, Australia, Belgium, Benin, Bolivia, Brazil, Burkina Faso, Cameroon, Chile, China, Congo, Costa Rica, Côte d'Ivoire, Cyprus, Czech Republic, Denmark, Ecuador, Egypt, Ethiopia, Ghana, Greece, Guinea, Hungary, India, Indonesia, Iran, Israel, Italy, Jordan, Kenya, Malaysia, Mali, Mauritania, Mauritius, Morocco, Norway, Oman, Pakistan, Panama, Peru, Poland, Portugal, Romania, Russia, Senegal, Slovakia, Sudan, Switzerland, Syria, Tunisia, Turkey, Uganda and Ukraine. Financial support for Bioversity's research is provided by more than 150 donors, including governments, private foundations and international organizations. For details of donors and research activities please see Bioversity's Annual Reports, which are available in printed form on request from Bioversity-publications@cgiar.org or from Bioversity's Web site (www.bioversityinternational.org).

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

Mention of a proprietary name does not constitute endorsement of the product and is given only for information.

Cover: A banana experimental farm at the National Research Centre for Banana, Tamil Nadu, India
(photo by MLJ Baroña)

Citation:
AB Molina, MLJ Baroña, VGO Sinohin, JD Generoso, editors. 2009. Advancing banana and plantain R&D in Asia and the Pacific—Vol 14. Proceedings of the 6th BAPNET steering committee meeting in Tiruchirapalli, Tamil Nadu, India, 22-25 October 2008. Bioversity International—Asia Pacific, Los Banos, Laguna, Philippines

Acknowledgements:
The Banana Asia Pacific Network is grateful to all participants to the 6th BAPNET SC meeting for their contributions. BAPNET also thanks NRCB for hosting the meeting under the leaderships of Dr. HP Singh and Dr. MM Mustaffa. BAPNET also likes to thank AB Molina, MLJ Baroña, VGO Sinohin, and JD Generoso for their work as editors to the proceedings, and to MLJ Baroña, who laid-out and designed this document.

Bioversity International encourages the use of this publication for educational and non-commercial purposed without permission from copyright holders. Acknowledgement of the material is required.

Editors' note: Some references have been submitted without complete publishing data. They may therefore lack the full names of journals and/or place of publication and publisher. Should readers have difficulty in identifying particular references, kindly get in touch with Bioversity International Asia-Pacific staff.

ISSN: 1729-0805

Bioversity International
Via dei Tre Denari, 472/a
00057 Maccarese
Rome, Italy

© Bioversity International, 2008

Table of Contents

Introduction 1

Messages

- MM Mustaffa 3
- Agustin B. Molina 4
- HP Singh 6i

Pisang Raja Award Citations 8

Country Presentations

- Australia 14
- Bangladesh 20
- Cambodia 27
- China 33
- India 38
- Indonesia 59
- Malaysia 67
- Papua New Guinea 71
- Philippines 82
- Secretariat of the Pacific Community 91
- Sri Lanka 94
- Taiwan 100
- Thailand 107
- Vietnam 112

Agreements and Action Points 117

Annexes

- Programme of the Steering Committee Meeting 123
- Participants to the Steering Committee 124
- Regional Fusarium wilt RDE Strategy 125

BAPNET 2008



Back Row**:** Dr. Yi Ganjun (China)**,** Dr. Yusdar Hilman (Indonesia), Dr. Abdul Hoque (Bangladesh), Dr. Nik Masdek (Malaysia), Mr. Bob Williams (Australia)**,** Dr. Chih-Ping Chao (Taiwan), Mr. Nguyen Van Nghiem (Vietnam), Dr. Preap Visarto (Cambodia). Front Row**:** Dr. Indra J. de Zoysa (Sri Lanka), Ms. Pitsawat Buara (Thailand), Dr Carmencita Kagaoan (Philippines), Dr. Agustin B. Molina (Bioversity –Philippines), Dr. HP Singh (India), Dr. Nicolas Roux (Bioversity-France), Dr. Mohamed Mustaffa (India), Dr. Joy Eusebio(Philippines), Dr. Mary Taylor (SPC).

introduction

The Banana Asia-Pacific Network (BAPNET) Steering Committee held its 6th meeting in Tiruchirapalli, India from October 22-24, 2008. The meeting was hosted by the National Research Centre for Banana (NRCB) and was attended by 21 committee members/representatives, including four observers from China's Guangdong Academy of Agricultural Sciences (GDAAS), and members of the Taxonomy Advisory Group (TAG).

In light of concerns regarding banana diseases posing threat to the lucrative banana exports and emerging banana industries of member countries, as well as concerns about prioritizing research to optimize finite resources, members zeroed in on Fusarium or Panama wilt as the top research agenda. The steering committee recognised that mitigation of wilt diseases with emphasis on Tropical Race 4 of *Fusarium oxysporum f. sp. cubense* (Foc) will thwart any large-scale damage that the disease might cause if otherwise left unchecked.

This year, the Committee also recognised the role of national programs in complementing multilateral research efforts. Recommendations have been made for concerted national and regional program initiatives that will take on the framework of the BAPNET /Bioversity collaboration. Project activities will be pursued at national levels, existing activities will be continued, and research results will be extrapolated into regional perspectives.

Aside from Fusarium wilt, nematodes and weevils are common major problems in the region, and that these pest and diseases are transmitted through infected planting materials. The group agreed to characterise the various seed systems in the Region so as to enhance the delivery of good planting materials to banana growers. The Committee also recognised the importance of *Musa* germplasm conservation and use, with Asia being the home of genetic diversity. The Committee then decided to continue to support and participate in the conservation and use of *Musa* germplasm. As a start, it was agreed upon that a regional training on conventional breeding techniques will be conducted.

To harness the use of local cultivars in the region, the group agreed to develop a handbook of important cultivars at the national levels and consolidate it into a regional compilation. This regional cultivar profile will complement the *Musa* Germplasm Information System (MGIS) characterisation, which is primarily intended for researchers and breeders.
Other issues discussed during the meeting were the Network's position on climate change, enhancing information development and exchange, and pursuing steps for capacity building. BAPNET's sustainability was also discussed, for which Committee recognised the importance of the Bioversity-coordinated network as a vital platform of collaboration to advance banana R&D in the Region.

Opening Program

Welcome Address

DR. MM.MUSTAFFA, Director
National Research Centre for Banana, India

Respected, Dy. Director General of ICAR, Dr. H.P.Singh Ji, Dr.Agustin B.Molina, Regional Coordinator-BAPNET, Dr.Nicolas Roux, Project Manager – Musa Genetic Resource Management of Bioversity International, France, Delegates / participants of BAPNET Steering Committee Meeting from different countries, TAG delegates from different parts of the globe, Dr.Sundararaju, Scientists from NRCB, Trichy and Media friends. Very Good Morning to everybody.

It gives me a great pleasure in welcoming our Hon'ble DDG (Hort.), who is also the Chairman of the 6th BAPNET Steering Committee Meeting. The BAPNET Steering Committee was started in the year 2002 with an objective of developing regional cooperation between the banana growing countries in the Asia Pacific regions. I am glad that this 6th Steering Committee Meeting is being conducted at Tiruchirapalli. This could happen because of our DDG's special interest to have this meeting in India, especially at NRC Banana, Trichy so as to have effective interaction with the international scientists assembled for this SCM. Since the banana is close to his heart, NRCB is organizing 2 important international group meeting during this week. Once again I welcome you Sir.

I extend my warm welcome to Dr.Agustin Molina, who is the man behind the BAPNET with his steering and untired work inspite of his ill health. He did a remarkable job in bringing all the members of the Steering Committee at Trichy. I extend my warm welcome to Dr. Molina.

Dr.Nicolas Roux, Project Manager of Genetic Resource Management Programme at Bioversity International is also with us. I extend a warm welcome to this Steering Committee Meeting of BAPNET.

I also welcome all the delegates of BAPNET SCM from different countries of Asia Pacific Region which is a hot-spot of the diversity of banana and where 2/3 of the banana is cultivated. I extend my warm welcome to all the delegates of BAPNET SCM. I also welcome the delegates of Taxonomy Advisory Group to this BAPNET SCM Inaugural Meeting.

I also extend my warm welcome to the Press and Media who have gathered here to cover this international event, without them the message will not reach the masses. I welcome all the press people. Last but not least, I extend my warm welcome to the Scientists and other staff members of NRCB without them this international event could not be arranged successfully.

Once again I extend my warm welcome to one and all to Tiruchirapalli, a Rock City of Tamil Nadu and wishes for a pleasant Stay.

Thanking you.

Message

DR. AGUSTIN B. MOLINA , Regional Coordinator
Bioversity International—CfL Asia Pacific and Oceania

Honorable Dr. HP Singh, deputy-director of the Indian Council on Agricultural Research, and presently the representative of India to the Steering Committee of BAPNET, and this year's Chairman of the Steering Committee; Dr. Mustaffa, the hardworking director of the National Research Centre on Banana; Dr. Nicolas Roux, project manager of Bioversity's *Musa* genetic resources research and management; respected members of the media who are here today; colleagues who are participating in the Taxonomy Advisory Group meeting; colleagues in Bioversity International; the dynamic and competent scientists and staff of NRCB, our primary institution partner in India; and last but not the least, my esteemed colleagues in the Steering Committee of BAPNET - the backbone in the pursuit of advancing banana research and development in the region, the fruits of which, will provide for the resource-poor banana growers a system by which we could help provide for their needs in the alleviation of their incomes and ultimately, upliftment of their livelihoods

I can not emphasize enough how important bananas are to the lives of millions of rural folks in Asia and the Pacific. We do not need look far because we are in India, the world's top producer and consumer of bananas. In Asia like Africa, most of the bananas are produced by small scale growers for food and income, and therefore anything we do to advance the production and profitability of this crop greatly resonates in the daily living of this marginalized sector of our society.

This year's meeting of the Banana Asia Pacific Network (BAPNET) Steering Committee is crucial as we once more address critical challenges that are facing the banana industry in Asia and the Pacific today. We need to review and look at our concerted efforts in facing these challenges, and how our network continues to play the role of collaboratively enhancing and advancing banana R&D in our region, and how we benefit from research collaborations from other regions and parts of the world as well, and vice-versa.

In a strategic approach, Bioversity has given importance to the development and maintenance of a functional regional network, where the spirit of regional collaboration fuels a synergized banana R&D making it easier among regional and national partners to solve common problems. BAPNET was created to provide that platform of regional collaboration, and also serves as an essential and efficient mechanism for Bioversity to achieve its goals and objectives.

Because of the importance of *Musa* diversity to the Region, Bioversity International Commodities for Livelihood's banana program (formerly INIBAP) and its BAPNET partners, have placed particular emphasis on supporting and pursuing regional efforts in *Musa* germplasm collection, conservation, characterization. I am glad to note that with the participation of BAPNET during previous Steering Committee meetings, we were able to help develop a global project of *Musa* conservation through the Conservation Trust Fund that is now going to be implemented in Asia-Pacific. Listening to our colleagues during the discussions in the TAG meeting, there really is an urgency to understand and conserve our *Musa* diversity. However, an equally important, if not more pressing, issue for us in the Region, is how to promote and protect the use of genetic diversity by farmers for income, food and livelihoods. Today in Asia, the dreaded and virulent Tropical Race 4 of Panama Wilt , the major production threat to Cavendish and many popular local cultivars, is spreading and is posing a real threat to the banana production both for local and export markets. Recently it has been found in the two major Cavendish-producing countries: China and the Philippines. The order of priority is containing the spread of this virulent pathogen within the country where they now occur, and preventing its spread to countries where they are not yet found. It is significant to note that there has been no report of TR4 in India and other countries in Asia. Mitigating the threat of this disease is a priority of our Region.
Thank you very much, and I look forward to a very productive meeting.

I hope that we will address this concern during the course of our meeting. Of course, there are other concerns and opportunities that we can work on in this meeting. It is interesting to note that after our BAPNET meeting, a conference addressing production and fruit quality management will also be held here in Trichy. This area of discussion in banana is certainly important if we are to further enhance the banana-growers' opportunities for income.

One final note: I believe it is timely and relevant that during the meeting, we'd be able to address the sustainability of the Network and how we can improve on its efficiency. This is highly important in view of recent restructuring and program realignment of Bioversity International. BAPNET remains to be significant partner in the way Bioversity International does its business, but we have to rationalize this partnership in view of new challenges and dynamics of international collaboration with the aim of further improving our ability to serve the banana farmers and those that depend on the crop.

Finally, I would like to thank Dr. Singh, Dr.Mustaffa and his NRCB staff for the wonderful preparation and arrangement for this meeting and their generous hospitality.

Inaugural Address

DR.H.P. SINGH, Deputy Director General (Hort)
Indian Council of Agricultural Research , & Chairman, Steering Committee BAPNET

Dear Dr. Augustin Molina, Dr. Nicolas Roux, BAPNET Delegates, distinguished representatives of different countries, TAG Participants, my colleagues Scientists, ladies and gentlemen.

At the outset, I would like to congratulate the recipients of the Pisang Raja Awards in recognition of their outstanding contribution to the banana research and development in respective countries. Way back to 1996, We had a meeting of BAPNET in the same hotel, then ASPNET, as already explained by Dr. Molina. At that time, two awards were conferred one to me and other to Dr. K.L. Chadha, the then DDG (Hort). Since then there have been a quantum jump in the contribution to the banana research and development. Earlier, banana research was in private sector but starting of INIBAP has provided global focus, as banana support the livelihood of million of people across the globe. I must compliment all those who are associated to take the cause of the banana. Network program which was initiated under IPGRI in 1985 as INIBAP had brought the focus and I was happy to be associated since 1988. We had an excellent understanding with Dr. de Lange and Dr. Nicolas and subsequently with Dr.Emile Frison, who took over around 1996 and then moved to Bioversity International as DG. He also visited NRC, Banana in 1996 and subsequently to Chennai and New Delhi.

In the last 20 years, definitely, there has been a lot of appreciation about banana owing to its contribution to livelihood of people. It is not only a crop of export, but it is food for people in many parts of the world, especially in South African countries. Even in India, plantains are grown which is used in breakfast and many of the items are used as food. About 9 years back, there was a news that '**banana is in the way for extinction due to diseases'**. This has brought worldwide attention.

Indian agriculture and horticulture has made rapid stride and the production and productivity has increased manifold. But the challenge continues to be more than before. We have to produce more from shrinking land and declining water. It is recognized that the climate is changing. There has been 11 hottest years in the last one decade. The climate change will result in increased temperature and unpredictable weather and also new pathogens. More and more biotic and abiotic stresses are likely to come. The solution against these problems will come from the effective utilization of diversity. Throughout the world race 4 of fusarium in banana has been a serious threats. Earlier it was identified in Taiwan, Republic of China and is now a serious problem in many countries, where Cavendish group of banana is grown. China has lost larger area of banana due race 4. Fortunately we are free till date. But, we do not know it may appear. Thus this needs more attention. The pathogen does not have any barrier of political boundaries and can move from one side to another. This is a very important issue which requires to be addressed collectively. Similarly, as I said, the climatic change across the world is talked about, we have organized several conferences on Climatic Change and have made programmes on adoption and mitigation. About four weeks back, we deliberated for two days about the impact of climate change on horticultural crops. There also, we could see that both advantages and disadvantages are likely to come. Advantages would be in terms of more photosynthesis due to increased carbon dioxide level but increased temperature and uncertainty of weather may be devastating.

There is a thinking to change C3 plant to C4 plant, which can be more efficient. Can we think it for banana also so that under high temperature it can produce more. With this change there could be high productivity even with minimum inputs under high temperature conditions. This issue need to be addressed because all the indications are that the major impact of the climate change will be on Asia and Pacific zone, where there will be more increase in temperature. This is another area which we should think seriously, and a solution can come from utilization of diversity. *Musa burmonicoide*s, which

have been a major gene source against leaf spot disease, originally from India, can be used for genomic restructuring of cultivated banana. That may be the wonderful thing, which will help to safeguard cultivated banana. Similarly, we have certain germplasms which are having immune system for "Wilt". Can you think in the context of genomic restructuring? When we talk about the likely problems, the gene revolution will give a lot of solutions. Not only the transgenics, but we can use as a breeding tool. We can speed up the process to resolve the difficulties faced in banana breeding.

Crop production problem seems to be almost same in all the regions. Thus, there are many issues where we can work together as a region. I definitely find that the problems are relating to each other and definitely the partnership mode is going to help us. Of course, in the deliberations you may be discussing the specific points from the different countries. But I again urge upon the Coordinator as well as Dr. Nicolas that we require more attention on banana that we have paid in the past. Because, I have seen some of the data produced by INIBAP itself that banana is the 4th largest food crop in the world after rice and wheat, and can add to food security system for many of the countries. Thus, banana can also be focused as food security item to attract many of the donors for funding in research and development of banana. Focus has to come about livelihood of people. Banana is a crop of small and marginal farmers. In India, 95% of banana growers have small holdings. There are rarely very big farms, more than 4-10 hectare. There are many challenges we have to face together and one of the challenges, I could identify is climate change. BAPNET should discuss and deliberate upon likely impact of the climate change, what kind of adoptive mechanism we should have, what kind of mitigation technologies we are likely to do and at the end of the meeting, we must have action plan. I am sure with the leadership of Dr.Molina and Nicolas from Bioversity and many of the distinguished experts from different parts of the world, the banana will continue to be the crop to support the livelihood of millions of people in the world.

India has large diversity in banana in the country. But, there has been limited work in past. Recognizing that banana is very important for the livelihood, some research initiatives were taken up way back in the 40's. But systematic research on banana was started in 1971 as the network programme under All India Coordinated Research Project. In 1993, we had National Research Centre for Banana at Trichy, and this is one of the institutes in the world exclusively working on banana. Recently, we have also launched several programmes, cutting across the disciplines Programmes on phytopthora and fusarium wilt have been initiated which also includes banana. As far as genomics are concerned in banana, I think INIBAP was the first to identify that the understanding of genomes is very essential and I am told that lot of work have been done. In India, we have completed the genomic understanding of rice. After understanding the total genomic system, we have been in a position to develop varieties very fast. Similarly, now we have another big programme running on the genomics of tomatoes, there also, we have moved quite fast. Recently, in the network mode, where different countries are partners, we have started on potato. Similarly our work in the genomics of banana has to be speeded up, then only, we can take and utilize the genes for the betterment of banana varieties, which will go in a long way for the betterment of the people across the world.

With these few words, I thank Dr.Molina for agreeing to host this meeting here. Thank you Dr.Nicolas, for coming all the way here for the discussion on taxonomy of banana which provided the opportunity for the Indian scientists to have interaction. Thank you all the delegates for the patient hearing. I wish you a fruitful meeting and comfortable stay.

Jai Hind.

Pisang Raja Awards

In this year's Network meeting, *Pisang Raja* awards were given to four partners in the Region who have shown exemplary capacity and service in advancing banana research and development in their respective countries and in the Regon as well. The awards were given by Bioversity International Commodities for Livelihoods Regional Coordinator for Asia and Pacific and BAPNET Executive Secretary Dr. Agustin Molina, and Deputy- Director-General (Hort.) of the Indian Council of Agricultural Research and BAPNET Chair Dr. HP Singh.



BIOVERSITY INTERNATIONAL
Commodities for Livelihoods

and the

BANANA ASIA PACIFIC NETWORK (BAPNET)

hereby confer this

Pisang Raja Award

to

DR. NIK MASDEK

In honour of his long and dedicated service as an active member and representative of Malaysia to the Steering Committee of BAPNET:

In recognition of his active and significant role in the host-country organization of several Bioversity International-sponsored international and regional symposia and training programs in Malaysia, among which, were the International *Musa* Testing Programme (IMTP) – Sigatoka Protocol Training Workshop (2000), the *Musa* Germplasm Information System (MGIS) Training Workshop (2003), the International Congress on *Musa* (2004), and the Fusarium Training Workshop (2006);

In acknowledgement of his active collaboration in the implementation of Bioversity/BAPNET collaborative activities among which, are the IMTP, the establishment of National Repository, Multiplication, and Duplication Centres (NRMDCs), and recently, the regional survey and characterization of Tropical Race 4 in the Region;

In grateful appreciation of his role in setting the network's research and development agenda by actively participating in all BAPNET meetings since its re-launching in Sri Lanka in 2001;

Given this 24th day of October 2008 at the National Research Centre on Banana, Trichy, India on the occasion of BAPNET's 6th Steering Committee meeting.

AGUSTIN B. MOLINA, JR.
Regional Coordinator
Bioversity International CfL-AP

HP SINGH
Chairman
BAPNET Steering Committee

The International Network for the Improvement of Banana and Plantains (INIBAP) and the International Plant Genetic Resources Institute (IPGRI) operate under the name, Bioversity International.



BIOVERSITY INTERNATIONAL
Commodities for Livelihoods

and the

BANANA ASIA PACIFIC NETWORK (BAPNET)

hereby confer this

Pisang Raja Award

to

DR. S. UMA

In honour of her dedicated service as a long time partner in *Musa* conservation, characterization and use within the framework of BAPNET/ProMusa collaboration;

In grateful appreciation of her role in the evaluation and promotion of improved varieties through her active participation in the International *Musa* Testing Programme (IMTP), and in promoting awareness towards *Musa* conservation;

In recognition of her active service as head curator of the field collection of the *Musa* genebank at the National Research Centre on Banana (NRCB), Trichy, Tamil Nadu; and as project leader in the exploration mission and collection of *Musa* germplasm in north and northeast India, a joint project with Bioversity International;

In sincere gratitude for her active participation in many international and regional banana research and development meetings/symposia in the framework of ProMusa, the latest of which, as an active member of the Taxonomy Advisory Group (TAG), a subnetwork of ProMusa;

In acknowledgement of her significant role in authoring/co-authoring several books, manuals and articles on bananas in India.

Given this 24th day of October 2008 at the National Research Centre on Banana, Trichy, India on the occasion of BAPNET's 6th Steering Committee meeting.

AGUSTIN B. MOLINA, JR.
Regional Coordinator
Bioversity International CfL-AP

HP SINGH
Chairman
BAPNET Steering Committee

The International Network for the Improvement of Banana and Plantains (INIBAP) and the International Plant Genetic Resources Institute (IPGRI) operate under the name, Bioversity International.



BIOVERSITY INTERNATIONAL
Commodities for Livelihoods

and the

BANANA ASIA PACIFIC NETWORK (BAPNET)

hereby confer this

Pisang Raja Award

to

MS. ROSA KAMBUOU

In honour of her significant contribution to the advancement of banana research and development in Papua New Guinea (PNG) in her capacity as a leading plant genetic resources scientist, and as head curator of the *Musa* collections of PNG;

In sincere recognition of her leadership and active role in collaborative activities, particularly in the area of *Musa* collection, conservation, characterization, and promotion of use; for her active participation in the collaborative project of mitigating the threat of Fusarium wilt in PNG, a project funded by the Australian Centre for International Agricultural Research (ACIAR) and coordinated by Bioversity International; for leading in organizing and implementing relevant banana research projects such as the Banana Agriculture, Science, Technology, Innovations (ASTI) Systems Case Study in PNG that paved way for an innovative system of advancing national banana research and development .

In sincere appreciation of her active participation and representation of PNG to the BAPNET Steering Committee since 2001 to present;

Given this 24th day of October 2008 at the National Research Centre on Banana, Trichy, India on the occasion of BAPNET's 6th Steering Committee meeting.

AGUSTIN B. MOLINA, JR.
Regional Coordinator
Bioversity International CfL-AP

HP SINGH
Chairman
BAPNET Steering Committee

The International Network for the Improvement of Banana and Plantains (INIBAP) and the International Plant Genetic Resources Institute (IPGRI) operate under the name, Bioversity International.



BIOVERSITY INTERNATIONAL
Commodities for Livelihoods

and the

BANANA ASIA PACIFIC NETWORK (BAPNET)

hereby confer this

Pisang Raja Award

to

DR. MOHAMMED MUSTAFFA

In honour of his significant contribution to the advancement of banana research and development in India in his capacity as scientist and director of the National Research Centre on Banana, a centre under the Indian Council for Agricultural Research;

In recognition of his active role in the organization of international and national banana conferences, the latest of which, were the National Conference on Banana (2007), and the International Conference on Quality Production of Bananas for Domestic and Export Market (2008), that benefit the advancement of the banana industry in India in particular, and Asia-Pacific and the world, in general;

In sincere appreciation of his active participation in, and representation of India to, the BAPNET Steering Committee from 2002 to 2007;

Given this 24th day of October 2008 at the National Research Centre on Banana, Trichy, India on the occasion of BAPNET's 6th Steering Committee meeting.

AGUSTIN B. MOLINA, JR.
Regional Coordinator
Bioversity International CfL-AP

HP SINGH
Chairman
BAPNET Steering Committee

The International Network for the Improvement of Banana and Plantains (INIBAP) and the International Plant Genetic Resources Institute (IPGRI) operate under the name, Bioversity International.

Country Presentations

AUSTRALIA

AUSTRALIAN BANANA R&D ACTIVITIES

Mr. Robert Williams, Science Leader
Department of Employment, Economic Development, and Innovation

The major banana producing areas in Australia are shown in Figure 1.

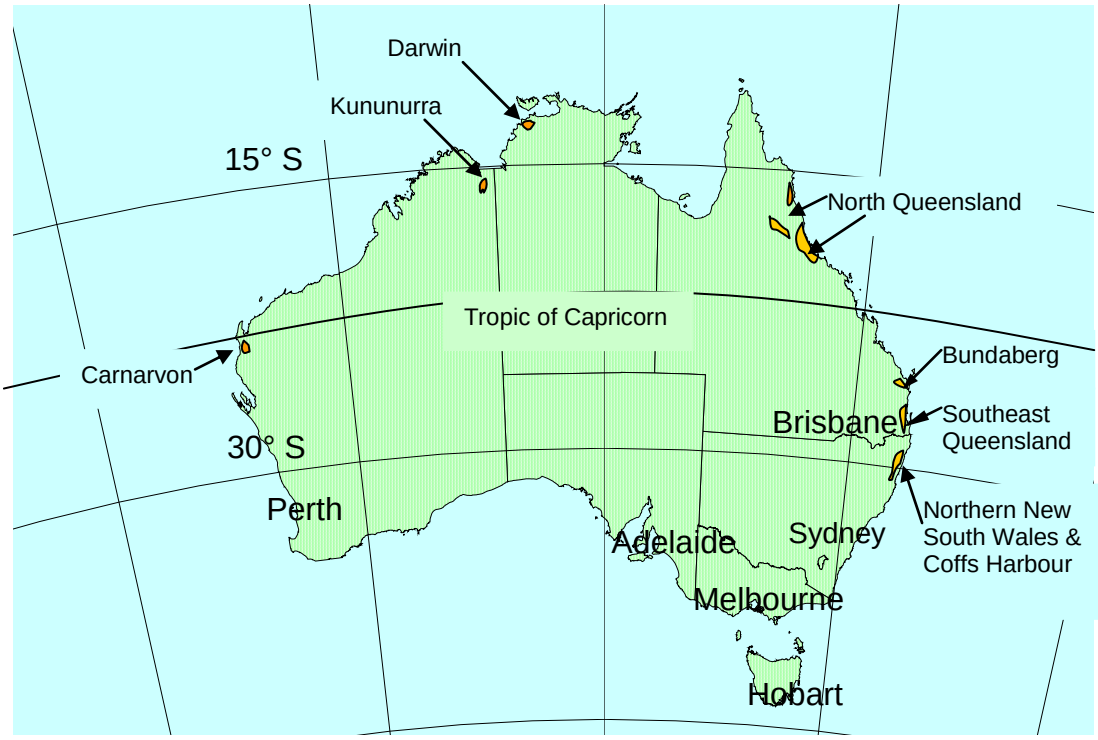


Figure 1. Banana producing areas in Australia

Priority Activities for Australian Banana

1. Production systems
2. Grow & market bananas that satisfy consumer needs
3. Improved value chains
4. Tailored marketing and promotion
5. Strengthen industry unity

Activities:

1. Production systems – Profitable, competitive & sustainable.
    - Soil & Plant Health
    - Biosecurity
    - Labour supply
    - Marketing based production systems
    - Externalities to the production system

2. Grow & market bananas that satisfy consumer needs.
    - Fruit quality & taste
    - New Varieties
    - New products
    - Innovative packaging

3. Improved value chains.
    - Crop forecasting
    - Product description language
    - Integrated logistics & transport planning

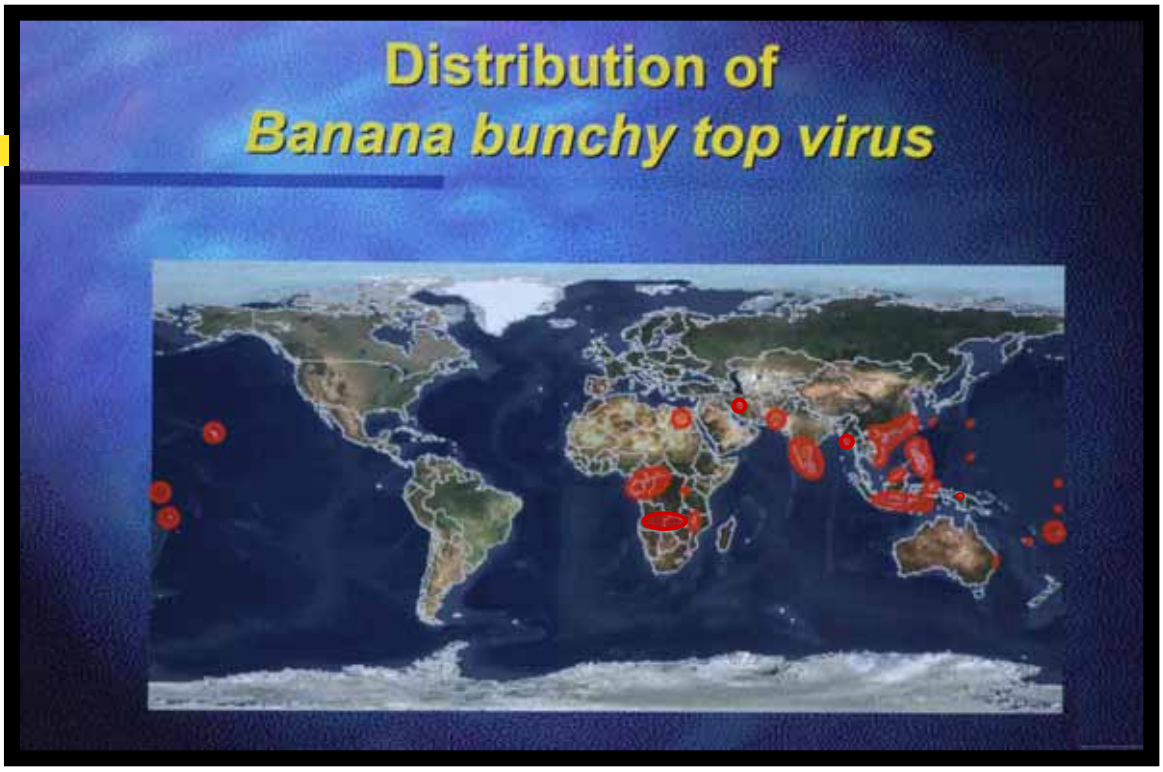
4. Tailored marketing and promotion.
    - "Aust Banana"
    - Promote diversification
    - Improve market knowledge

Strengthen industry unity.
    - Industry strengthening initiatives
    - Enhancing communication
    - Leadership and succession planning
    - Facilitate industry development

<u>Current Initiatives</u>

- Poster on biosecurity & training
- BBTV Eradication from Australia
- Banana Crop Forecasting
- Re-engineering the Banana Production System

BBTV Eradication



Spread of the virus:

Long distance—through transfer of planting material

- To Australia and Sri Lanka in 1913 in suckers from Fiji
- New Caledonia ca. 1999 probably from suckers from nearby island

Local – through aphids (mostly) and planting material

BBTV History in Australia

- 1913 introduced to the Tweed River area
- 1916 Currumbin
- 1923 Brisbane, Richmond River
- 1925 Caboolture
- 1927 Grafton to Yandina

Factors Favoring Eradication Now

- 5 - 7 years of drought
- Decline in the production area
- Significant increase in urban development
- Desire by industry to eradicate.

Critical factors for control

- Effective quarantine
- Location of all plants
- Efficient visual inspection
- Adequate inspection interval
- Prompt eradication

Effective quarantine

- Regulatory powers set by Government
- Inspectors
- Clean planting

Banana Crop Forecasting

Banana Crop Forecasting Sytem - the prediction or forecasting of future production supplies. It aims to forecast for 3 – 5 months in advance. It is a computerised system using software for business computers & the internet.

3 main options for crop forecasting:

- Climate-based heat sum method
- Fruit growth measurement
- Historical bunch filling periods

Forecasting is based on weekly bell injection numbers and other farm data:

- Crop area treated
- Estimate of field losses (%)
- Estimate of packout ratio (boxes/bunch)
- Current harvest records

A predicted bunch emergence to bunch harvest interval for each week of the year in a range of localities (historical data).

The system makes individual and industry forecasts through: a) Farm forecasts on business PC's; b) Industry forecast created by uploading individual business information to internet-based database; c) Industry forecast accessed at the BCFS website.

Figure 2 shows an example of forecasting system.

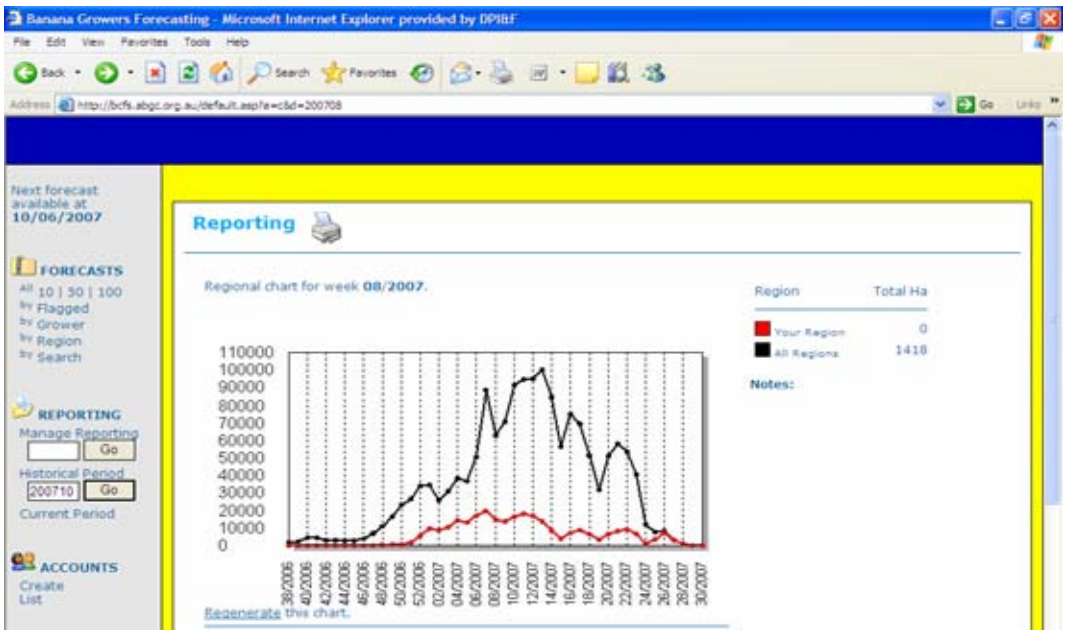


Figure 2. Banana growers forecasting

Re-Engineering Banana Production System

For the Australian banana industry to be internationally competitive, it must address external constraints, i.e.:

Profitability
Impact of farming on the environment
Labour costs and supply
Energy use
Market access and expectations.

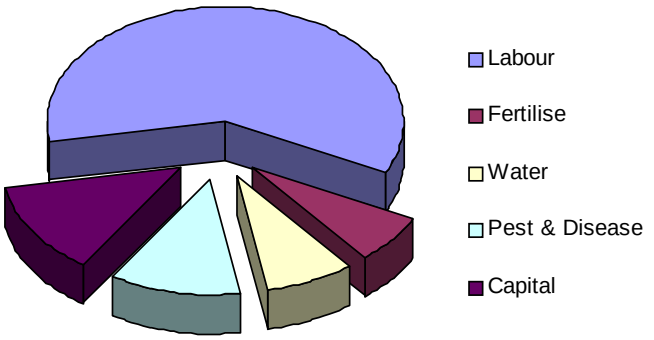


Figure 3. Production costs

Objectives:

- To compare aspects of crop phenology for sequentially planted banana plantlets at differing density and planting arrangements with a conventional sucker and bit planting over several crop cycles

- Observe seasonal variations in pest and disease incidence associated with the treatments

- Demonstrate and monitor nutrient BMP's and associated biophysical impacts (subject to funding**)**

BANGLADESH

BANANA RESEARCH AND DEVLOPMENT IN BANGLADESH

Dr. Abdul Hoque , Chief Scientific Officer
Horticulture Research Centre, Bangladesh Agricultural Research Institute

Bangladesh is an agricultural country. It has an area of 144,000 sq km between latitudes 20.5^{o} and 26.5^{o}N and longitude 88.5^{o} and 92.5^{0}E. The land can be classified as 79% flood plain, 12.6% hilly areas and 8.3% terrace soils. The P^{H} of soil ranges from 4.5 to 6.5. It has a subtropical monsoon climate with temperature ranging from 4^{0}C in winter to 42^{0}C in summer and an average temperature of 27^{0}C. July is the hottest and January is the coldest month. Cold waves are frequent in winter. Low temperature for 2-3 months causes injury to banana, particularly in the northern part of the country. Annual rainfall varies from 100 mm in the west to 2500 mm in the southeast. Three quarters of the rainfall occurs in the hot and humid months of June to September. There are three distinct seasons; winter (Nov.to Feb), summer (March to May) and rainy (June to October) in the country.

Banana is the number one fruit in Bangladesh in terms of its year-round availability, popularity and production. It is an important and cheap fruit among the rural poor people. It accounted for 4% of the total fruit production, but occupied only 24 % of the total fruit area. Area and production of banana for the last 7 years are given below.

Table 1. Area and production of banana (2000-2006)

Year	Area (000 hectare)	Production (000 M tons)
1999-2000	40	572
2000-2001	42	606
2001-2002	44	654
2002-2003	45	649
2003-2004	49	706
2004-2005	53	898
2005-2006	56	909

Commercial cultivars

Amritsagar (AAA group): Amritsagar is the most popular table banana of Bangladesh. Plants are medium sized, weak and cannot withstand strong winds. The ripe banana develops a bright yellow colour. The pulp has a good taste. The bunch has 5-7 hands and 12-13 fingers in each hand.

Sabri (AAB group): Syn: Malbhog, Onupam, Martanan. It is like the Rasthali of India. This is a favourite table variety and is a delicacy. According to some consumers, it is superior to Amritsagar. The plant is tall and can be identified by the yellowish green pseudostem. Bunch weight is about 10 kg. A bunch contains 85-120 fingers. Fruits are medium sized with a thin peel, ivory yellow in colour, flesh is firm in texture, sweet and very tasty. It is highly susceptible to panama wilt which threatened its cultivation and cannot be cultivated more than 2 to 3 times in a ratooning system. The other demerits are easy dropping of ripe fruits from the hand and formation of hard lumps in the pulp. This is widely grown in the north and western areas of Bangladesh.

Champa (AAB group): Champa is one of the hardiest, tall cultivars grown all over the country under the rationing cultivation system. Its cultivation is extensive in Chittagong and Chittagong Hill Tracts. It can be cultivated under rainfed condition or with scanty irrigation. One of the distinguishing characters of the plant is the rose pink colouration of the outer side of the midrib when young. The plant is tolerant to panama wilt and fairly tolerant to bunchy top diseases. Fruits are small in size with thin peel, creamy pulp and subacid taste. Fruits turn golden yellow when ripe and have excellent keeping quality. The bunch contains 150-250 fingers and its weight is about 16 kg. One high yielding variety has been developed through selection from local collection and released in the name by BARI Kola-4.

Kabri (AB group): The plant is hardy and can be grown without much care. The ripe banana is very sweet, with a light yellow to yellow skin colour and contains a few seeds in most cases. One high yielding variety has been developed from kabri germplasm through selection and released as BARI Kola -3.

Mehersagar (AAA group): The plants are semi-dwarf. Fruits are large, greenish to dull yellow colour when ripe. The flesh is soggy and sweet. The keeping quality of the fruits is poor and the market price is low. The average bunch weight is about 15kg. It is highly susceptible to leaf spot but resistant to wilt.

BARI Kola -1: It is high yielding variety developed through selection. Bunch weight is 25kg. Fruits are big, yellow at ripen and sweet in taste. At present it is number one variety due to its high yield.

Seeded banana: There are many seeded cultivars growing carelessly in the homestead areas, roadsides and forests all over the country. These are tall cultivars, produced large bunch and are grown mostly in the backyard. Plants are hardy and drought tolerant. Fruits are very sweet. Usually poor rural people eat these bananas. Its inflorescence is eaten as vegetable.

Plantain (AAB or ABB group): Plantain is grown in the backyard. Plants are hardy and drought tolerant. Nine cultivars of plantain are being grown throughout the country. Fruits are in different shapes, sizes and colour with different cooking qualities. A bunch, on an average weight is 8.7kg and contains 53 fingers. BARI has selected FHIA-3 as a variety of plantain in the name of BARI Kola -2.

Major constraints

Lack of high yielding varieties: Bangladesh has more than 15 cultivars of dessert bananas but commercial cultivars are Amritsagar, Sabri, BARI kola -1, BARI kola -4. All these varieties are poor yielder and very much susceptible to diseases.

Lack of quality planting materials: Farmers knowledge on quality planting material is poor. Moreover, Tissue cultured plants are not available sufficiently.

High incidence of diseases: Disease is one of the major problems of banana cultivation in Bangladesh. The fetal diseases are Fusarium wilt, Sigataka and Bunchy top. Most of the local cultivars are susceptible to Fusarium wilt. Sigatoka is common to all cultivars which can be controlled by spraying fungicide. Bunchy top is a serious viral disease which can not be controlled except uprooting and destruction of infected plants. It is practiced in commercial orchard only. Bunchy top infected plants are randomly seen in non-commercial areas which is the source of virus dissemination.

Post-harvest management: The post-harvest losses of banana in Bangladesh are high (20-30%). This is mainly due to the delicate nature of the fruit when it ripens and lack of suitable infrastructure for transport from production point to consumers. Banana cheeps are the processed products marketed in Bangladesh. Due to rainfed cultivation, cyclones and monsoon storms, bananas have to be grown at the same period, resulting to over supply in the market during harvest season. Natural ripening of banana is done for home consumption only. Ethrel spray is the common method for ripening banana. Traders are

usually spraying ethrel on the whole bunch before loading it on the truck for shipment to the market. Sometimes immature bunches are harvested. Heat treatment is another method to hasten ripening banana. In this system the firmness or texture of banana is partially damaged due to high temperature. About 10-15% bananas are damaged within a day due to overheating. Fruit colour also becomes pale.

Research Activities

Development of high yielding varieties: Local cultivars have been collected for characterization and evaluation with a view to find out the high yielding disease tolerant varieties. Attempt has already been taken to collect the lines from exotic sources too. In this respect, 23 accessions were collected from International Transit Centre (ITC) in Belgium for field evaluation. The results of evaluation trial are given below.

Materials and Methods

Six exotic banana varieties and five hybrid lines were included in this study along with a local cultivar Sabri. All the exotic germplasm were collected from International Transit Centre of Musa Germplasm, Belgium with the help of INIBAP. The experiment was laid out in RCBD with three replications.

Growth characteristics

A highly significant difference was found among the accessions in respect of crop duration (planting to harvest) (Table 2). ITC 1264 took maximum duration (683 days). The accession ITC 1123, ITC 1418 and ITC 1283 required more than 600 days to complete their life cycle. The rest of the accessions including local Sabri took 311 to 383 days. ITC 1123 produced the tallest plant (3.50m). The shortest plants were produced by ITC 570 (1.55m) closely followed by ITC 712 (1.67m). The plant height of Sabri was 2.84m. The maximum number of functional leaves at flowering was recorded in ITC 570 (17.17) closely followed by ITC 1320 (15.90) while ITC1283 had minimum number of leaves (7.67).

Table 2. Growth parameters of banana germplasm

Germplasm	Accession name	Crop (days)	Plant height (m)	Pseudostem girth (cm)	Green leaves at shooting (number)
ITC 1441	Pisang Ceylon	324 fg	2.86 c	48.43 d	14.90 bc
ITC 570	William	333 efg	1.55 g	44.83 e	17.17 a
ITC 611	Pisang Berlin	358 def	2.03 e	33.57 f	12.67 d
ITC 712	Rose	311 g	1.67 fg	24.83 g	11.33 de
ITC 1320	B-7925	372 de	2.08 e	50.53 d	15.90 ab
ITC 1418	FHIA -25	621c	2.69 c	75.13 a	13.27 cd
ITC 1283	SH 3436-9	635 bc	3.08 b	62.00 b	7.67 f
ITC 1264	FHIA -17	683 a	3.25 b	57.67 c	12.10 de
ITC 180	Grande Naine	347 defg	1.78 f	36.67 f	13.33 cd
ITC 1271	GCTCV-215	383 d	2.32 d	62.33 b	8.83 f
ITC 1123	Yangambi Km -5	666 ab	3.50 a	63.00 b	11.43 de
Local	Sabri	350 defg	2.84 c	42.67 e	10.67 e

Note : The figures in the same column marked with different letters are significantly different at 5% level.

Yield and yield contributing characters

The highest yield per hectare was received from ITC 1418(77.09 t) but it took 621 days in the field. The lowest yield was recorded in ITC 712 (8.36 t). Medium yield was recorded in other varieties ranging from 33.18 to 43.37 t. The germplasm ITC 1418 produced the heaviest bunches (30.84 kg). ITC 1418 produced the highest number of hands per bunch (14.70). Sabri produced the lowest number of hands per bunch (6.00) which was similar to ITC 1264 (7.17)and ITC 611 (7.33). The rest of the varieties had 7.50 to 9.83 hands/bunch. The highest number of fingers was recorded in ITC 1418 (268.1) and the lowest in Sabri (99.0).

Table 3. Yield and yield contributing characters of banana germplasm

Germplasm	Yield/ha (t)	Bunch weight (kg)	Hands/bunch (number)	Fingers/bunch (number)
ITC 1441	36.11 de	14.44 de	9.83 b	162.9 b
ITC 570	37.75 cd	15.10 cd	8.67 bcd	145.3 bc
ITC 611	11.85 f	4.74 f	7.33 cde	115.6 cd
ITC 712	8.36 g	3.34 g	8.17 cd	117.5 cd
ITC 1320	43.37 b	17.35 b	7.63 cd	121.2 cd
ITC 1418	77.09 a	30.84 a	14.70 a	268.1 a
ITC 1283	33.57 e	13.43 e	8.67 bcd	150.3 bc
ITC 1264	12.54 f	5.01 f	7.17 de	148.9 bc
ITC 180	34.58 de	13.83 de	7.67 cd	100.7 d
ITC 1271	40.84 bc	16.34 bc	8.77 bc	123.5 cd
ITC 1123	13.94 f	5.57 f	7.50 cd	176.0 b
Sabri	33.18 e	13.27 e	6.00 e	99.0 d

Note : The figures in the same column marked with different letters are significantly different at 5% level.

Fruit characteristics

Fruit characteristics, such as weight, TSS content, peel colour, sweetness and firmness are presented in table 4.

The highest individual fruit weight was recorded from the genotype of ITC 1320 (127.60g) closely followed by ITC 1271 (121.80g), Sabri (120.70g) and ITC 180 (115.10g). The highest TSS was observed in fruits of ITC 1123 (27.20%) closely followed by ITC 1264 and ITC 712. Besides, TSS more than 24% was recorded in fruits of ITC 1441 (25.50%), ITC 611 (24.20%) and Sabri (24.83%).

In Bangladesh, peel colour at ripening is an important character of dessert banana for acceptance to the consumers. The fruits of ITC 1441, ITC 611, ITC 712, ITC 1264, ITC 1123 and Sabri were yellow to deep yellow at ripening while others were light yellow in colour. Fruits having very soft texture were observed in ITC 1320 and 1418 while the fruits of other germplasm were firm to soft. The fruits of ITC 1441, ITC 611, ITC 712, ITC 1264, ITC 1123 and Sabri were sweet to taste while others were less

sweet.

Table 4. Fruit characteristics of banana germplasm

Germplasm	IndividualFruit weight (g)	Fruit length (cm)	Fruit diameter (cm)	TSS (%)	Peel color	Size	Firmness	Sweetness	Aroma
ITC 1441	76.77 cd	11.61 e	3.89 abc	25.50 bc	deep yellow	medium	firm	Sweet	Acceptable
ITC 570	91.40 bc	8.91 f	3.52 cd	22.46 e	light yellow	medium	soft	less sweet	Acceptable
ITC 611	35.13 e	9.01 f	3.21 d	24.20 d	deep yellow	Small	firm	Sweet	Non-Acceptable
ITC 712	23.13 e	19.74 a	4.11 a	26.33 ab	Yellow	Very small	soft	Sweet	Acceptable
ITC 1320	127.60 a	20.77 a	3.97 ab	21.50 e	light yellow	Big	Very soft	less sweet	Acceptable
ITC 1418	94.37 b	14.13 d	4.17 a	18.26 g	light yellow	Big	Very soft	less sweet	Acceptable
ITC 1283	71.83 d	13.42 d	3.93 abc	19.46 f	light yellow	medium	soft	less sweet	Acceptable
ITC 1264	22.30 e	7.70 g	2.64 e	26.33 ab	Yellow	Very small	firm	Sweet	Acceptable
ITC 180	115.10 a	18.45 b	4.17 a	22.23 e	light yellow	medium	soft	less sweet	Acceptable
ITC 1271	121.80 a	11.67 e	3.63 bc	25.50 bc	light yellow	medium	soft	Sweet	Acceptable
ITC 1123	21.03 e	6.25 h	2.52 e	27.20 a	Yellow	Small	soft	Sweet	Acceptable
Sabri	120.70 a	15.67 c	3.87 abc	24.83 cd	Yellow	medium	firm	Sweet	Acceptable

Note : The figures in the same column marked with different letters are significantly different at 5% level.

Insect-pest and disease reactions

Insect pest

No serious insect pest except leaf and fruit beetle was observed in the field. Even the infestation of this beetle was also low.

Diseases

Leaf spot diseases: Diseases on leaf spot (yellow sigatoka and black sigatoka) caused by *Mycosphaerella musicola* and *Mycosphaerella fijiensis* are the serious diseases of banana plants. Youngest Leaf Spotted (YLS) and Number of Standing Leaves (NSL) were presented in table 5.

YLS: The youngest leaf (5.17) attacked by leaf spot diseases was observed in ITC 1271 which was similar to sabri (5.33), ITC 1283 (5.50), ITC 180 (5.67) and ITC 570 (6.17). It indicated that these germplasm were most susceptible. On the other hand, the line ITC 1418 was highly tolerant showing decease symptom on the leaf number of 13.60 closely followed by ITC 1320 (12.83). Rest of the varieties were medium tolerant.

NSL: The highest number of standing leaves was recorded in ITC 570 (17.17) and the lowest in ITC 1283 (8.07).

Table 5. Leaf spot diseases of banana germplasm

Germplasm	YLS	NSL
ITC 1441	8.07 c	15.73 b
ITC 570	6.17 d	17.17 a
ITC 611	10.87 b	13.20 cd
ITC 712	11.00 b	11.33 ef
ITC 1320	12.83 a	15.90 b
ITC 1418	13.60 a	14.27 c
ITC 1283	5.50 d	8.07 h
ITC 1264	10.50 b	12.27 de
ITC 180	5.67 d	13.33 cd
ITC 1271	5.17 d	9.77 g
ITC 1123	10.90 b	11.60 ef
Sabri	5.33 d	10.67 fg

Note: The figures in the same column marked with different letters are significantly different at 5% level.

Other diseases: Other diseases such as panama (caused by *Fusarium oxysporum*), bunchy top virus and cucumber mosaic virus were not found among the varieties under this study.

The germplasm having more tolerance to leaf spot diseases were found either low yielding or to produce poor quality fruits. Considering crop duration in the field, yield potential, disease tolerance and fruit characteristics such as peel colour, firmness, sweetness, TSS and aroma, the germplasm ITC 1441 and ITC 1271 were found superior to others.

References

Anonymous. 1993.Regional evaluation of banana varieties. BARI annual Report, 361-362 pp.

Anonymous. 2000. Statistical Year Book. Bangladesh Bureau of Statistics. Dhaka. 161 p

Haque, M.A. 1988. Studies on the irrigation requirement of banana during dry months. Bangladesh J. Agri. 13(1): 59-60

Hoque, M.A. and M.R Ahmad. 2003. Performance of local and exotic banana varieties. Bangladesh J. Agri. Res. 28(1): 81-85

Islam, M.N., M.N. Islam, S.K. Saha, A. Quasem and A.K.M. Amzad Hossain. 1995. Evaluation of seven dessert banana cultivars. Bangladesh Hort. 23 (1&2): 45-48

Karim M.A., M.M. Hossain and A.K.M. Amzad Hossain. 1988. performance trial of seven table varieties

of banana at Jamalpur. Bangladesh J.Agril. Res. 13(1) : 37-40

Ortiz R., D. Vuylsteke, R.S.B. Ferris, J.U.Okoro, A.N Guessan, O.B Hemeng, D.K.Yeboah, K. Afreh – Nuamah, E.K.S Ahiekpor, E. Foure, B.A Adelaja, M. Ayodele, O.B. arene, F.E.O. lkiediugwu, A.N.Agbor, A.N. Nwogu, E. Okoro, G. Kayode, I.K. Ipinmoye, S. Akele and A. Lawrence. 1997. Developing new plantain cultivars for Africa plant varieties and Seed, 10: 39-57

Rashid, M.A. 1990. Regional evaluation of banana varieties. Annual Report fruit Improvement, BARI, Gazipur, 66-69 pp.

Saha, S.K. and M.Z. Uddin. 1992. Comparative performance of six dessert banana varieties at Jaintiapur, Sylhet, Bangladesh J. Sci. Res. 10 (1) : 43-48

CAMBODIA

Status of Banana Research and Development in Cambodia

Dr. Men Sarom, Dr. Preap Visarto, Dr. Sakhan Sophany and **Dr. Thun Vathany**
Cambodian Agricultural Research and Development Institute

Introduction

In Cambodia, banana is cultivated anywhere in the country stretching from the sea level to the highland regions, but it is predominantly found along the river banks and in the central and northeast highland regions of the country. Bananas and plantains (*Musa* spp.L.) are giant perennial herbs that thrive in the humid and subhumid tropics. They evolved from intra- and inter-specific hybrids of the two diploid wild species *Musa acuminata* Colla. and *Musa balbisiana* Colla. in the EuMusa series of the genus *Musa* (Simmonds and Shepherd, 1955; Simmonds, 1995). Banana fruits provide one of the major commodities in international trade, but they far more important as a starchy staple in local food consumption.

Banana plays a very important role in the daily diet of the Cambodian people. It is consumed fresh, but also eaten in processed forms like dried, boiled, fried and as cake. An economical and cultural crop, bananas are used in all religious and traditional ceremonies of the country. Regardless of the important contribution that bananas can play to the country's economy, investment in banana research is still very limited.

Currently, the production of banana in Cambodia is still a small-holding industry. A constant threat to the expansion of the crop is the damage caused by pests and diseases, such as fusarium wilt among others. Fusarium wilt caused by *Fusarium oxysporum* f. sp. *cubense* (Foc) has been reported a serious problem in Banana production world wide including Cambodia (Shin and Wen 2004 & Preap et al. 2006). In additional black and yellow Sigatoka are also found in some plantations in Cambodian (Preap et al. 2006).

National Repository

Cambodia is rich in genetic diversity of *Musa*. However, the fragility of the crop against vast changes in the world ecological conditions presents strong need for their protection from permanent disappearance. In this regard, the Cambodian Agricultural Research and Development Institute (CARDI) have taken special attention on the issue and significant progress has been made. Twenty three accessions introduced by INIBAP's project was tested and conserved to improve such as a kind of crop and it will make a significant contribution to the national research priority and poverty reduction program.

1. Collection

A total of 143 accessions of banana germplasm from six provinces of Kandal, Kampong Cham, Kampong Thom, Battambang, Pursat and Takeo were successfully collected in Cambodia during the last 4 years (2003-2006) (Table 1). Amongst those collected some are currently cultivated by the farmers for food, for medicine, and also wild types (Fig. 1).



Fig 1 Collection activities

Table 1 Banana collection from 2003-2006 in Cambodia

No.	Type of Banana	Location							
		Kandal (2003)	Kampng Thom (2003)	Kampong Cham (2003)	Kandal (2006)	Kampong Cham (2006)	Battambong (2006)	Pursart (2006)	Takeo (2006)
1	**Namva**	3	-	2	1	-	1	-	-
2	**Namva Barang**	-	-	2	-	1	-	-	-
3	**Namva Damrey**	-	-	-	-	-	1	-	-
4	**Namva Thai**	-	-	-	1	-	-	-	-
5	**Ambong**	3	-	3	2	-	1	-	1
6	**Ambong Kraharm**	-	-	1	-	-	-	-	-
7	**Ambong Khmau**	-	-	1	-	-	-	-	-
8	**Ambong Kheav**	-	1	1	-	-	-	-	-
9	**Ambong Youn**	-	1	-	-	-	-	-	-
10	**Ambong Snaerng**	-	1	-	-	-	-	-	1
11	**Ambong Kposh**	-	-	-	-	-	-	1	-
12	**Ambong Toeu**	2	1	-	-	-	-	-	-
13	**Pong Moan**	2	-	3	2	-	1	-	-
14	**Pong Moan Pluk**	1	-	-	-	-	-	-	-
15	**Pong Moan Youn**	-	-	1	-	-	-	-	-
16	**Chvea**	3	3	2	-	1	1	-	-
17	**Cham Bdei**	-	1	-	-	-	-	-	-
18	**Chou**	-	-	1	-	-	-	-	-
19	**Damrei**	-	-	-	-	-	-	-	2
20	**Kreab**	-	1	-	-	-	-	-	3
21	**Kraham**	-	2	-	-	-	-	-	5
22	**Krarchark Andoek**	-	1	-	-	-	-	-	-
23	**Krarchark Chab**	1	-	-	-	-	-	-	-
25	**Kralarng Chom**	-	1	-	-	-	-	-	-
26	**Lak**	2	2	1	1	2	1	-	1
27	**Lak Sor**	-	-	-	-	1	-	-	-
28	**Meas**	1	-	1	1	1	-	-	-
29	**Moha Kal**	-	-	-	-	-	-	-	1
30	**Muoy Roy Snit**	1	-	-	-	-	-	-	-
31	**Meas Sgnuon**	1	1	2	2	1	-	-	-
32	**Morha Thlai**	-	3	1	1	1	-	-	-
33	**Nakry**	1	-	2	-	-	-	-	-
34	**Nuon**	3	-	-	2	-	-	1	1
35	**Nuon Kra-arob**	-	1	-	-	-	-	-	-
36	**Nuon Meas**	-	-	-	1	-	-	-	-
37	**Nuon Pesey**	-	2	-	-	-	-	-	-
38	**Prey**	-	-	2	-	-	1	-	-
39	**Paes**	-	1	-	-	-		-	-
40	**Phot Tro Yong**	-	-	-	-	1	-	-	-
41	**Rea Sei**	1	-	-	-	1	-	-	-
42	**Reach Sei**	-	1	-	-	-	-	-	-
43	**Snap Muok**	4	-	2	1	1	1	-	-
44	**Slat**	-	1	1	-	-	-	-	-
45	**Snaerng**	-	-	1	-	-	-	-	-
46	**Tuk**	3	-	2	-	-	-	-	1
47	**Yakuy**	-	-	-	-	-	-	-	2
Total		**32**	**25**	**32**	**15**	**11**	**8**	**2**	**18**
Grand Total									**143**

2. Characterization

Samples collected were characterized and also identified some existing specific traits such as tolerant to flood, sole stem and flower development. We found there were varieties which were tolerant to flood or could survive in flooding conditions for a long period of time. Those varieties are Chek Tuk, Chek Chvea and Chek Kreab. Some varieties produce no sucker such as Chek Cham Pdei, and early flower- Chek Pong Moan. Passport data of those germplasm have already been input into the database.

3. Conservation

All collected materials were conserved in a field gene bank at the institute field station. For protection from insect, diseases, draught and wind they are also planted in pots in the institute screen house. In vitro conservation was conserved all accessions introduce by INIBAP's project and few local samples. Unfortunately, in the early of 2008, growth chamber was broken by increased temperature so all plantlets germplasm died. On the other, because of laboratory moving and it is still establishing, banana tissue culture is not perform yet but (at the present day) there remains 40 accessions in tissue culture room (Fig. 2).



Fig 2 Conservation

Research Activities

1. Variety testing

In 2005, a varietal testing with 23 accessions from the International *Musa* Testing Programme along with 3 local varieties (Chek Namva, Chek Ambong and Chek Pong Moan) was conducted to assess fruit quality and yield potential.

The experiment was done in six locations in Siem Reap, Kampong Cham, Preah Vihear, Kandal, and CARDI. Trial was designed in Randomized Complete Block design (RCBD) with two replications. Plot size was 2m x 6m and spacing between plants was 2m x 3m. The overall size of the experiment was 16m x 23m (368 m^2).

The following data were collected during pseudostem height, pseudostem girth, days to flowering, number of sucker, bunch weight, number of hands, number of fingers, fruit weight, fruit length at maturity stage and yield.

Among the 26 entries, Williams yielded the highest with highest weight per bunch. Another 5 lines including FHIA-03, Gros Michel, TMBx 5295-1, FHIA 18 and FHIA 21 also provided higher yield compare to the local checks. However, despite that, local checks were still selected because of their preferred taste (Table 2).

Table 2 Result from an experiment with 23 varieties introduced from IMTP in 2005

No	ITC	Accession name	Mean		
			Yield t/ha	Weight/ bunch (kg)	Finger length (cm)
1	ITC.0312	Pisang Jari Buaya	3.25	3.90	9.50
2	ITC.0504	FHIA-01	2.33	2.80	6.50
3	ITC.0505	FHIA-02	2.24	1.35	6.88
4	ITC.0506	FHIA-03	16.68 ± 5.8	13.78	13.63
5	ITC.0570	Williams (Bell, South Jonhstone)	23.53	28.25	15.50
6	ITC.0643	Cachaco	13.68±5.38	11.18	16.25
7	ITC.0712	Aacv Rose	4.66	5.60	10.50
8	ITC.1122	Gros-Michel	22.07	26.50	8.85
9	ITC.1123	Yangambi KM5			
10	ITC.1264	FHIA-17	7.74	9.30	13.50
11	ITC.1265	FHIA-23			
12	ITC.1282	GCTCV-119			
13	ITC.1283	SH 3436-9	11.0	13.25	7.00
14	ITC.1296	TMBx 1378	8.33	5.00	8.75
15	ITC.1297	TMBx 5295-1	15.88± 10.2	16.48	18.50
16	ITC.1307	SH-3640	11.80± 7.9	8.95	14.50
17	ITC.1319	FHIA 18	15.28± 3.71	14.55	16.18
18	ITC.1332	FHIA 21 (# 68)	14.03± 2.5	12.10	20.67
19	ITC.1344	CRBP 39	8.47± 6.8	6.18	9.50
20	ITC.1418	FHIA 25	12.82	15.40	6.00
21	ITC.1441	Pisang Ceylan	11.99	7.20	10.85
22	ITC.1442	GCTCV-106	10.68± 4.1	8.75	9.75
23	ITC.1443	GCTCV-247	6.41± 5.5	4.60	5.25
24	CBT.0001	Chek Pong Moan	5.85±3.56	4.48	8.55
25	CBT.0002	Chek Ambaung	7.66± 3.88	6.08	15.13
26	CBT.0003	Chek Numva	13.97± 8.21	14.33	7.55

2. Fusarium Wilt survey

In 2007 a banana fusarium wilt survey was conducted in two provinces of Kampong Cham and Kandal at seven districts of *Saang, Kien Svay, Muk Kampoul (*Kandal*), Chamkar Leu, Tbong Khmom, Ponhear Krek,* and *Memot* (Kg. Cham).

Banana survey farms were prepared and used to evaluate banana production systems, from monoculture to mixed cropping. The monoculture is mostly a single variety (*Namwa*) farms. The farm size varied according to the farm owner; it varied from 500 sqm to 07 hectares. The incidence percentage of Foc was 26% with standard deviation of 20% in monoculture in *Chamkar Leu* district. However, in small farms or backyard crop in other six studied districts was lesser incidence. The highest Foc incidence was observed in oldest cropping.

A total of 171 samples of infected plants were collected from 30 surveyed farms to determine the fusarium pathogen. Samples were isolated for pathogen at CARDI's laboratory and the duplicated samples were sent to Pretoria University for VGC analysis.

Fusarium wilt incidence was recorded mainly in *Namwa* variety. Along with Fusarium Wilt, black and yellow sigatoka and moko were also observed. However, the later appeared to be more a specific to type of banana. Moko disease was affected on *Ambong* variety while black and yellow sigatoka only occurred on *snab muk* variety (Table 4).

Table 4 Diseases occurrences in difference banana variety in Cambodia

Variety	**Disease**			
	F. wilt	B.sigatoka	Y. sigatoka	Moko
Namwa	++	+	+	-
Pong moan	-	+	+	+
Ambong	-	-	-	+
Snabmuk	-	++	++	+

Constraints

The banana R&D in Cambodia faces tough challenges coming from different directions including:

Funding - Investment on research, in general but more particular on banana is very low in Cambodia
Infrastructure – Rural infrastructures including information centres, markets, processing factories, rural banking systems, roads and etc. are poorly available
Human Resource - Limited skills in banana research in Cambodia is one of the major factors responsible for a slow progress in the development of the industry
Pest and diseases - Many pests and diseases are found in the country which significantly affect the production and quality of the crop. Most predominant problems are *fusarium wilt* and nematodes, and
Information – General knowledge on banana as a plant is still very limited

Areas for future research

1. ***Collection and Characterization –*** Just a small proportion of banana cultivars and wild related species has been collected. Most of them has not been able to characterized and evaluated for specific traits important for future breeding activities
2. ***Conservation –*** Banana cultivars or all wild related species that have been collected are under threat of losing back, if this issue is not considered wisely
3. ***Variety Development –*** Development of new high marketable banana cultivars, high yielding, tolerant to major pests in the country, and suitable to new production technologies
4. ***Value adding -*** Development and/or extend widely of existing/indigenous/new processing technologies of banana
5. ***Pests and diseases monitoring/survey –*** Incidences of pests and disease are still not fully known for banana and *Musa* related species in Cambodia and just part of the country was included in previous studied about some potential diseases including fusarium wilt. This should be continued and expanded in a bigger scale, and

Human Resources Development - To provide a base for banana R&D in the country.

Conclusion

Start from a scratch, banana R & D in Cambodia has reached a significant success within the last few years. Significant number of cultivars have been collected and conserved in-vitro and in the field.

Some specific traits of some banana cultivars have been identified for either direct utilization or for breeding requirements in the future. Information on some banana diseases such as *fusarium wilt* has been documented. New introduced cultivars appeared to be not very attractive to local farmers unless

some production and processing technologies are coming along the line, and more investments on banana R&D are required.

Acknowledgement
The authors wish to thank to all individuals and/or institutions involved for a success story reported in this paper. Financial support provided by CARDI and INIBAP for the work is highly acknowledged.

References:
Shin- Hwang and Wen-Hsiung Ko. 2004. Cavendish Banana Cultivars Resistant to Fusarium Wilt Acquired through Somaclonal Variation in Taiwan. The American Phytopathological Society. Plant Disease/Vol.88 No. 6.

Preap V., Sim P. and Soeur S. 2006. Fusarium wilt survey report. Unpublished data.

Status, Challenges and Trends of Chinese Banana Industry

Ganjun Yi, Chunyu Li, Yuanli Wu ,Bingzhi Huang, Yuerong Wei
Fruit Tree Research Institute, Guangdong Academy of Agricultural Sciences, China

China is one of the origin centers of banana and it has been cultivated in China for more than 2000 years. In last two decades, banana has become one of the most important fruits in China, only inferior to apple, citrus and pear. Since 2003, the industrialization process of banana production has been promoted effectively through the implementation of "Banana Industrial Upgrading Plan" developed by Agricultural Ministry. On the other hand, Chinese banana production is still facing many challenges such as pests and diseases, adverse weather conditions and low level of industrialization.

1. Current Situation of Banana Production in China

1.1 Chinese share in world banana production and trade

Based on statistics from FAO, the area harvested and the production quantity of banana were 279,500 hm^2 and 7,053,000 t respectively in 2006. China is the third biggest banana producers around the world in terms of production quantity (Figure 1). As to yield per hectare, Chinese data (25.32 t/hm^2) is higher than world average, but much lower than Maldives (79.33 t/hm^2), which is the country with the highest yield per hectare in 2006. According to China Customs Statistical Yearbook, although China is one of the most important banana producing countries around the world, the imports of banana in 2005 were high reaching to 355,697.85 t; on the other hand, the exports of banana were only 23,550 t. At present, main export markets for Chinese banana are Russia, Hong Kong, Japan and Macau, the total exports has increased in recent years (Table1).

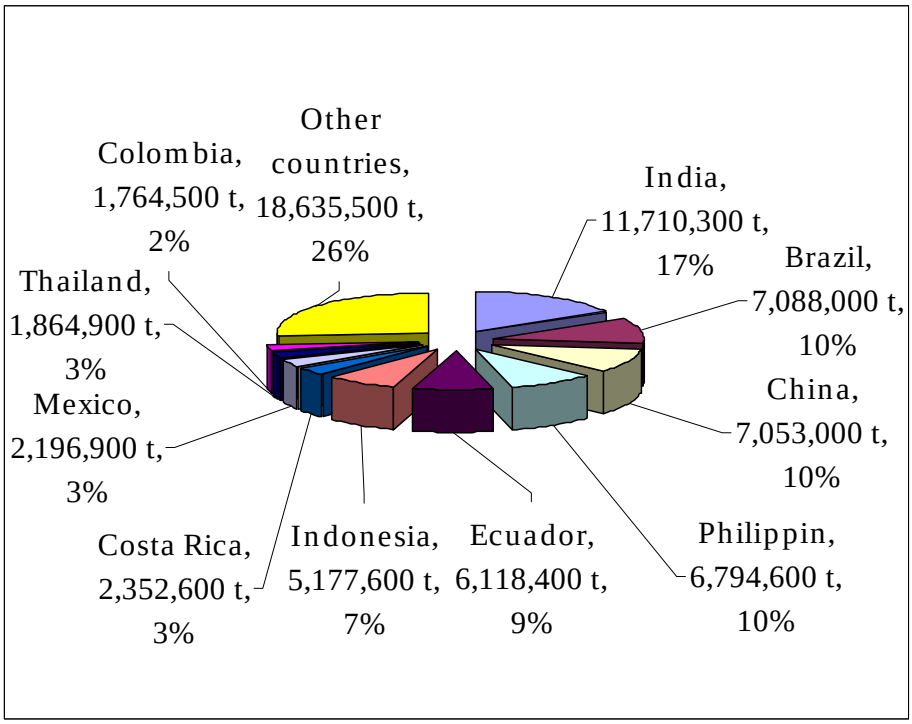


Figure1. World banana production in 2007 (FAO)

Table1. Chinese banana export quantity from 2001-2005 (t)

	Korea	Hong Kong	Japan	Macau	Mongolia	Russia	Total exports
2001	153	2175	5830	3662	315	1486	13622
2002	260	2351	3853	2105	520	5746	14911
2003	10	7952	2743	1419	132	7601	19859
2004	23	12333	3616	1083	231	6069	23422
2005	24	9362	2875	1018	215	10050	23550

1.2 Development of Chinese banana production in recent years

1.2.1 Cultivation area and production quantity

Banana is mainly cultivated in Guangdong, Guangxi, Hainan, Fujian, Yunnan Province and Taiwan; of which Guangdong's cultivation area and production quantity both rank first in China (Figure 2 and Figure 3). Based on statistics from Ministry of Agriculture of the People's Republic of China, domestic banana cultivation area and production quantity have increased from 180,200 hm^2 to 285,700 hm^2, from 2,892,276 t to 6,901,249 t respectively from 1996-2006.

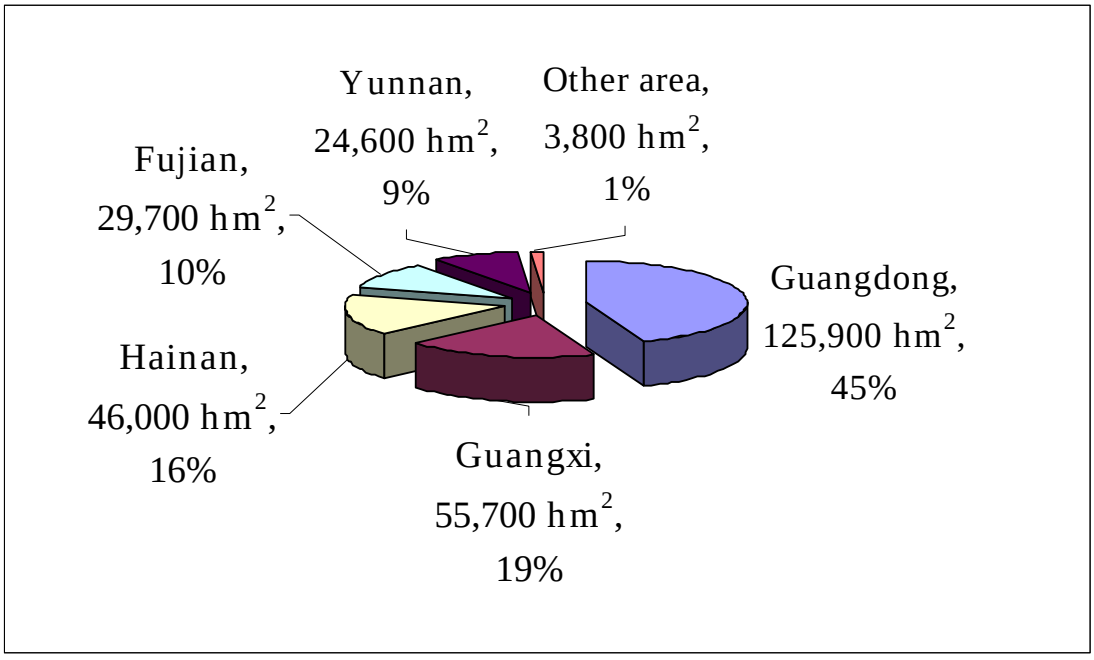


Figure2. Chinese banana cultivation area in 2007

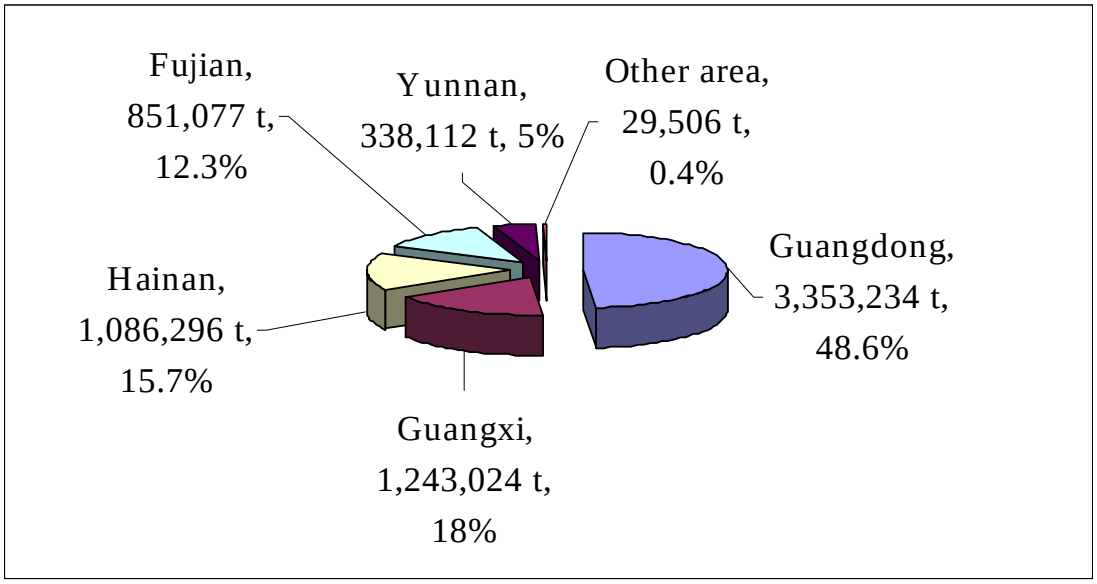


Figure3. Chinese banana cultivation area in 2007

1.2.2 Optimal regional distribution of Chinese banana production

Under the guidance of Agricultural Ministry, four banana industrial belts with advantage have been developed and established in Chinese main producing areas: Hainan---Leizhou Peninsula, west Guangdong---south Guangxi, west Guangxi---south Yunnan and the Pearl River Delta---east Guangdong---south Fujian. In the areas mentioned above, banana production also promotes the development of other related industries such as pesticides, fertilizer, packing materials and transportation.

1.2.3 Selection and promotion of new varieties

In actual production, Chinese banana cultivars are separated into four types according to part of morphological characters and flavor--- Xiangyajiao (AAA group), Dajiao (ABB group), Fenjiao (ABB group) and Longyajiao (AAB group), of which Xiangyajiao (Cavendish subgroup) are the most important commercial cultivars in China, and more than 90% of cultivars are Xiangyajiao. At present, most of commercial cultivars in China are local cultivars and the ones introduced from abroad; the others are obtained through bud mutation, somaclonal variation and physical mutation.

1.2.4 Development of production measures

A series of high-yield and good-quality production techniques has been widely adopted by growers, including the acclimation of rooted plantlets, banana fertilizer recommendations based on the result of nutritional diagnosis, the development and promotion of special fertilizer for banana, the production of off –season banana while minimizing the damage caused by typhoon and low temperature, water-saving irrigation techniques for banana cultivated on hillside, the control of banana diseases and pests, banana fertilizer recommendations and irrigation schedule according to the numbers of leaves (leaf area) and the growth of bunch, bunch management and harvest for improving fruit quality. On the other hand, 65% of planting materials are micropropagated plantlets which have been commercially produced in China. Production measures mentioned above guarantee domestic banana are now available on market all year round.

1.3 Banana production plays an important role in local economy

Banana production is treated as a pillar industry in each main producing area; it plays an important role in local economy and rural development. For example, the output value of Hainan's banana production is 53% and 25.62% of gross provincial output value of fruit and agriculture respectively in 2006. In Dacheng Town, Pubei County of Guangxi Province, more than 90% of paddies are used to cultivate

banana, the output value of banana production is more than 80% of the town's gross output value of agriculture. 90% of banana consumed on domestic market are those produced at home, the other 10% are imported from abroad. The output value of Dacheng Town's banana production was more than 95,000,000 RMB, and output value per capita was about 3,000 RMB in 2006.

2. Current Situation of Banana Research in China

2.1 Evaluation of banana germplasm resistant to Fusarium wilt disease

In order to solve the problem of identification of banana, AFLP, SSR and other molecular methods are used to assess their diversity, genetic relationship among the germplasm resources that deposited in Guangzhou banana germplasm bank. Guangzhou banana germplasm bank was built in 1989 and has committed many national and local funds. The bank had collected 350 banana germplasm and from them, some fine cultivars were selected and popularized in the production.

2.1.1 Cell engineering breeding of banana

Establishment of a stable embryogenic cell suspension (ECS) is a prerequisite for the biotechnological breeding methods. A mature system for embryogenic cell suspension was established from 60 days old immature seeds of Musa itinerans Cheesm, Brazilian (AAA), Grand Naine (AAA), Fenjiao (AAB), plantain (ABB) and etc, some important germplasm in China. A mature protocol for plant regeneration from protoplast of some banana varieties via somatic embryogenesis was developed. Viable protoplasts were isolated from embryogenic cell suspension (ECS)in a enzyme mixture. The embryogenic cell suspension (ECS)of banana (Musa spp.AAA group) was also used as material for in vitro screening of clones resistant to Fusarium wilt.

2.2 Molecular biology

To manipulate the development process of banana, including ripening, a better understanding of their mechanisms is necessary. The isolation of mRNA transcripts encoding proteins associated with the relative process is a powerful tool for this purpose, and two methods were adopted. The first one is constructing a suppression subtractive hybridization (SSH) cDNA library, then the clones were sequenced, and at last, cDNA microarray analysis was conducted. The second method is that constructing the SMART (switching mechanism at 5'end of RNA transcript) cDNA library and then sequenced the clones.

2.3 The mechanism of disease resistance

Most of the research was concentrated on Fusarium Wilt disease. The research can be divided into several categories: (1) The difference of pathogencity between Foc1 and 4; (2) Cloning the resistant genes to Foc1 and 4 from banana by the method homologous cloning. (3) Biology control of Foc4 by Tricoderma, actinomycete, *Bacillus subtilis* and etc. (4) The defense mechanism of the resistant cultivars to Foc4. The results contribute to control the devastating disease.

3. Challenges on Chinese banana industry

3.1 Fusarium wilt

At present, Fusarium wilt caused by *Fusarium oxysporum* f. sp. *cubense* (*Foc*) has become the major constraint for banana production. Fusarium wilt of banana is now found in Guangdong, Guangxi, Fujian, Hainan and Yunnan Province (Qi, 2000). The reliance on Xiangyajiao cultivars and the practice of successive planting without crop rotation resulted in widespread and severe losses (Zhou et al., 2005). Until 2005 more than 3,000 hectare banana plantations had been attacked by Fusarium wilt in Guangdong (Huang and Chen, 2005). Although research progress has been made recently, chemical control (Lin et al., 2003; Fan et al., 2004; Xu et al., 2004) and biological control (Xiao et al., 2004; Cheng et al., 2005) have not yet been effective in managing Fusarium wilt. Genetic resistance offers the greatest opportunity for managing this disease in infested soils. To date, several pre-existing resistant cultivars have been introduced to China (Huang et al., 2005); biotechnological research is currently underway to produce resistant hybrid (Pei et al., 2005).

3.2 Adverse weather conditions

Many banana plantations are in the frontier regions free of typhoon and low temperature such as Qingyuan and Leizhou of Guangdong Province, Guangxi and Yunnan Province. In other words, most of banana belt except for Hainan and west-south Guangdong are often attacked by cold current in winter and spring. The decrease in production quantity caused by cold temperature in 1991-1992, 1999-2000 and 2002-2003 was more than 30% respectively (Liu, 2006), the damage caused by the one in 2007-2008 was devastating.

3.3 Industrialization of banana production at low level

Firstly, low level of industrialization and organization. Most Chinese banana farms are about the size of 0.5 to several hectares, much small than those in foreign countries. There are no efficient organization of farmers. Many farmers use chemical fertilizers or pesticides excessively in fear of loss due to bad decisions made. In some areas, "expanding agent" is widely used for increasing the size and production of banana. Although there are organic fertilizer suppliers and sales network in China, a large number of banana farmers are lack of knowledge on commercial organic fertilizers.

Secondly, there is no efficient sales network for Chinese banana. Seventy percent of bananas are traded at farm level, and there are no companies that can both produce and sell banana. In years when there is excessive supply of banana, buyers will negotiate with farmers and buy their bananas at low price. This means increase of banana production did not bring better income to farmers.

Thirdly, similar to other agricultural industries, banana industry lacks of financial support. Most farmers have to rely on their own fund or social idle fund.

4. Prospects

At present, the production cost of domestic banana is 600-1000 RMB/ton, and the price off banana plantation in cultivation area is 1000-2400 RMB/ton, while the CIF price for imported banana is about 3900 RMB/ton, not including tariff and transportation fee. Secondly, the quality of domestic banana is high. It is widely accepted that the taste, flavor and texture of domestic banana are superior to imported one, while its appearance is inferior to imported one according to banana quality standards such as color, the arrangement of clusters, the length and thickness of fingers, and absence of blemishes and defects. Although the proportion of class I and "extra" class banana in domestic banana is rather small, its appearance traits are nearly identical to that of imported one. On the other hand, domestic banana market has great potential. At present, China imports more than 300,000 t banana from abroad annually, to meet the demand of high-consuming group. It also could be treated as a pulling force for the development of domestic banana market. In other words, there is huge developmental opportunity for the Chinese banana industry.

INDIA

Country Paper on Banana in India

Dr. H.P.Singh, Deputy Director General (Horticulture)
Indian Council of Agricultural Research

Introduction

India, traditionally an agrarian country, produces 230 million tonnes of cereals from 2.3% of the world's cultivated land. Agriculture contributes 18.3% of the total national income, but it provides livelihood of nearly 60% of the population. Green revolution started in 1966 and revolutionized the Indian agriculture by which, India became self-sufficient in cereal production, especially in wheat. Green revolution has also made the country both sufficient in agricultural growth and food security for a period of more than two decades and food grain out put has increased to 230 million tonnes. New concerns have risen for environmentally sustainable agricultural growth with newer agricultural technologies like biotechnology, information technology and eco-friendly techniques which will be explored and harnessed to achieve the expected growth of 4% as envisaged in the 11th Five Year Plan proposal.

India is endowed with wide varieties and different agro-climatic conditions and is enviably positioned in the horticulture map of the world. Almost all horticulture crops can be grown in one or the other regions. Horticulture growth is 8% of the gross crop area and contributes 24.5% of the gross value of agricultural output. India is the 2nd largest producer of both fruits and vegetables and the total production of fruits is 44 million tonnes and vegetable is 77.83 million tonnes with a share of 10 and 14% respectively. With the opening-up of global market and removal of quarantine restrictions in the WTO agreement, export-import scenario is likely to change at much faster pace. To achieve this, horticultural technologies have been developed, which includes use of micro propagation materials, integrated nutrient and water management, integrated pest management, protected cultivation, organic farming, use of molecular immunodiagnostic techniques and hi-tech post harvest technologies including cold-chain to foster the growth. To meet the growth, the Government of India has alloted Rs 5000 crores for the horticultural sector during 10th Five Year Plan.

Globally, banana (*Musa* sp.) is grown in 8.84 million ha producing 97.15 million tonnes of banana and plantain. However, 80 per cent of the production is consumed domestically and has a small share (20%) in the global trade. In India, banana is largely grown by small and marginal farmers accounting more than 90 per cent of the holdings and contributes 1.99% of the Indian GDP. India is the largest producer of bananas and plantains with an annual production of 19.19 million tonnes from an area of 0.65 million ha and accounts for 19.2 of the world's production. Brazil is the second largest producer followed by China, Ecuador and Philippines. However, Costa Rica ranks first in productivity followed by Mexico, Ecuador, Colombia, India and China. Per capita consumption is the highest in Uganda followed by Burundi, Rwanda, Ecuador and Ghana. In banana trade, Ecuador, Costa Rica, Philippines and Colombia alone contribute 64% of the world's banana export while the Philippines is the largest Asian exporter.

For figures on area, production and productivity of banana and plantains , see next page for Table 1.

Table 1. Area, production and productivity of banana and plantains

Country	Area 000'ha		Production (MT)		Productivity(mT)	
	2001-02	2005-06	2001-02	2005-06	2001-02	2005-06
India	466	565	14.20	19.19	30.50	34.00
Brazil	513	491	5.74	6.58	11.18	13.41
Philippines	400	415	5.06	5.63	12.65	13.56
Indonesia	285	315	3.60	4.87	8.14	15.49
China	259	269	5.40	6.25	20.84	23.20
Ecuador	298	227	8.03	6.13	26.94	27.07
Cameroon	312	082	2.25	0.798	7.21	9.72
Mexico	074	078	1.97	2.36	26.62	29.99
Columbia	444	062	4.20	1.58	9.45	25.15
Costa Rica	054	042	2.32	2.22	42.96	52.54
Others	5,705	5,705	41.77	41.77	7.32	7.32
Total	8,810	8,251	94.56	97.378	203.81	251.45

In India, banana is well adopted in the regions varying from humid tropics to humid sub-tropics and semi-arid subtropics, and from sea level to 2000 m above mean sea level. Availability of wide genetic diversity, varying production systems and its suitability to a wide range of agro-climatic conditions are attributed for wider adoption of banana. It is grown in homestead gardens and also cultivated commercially in large areas. Commercial production system depends largely on irrigation facilities while subsistence cultivation is practiced under rain fed farming.

The major banana growing states are Andhra Pradesh, Assam, Bihar, Gujarat, Karnataka, Kerala, Madhya Pradesh, Maharashtra, Orissa and West Bengal. Tamil Nadu has the largest area followed by Maharashtra and Karnataka. Tamil Nadu also ranks first in production, followed by Maharashtra. However, the highest productivity is recorded in Maharashtra followed by Tamil Nadu and Madhya Pradesh. Maharashtra excels in productivity owing to monoculture of high yielding Cavendish clones coupled with adoption of improved technologies like high density planting, fertigation, growing tissue culture plants etc.

Table.2 State wise area, production and productivity of banana in India

State	Area('000ha)	Production ('000 ha)	Productivity (MT/ha)
	2005-2006	2005-2006	2005-2006
Andhra Pradesh	61.1	1528.7	25.0
Assam	47.0	699.4	14.1
Bihar	28.0	959.3	34.2
Gujarat	49.2	2498.8	51.0
Karnataka	56.4	1399.1	25.0
Kerala	56.5	937.1	16.5
Madhya Pradesh	15.4	615.6	41.0
Maharashtra	73.2	4608.5	63.6
Tamil Nadu	94.6	4647.6	49.4
West Bengal	27.8	544.9	19.5
Others	56.2	756.5	13.5
Total	565.5	19195.5	34.0

Source : FAO Statistics 2005

Production constraints in Banana and Plantain

Availability of clean planting material

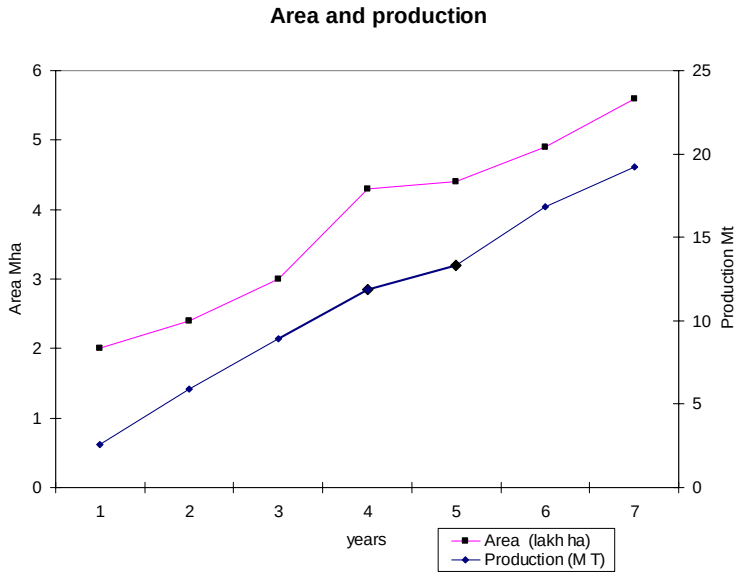
Quality planting material is important for successful production of banana. India has the largest area of 6.65 lakh ha under banana and the requirement of planting material works out to be 125 billions per annum at 2500 per ha. The soil borne pathogens like *Fusarium oxysporum* fsp. *cubense (FOC)*, Erwinia, nematodes and plant viruses are of greater concern in the context of clean planting material. Second issue of concern is India is a predominant polyclonal system of cultivation. Although 'Grand Naine' and other Cavendish clones constitute 60-65% of the total banana industry, remaining 35-40% is under local cultivars grown in respective states. Tissue culture industry mainly produces only Cavendish clones and other cultivars are neglected.

Biotic stresses

Various biotic stress viz., *Fusarium oxysporum* fsp*. cubense,* Sigatoka leaf spot complex, Erwinia rot, viruses, various nematode species, weevils and borers constitute the major constraints in the production of banana and plantain. Fusarium is a serious soil borne pathogen, which remains viable for more than a decade in the soil and causes infection under congenial conditions. Similarly, Erwinia, a soil borne pathogen that is becoming a serious threat to the tissue culture plantations. It affects the plant during the early stage of crop growth. Nematodes, which spread along with the infected planting material and are causing considerable damage especially in tissue cultured plants. Banana weevil is another pest of importance, inhibiting the underground rhizome and gets spread through unclean planting material. Most of these production constraints can be successfully overcome by the use of clean planting material.

Abiotic stresses

Drought and salt stress constitute the major abiotic stresses in banana and plantain. Drought is generally associated with salinity problems.



Measure taken to overcome the production constraints

Availability of clean planting material

Realizing the need for clean planting material many private tissue culture companies have emerged both with and without government support.

Table.3 Growth of tissue culture industry in India

	in millions			
	1990	2000	2007	2015
No. of plants supplied	2-3	10	50-55	120
Area 000' ha	420	466	580	700
Production	1-16	14.2	19.0	25.0
Productivity	27.5	30.5	34.0	40.0

The production of tissue culture plants was only 2-3 million in 1990 and was 10 million in 2000. A great leap was observed in the supply of tissue culture plants by the private firms reaching to 50-55 million by 2007 with a tentative target of 120 millions for 2015. In 2007, a total of 0.4 % of total requirement of the country was supplied through tissue culture plant material and by 2015; it is expected to increase to 7.0 %. This results in approximately 1.0% growth of tissue culture plant production in the country per annum.

Due to the increasing demand in the tissue culture plants and to produce quality planting materials, Government of India in association with Department of Biotechnology and NRCB has developed standards for tissue culture companies. Minimum standards are to be maintained by private firms producing Tissue culture plants. Apart from this, for assured supply of diseases free and true to type planting material, Department of Biotech has also identified National Accreditation Labs for Virus Indexing and genetic fidelity testing apart from 'Referal Labs' at national level. National awareness has been created across the country about the use of Tissue Culture plants and to procure plants from

certified companies confirming its genetic fidelity and freeness from known viruses.

Along with national programmes, Food and Agriculture Organization-Rome also supported a programme for clean planting material for local poor through projects by adopting three major banana growing states.

Indigenous Virus Indexing Facility

The viral pathogens are a major impediment in banana tissue culture industry. Diagnosis against viruses has become an integral part in the management of viral diseases in banana. Early and correct diagnosis of viruses is very important in checking further spread of disease especially to a new area. So, early detection by sensitive molecular diagnostic methods is the only way to control them. These viral pathogens cannot be eliminated through shoot tip culture which is adopted by the TC industries for mass propagation.

NRCB has developed various diagnostic techniques for major four Indian viral pathogens isolates of banana. Different molecular diagnostic techniques have been used to detect the banana viruses in tissue culture plants as well as mother plants used by the tissue culture industries. NRCB is offering contract services for virus testing to tissue culture industries and also for banana growers. Apart from this, commercial entrepreneurs are also trained in using molecular techniques for virus indexing. Contractual services are also extended to commercial firms to develop virus indexing laboratories attached to their tissue culture units.

Table 4. Virus diagnosis kits available at NRCB

Sl. No	Viruses	Test methods			
		PCR / RT-PCR/ IC-PCR/ DB-PCR/ IC-RT-PCR	ELISA / DIBA	Nucleic acid spot hybridization (NASH)	Southern and northern blots
1	Banana Bunchy Top Virus (BBTV)	√	√	√	√
2	Banana Bract Mosaic Virus (BBrMV)	√	-	√	√
3	Banana Streak Virus (BSV)	√	-	√	√
4	Cucumber Mosaic Virus (CMV)	√	√	√	√

Success have been reported in the rejuvenation of an elite land race, 'Hill Banana' which was on the verge of extinction due to BBTV, by the interventions of Tamil Nadu Government, NRC banana, Tamil Nadu Agricultural University, Farmers' associations and growers in Kodaikanal hill region. Similarly, efforts are being made to rejuvenate an silk ecotype, Rasabale of Karnataka which has been wiped out due to Fusarium wilt.

Richness of *Musa* diversity in India

Banana is one of the few crops where man-made hybrids failed to excel the natural hybrids. Most of the present day bananas grown both nationally and internationally are the natural hybrids, which have

evolved and acclimatized to various agro-ecological conditions. Presently, Grand Naine is the important commercial variety in the global banana industry. Situation is almost the same in India, where Cavendish clones like Robusta, Dwarf Cavendish, Shrimanthi, Giant Governor, Mahalakshmi etc., are being commercially cultivated. Present survey has indicated an alarming situation by commercialization of few selected varieties inadvertently. The distribution of Cavendish clones was only 50-55% until 1980's, which has increased to 70% in 2005-06. This is owing to high productivity, good economic returns and wide market acceptability. Although it has improved the living standards of the banana farming community in the country, there ia always an apprehension due to the problems associated with monoculture. Cavendish clones and its high susceptibility especially to leaf spot and heart rot diseases and also possible threat due to the Fusarium tropical race 4 can result in repeat of the history, where Gros Michel banana was wiped out because of *Fusarium* wilt.

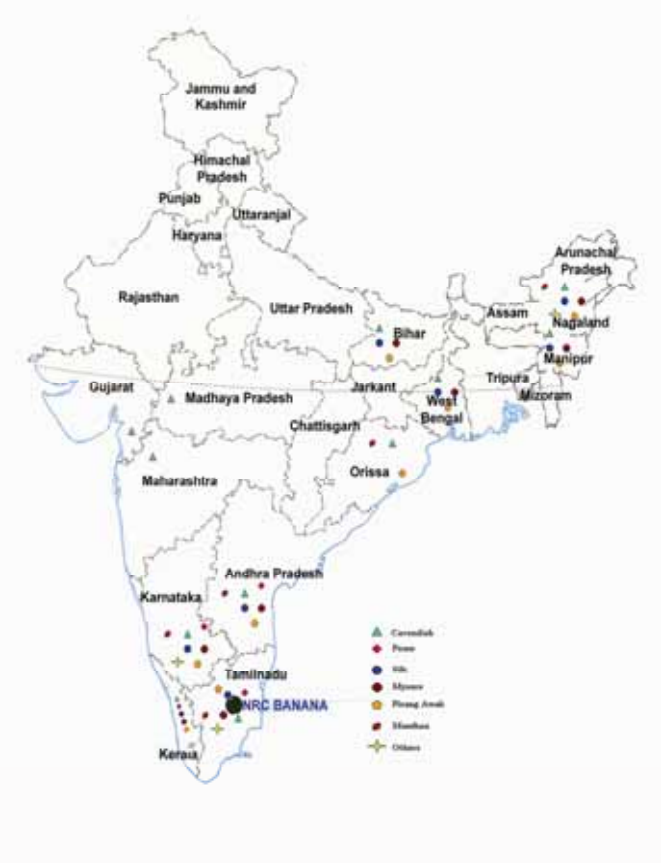
In India, the situation is slightly different owing to the polyclonal situation where more than 20 varieties are grown to cater to the local market demands. This include varieties like Poovan (Champa), Rasthali (Silk), Nendran, Karpuravalli (Cheeni Champa), Kunnan, Ney Poovan (Elakki Bale), Thella Chakkara Keli, Monthan and so on. Pisang Awak has been a hardy variety adopted in marginal lands of Bihar, West Bengal and most of the north Eastern States. Poovan has been another hardy clone largely grown in southern states where wilt disease is more common. Elakki Bale or Ney Poovan has been well adapted to subtropical and tropical zones of Karnataka and Tamil Nadu. There are many more traditional varieties and landraces grown in different Indian states cushioning the ill effects of monoculture. Kothia, Chakia, Muthia are some of the cooking varieties of northern India while Monthan and Bluggoe are ruling the southern markets as culinary varieties.

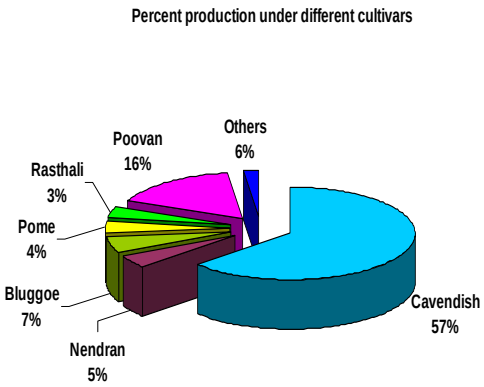
Table 5: Important cultivars of banana grown in different states

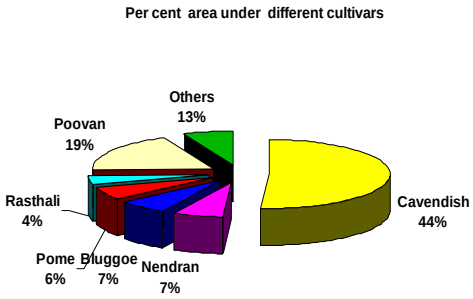
State	Cultivars
Andhra Pradesh	Grand Naine, Dwarf Cavendish, Robusta, Thellachakkarakeli (Cavendish), Amrithpani, Monthan, Yenagu Bantha, Karpurachakkarakeli (Mysore)
Assam	Jahaji, Borjahaji, Manjahaji, Robusta, Honda, Chenichampa (Mysore), Digjowa (Silk), Kulpait (Silk), Manohar, Bhimkol, Kanchkol, Attikol, Bharatmoni
Bihar	Dwarf Cavendish, Chinia, Chenichampa, Alpan (Mysore), Malbhog (Silk), Muthia (Bluggoe), Kothia (Bluggoe), Gauria (Bluggoe), Kanthali (Pisang Awak)
Gujarat	Grand Naine, Dwarf Cavendish, Lacatan, Harichal, Gandevi Selection
Karnataka	Grand Naine, Elakki Bale, Dwarf Cavendish, Robusta, Poovan (Mysore), Karibale (Monthan), Rasabale (Silk), Jwaribale (Pome)
Kerala	Njali Poovan, Red banana, Nendran (Plantain), Palayankodan (Mysore), Poovan (Silk), Monthan
Maharashtra	Grand Naine, Safed velchi (AB), Dwarf Cavendish, Sindhuri, Ardhapuri, Lalvelchi (Mysore), Rajeli (Plantain)
Tamil Nadu	Grand Naine, Matti, Sevvazhai (Red Banana), Ney Poovan, Robusta, Poovan (Mysore), Rasthali (Silk), Virupakshi (Pome), Pachanadan (Pome), Nendran, Karpuravalli (Pisang Awak), Sakkai (Bluggoe), Monthan, Peyan
West Bengal	Amrit Sagar, Giant Governor, Lacatan, Mortman (Silk), Champa (Mysore), Kanthali (Pisang Awak)

Under All India Co-ordinated Research Programmes (AICRP), various exotic collections have also been introduced through NBPGR especially from INIBAP Belgium.

Banana varieties grown in India







RESEARCH INFRASTRUCTURE

National Agricultural Research System (NARS)

This comprises of *Indian Council of Agricultural Research (ICAR)* at National level and State Agricultural University system (SAU) at State level. ICAR is the apex organization at national level to promote science and technology programmes and coordinate the agricultural research conducted by different institutions. The ICAR is mainly supported by the Government of India and from the proceeds of Agricultural Produces Cess. NARS has a strong network of National Bureaus, Project Directorates and Research Institutes which are as follows:

4 National Research Bureaus (NRB)*,
10 Project Directorates (PD),
46 Research Institutes (CRI),
30 National Research Centres (NRC) *,
79 All India Coordinated Research Projects (AICRP) *,
8 Zonal Coordinating centres (ZRC)
261 Krishi Vigyan Kendras (KVK) *
Trainer's Training Centres (TTC)
More than 1000 AP CESS funded Projects

Regional Research Stations and Project Sub-Centers across the country

* ***Involved in banana research***

Under the State Agricultural University (SAU)
29 State Agricultural Universities,
120 Zonal Research Centres,
More than 200 Colleges
One Central Agricultural University

Other general colleges and research institutions
Depending on the importance of the banana crop, research is carried out under various agricultural universities, Krishi Vigyan Kendras and also under All India Coordinated Research Projects.

All India Coordinated Research Projects (AICRP)
Research and Development of banana in the country has a strong network of different research centers working on identifying and addressing regional problems with respect to banana production and productivity. In this mission node approach, several problems like pseudostem weevil, Fusarium wilt, fruit scarring beetle were addressed through integrated pests and disease management. Nutrient tailoring, precision farming, organic production and germplasm utilization are some of the thrust areas being studied at different centers. Earlier these projects were coordinated by the project coordinator; the technical programme will be coordinated by NRCB.

Systematic research on banana started in 1949 with ICAR sponsored scheme at Banana Research Station, Aduthurai, Tamil Nadu. Simultaneously banana research stations were started in Bihar, Maharashtra, Kerala and West Bengal. Major thrust to banana research was given with its inclusion in All India Coordinated Research Project (AICRP) in 1971 with four centers, which expanded to eight centers (Tab- 5) covering major banana growing regions. The research findings are put into multi-locational trials under supervision and guidance from these centers. They are compiled and disseminated by the central research coordinating unit. These research efforts have resulted in significant increase in production and productivity.

Table-6 : Centers working on banana under AICRP

Centers	Agro-Ecological	Major Programme
University-Based		
1. Coimbatore(TNAU)	Tropical	Germplasm, Improvement & Production technology
2. Kannara (KAU)	Humid tropics	Germplasm, Improvement, & Production technology Protection technology
3. Jorhat (AAU)	Humid tropics	Production technology Protection technology
4. Jalagaon (MPKV)	Arid subtropics	Production technology
5. Gandevi (GAU)	Sub-humid tropics	Production technology
6. Kovvur (APAU)	Humid tropics	Production technology Protection technology
7. Pusa (RAU)	Semi arid subtropics	Germplasm management Production Technology
8. Arabhavi (UAS- Dharwad)	Tropical	Production technology

Institutes-ICAR Based

1. Bangalore (IIHR)	Mild subtropics	Germplasm management Production Technology
Trichy (NRCB)	Humid tropics	Germplasm management, Improvement of banana, Production Technology, Bio technology, Post-harvest Technology.

Other institutions involved in banana research

1. National Bureau of Plant Genetic Resources (NBPGR), New Delhi

    Conservation
    Molecular Characterization
    Virus indexing (initiated)

2. Bhabha Atomic Research Center (Dept. of Atomic Energy), Mumbai

    Genetic Transformation
    Molecular characterization
    Improvement through mutation breeding
    Tropical Botanical Garden and Research Institute (Trivandrum, Kerala)
    Germpalsm collection
    Tissue culture production

National Agricultural Innovative Projects

The National Agricultural Innovation Project (NAIP) programme is expected to contribute to the sustainable transformation of Indian agricultural sector to more of a market orientation to relieve poverty and improve income. The specific aim is to accelerate collaboration among public research organizations, farmers, the private sector and stakeholders in using agricultural innovations.
The project has four components:

Component 1 strengthens the Indian Council of Agricultural Research (ICAR) as the catalyzing agent for managing change in the Indian National Agricultural Research System (NARS)
Component 2 funds research on production-to-consumption systems.
Component 3 - funds research on sustainable rural livelihood security.
Component 4 - supports basic and strategic research in frontier areas of agricultural sciences.
By now several projects have been funded under NAIP and banana is one of the commercial crops which received lot of emphasis.

PRODUCTION AND MANAGEMENT

High Density Planting (HDP)

High density planting is one of the successful approaches for increasing the production / unit area. Under Indian conditions, 2500 plants is the normal density which can be increased to 4500-5200 plants / ha under high density planting. The reduced per plant yield is compensated by the increased number of bunches produced per unit area. It is also found to have a positive influence on the soil micro flora and natural weed control. Banana is a heavy feeder of nitrogen and potassium and the recommended dose varies from 200-300 g N, 40-60 g P_2O_5 and 300-450g K_2O / plant / year depending on the soil and variety. P_2O_5 is applied as a basal dose and nitrogen and potassium in 3-5 splits,

depending on the varietal duration was found to be beneficial.

Fertigation, a technique where the fertilizers (N and K) are applied daily to the roots of individual plants in small quantities through drip. HDP coupled with fertigation increased the yield by 2-$2^1/_2$ times. In Robusta, 1.8 x 1.8m spacing with weekly fertigation of 75% of recommended dose of N & K produced highest yields with a mean bunch weight of 35.5 kg / plant. Similarly paired row planting recorded 23.3% higher yield than conventional planting. In Rasthali, 20% higher yield was recorded under paired row planting system with 50% recommended dose of fertilizers. Saba a cooking banana also responded positively for the paired row planting and fertigation with 50% recommended dose of N & K recording 24% higher yield.

Organic banana has created a niche market both at the national and international levels. Although, organic cultivation is not profitable in the initial years, it has been found promising after 2-3 years. The sources of organic manures to be used in the organic farming have been defined by the International certification agencies. Among the organic manures, compost, vermicompost, neem-cake and poultry manure (2.5 + 1 + 1 + 2.5kg respectively) at 3rd, 5th and 7th month after planting recorded better yield per unit area. Interestingly, these organic sources have a positive effect in controlling Sigatoka and nematode infestations and extended the shelf life and quality of fruits.

Among the alternate sources of inorganic nutrients explored for use in banana cultivation, Cement Kiln Flue Dust (CFKD) is found to be a best supplement for K in banana. Among various bio-fertilizers used to enrich soil, phosphobacteria is found superior than *Azospirillum* and VAM. Application of rice husk ash is superior than vermicompost and poultry manure in increasing the bunch weight.

Targeted yield concept was attempted using different fertilizer adjustment equations for commercial varieties for maximum profitability. DRIS chart has been constructed through an extensive nutrient indexing survey, which help in input monitoring and maintaining of different nutrient ratios at optimal level for better productivity in banana.

Precision Farming

Increasing efficiency in management system is the key aspect in Precision farming especially in small holdings by better management of farm resources. It is basically information and technology based management system, which includes Geographical Information System (GIS), Geographical Positioning System (GPS), yield monitoring devices, soil, plant and pest sensors, remote sensing etc. This technology allows the farmers to identify, analyse and manage the spatial and temporal variability of soil and plants for optimum profitability, sustainability and environmental protection. Precision farming in banana should include soil fertility status, weather data, forecasting models for yield, pest and disease outbreak, controlled irrigation and fertigation for a profitable and sustained production.

PLANT PROTECTION

Pests

Corm weevil (*Cosmopolites sordidus*), pseudostem borer (*Odoiporus longicollis*) and nematodes are the major insect pests threatening banana production and productivity in the recent years.

Corm weevil is globally important, infesting most of the commercial varieties. In India, it is more prevalent in Kerala, and Nendran is the most susceptible commercial cultivar. Nendran under perennial system of cultivation is highly vulnerable to weevils attack and causes great yield loss. Chemicals have been successfully used to control corm weevil infestation but they are expensive and not eco-friendly. Hence, eco friendly control methods using bio control agents have been identified and standardized in banana.

Pseudostem borer is becoming a serious problem in all commercial varieties of late and Cavendish bananas are being the most susceptible followed by plantain. Cut pseudostem of one foot length is used

as the delivery system for the bio-control agents (*Beaveria bassiana*) and entomopathogenic nematodes (*Heterorhabditis indica)* for monitoring and controls the pests. Semio- chemical based Kairomones have also been identified. It is being tested under laboratory conditions as an effective trap. Controlling of pseudostem borer using pseudostem trap has been successfully demonstrated under highland production system as an eco-friendly approach.

Banana rust thrips (*Chaetanophothrips signipennis*) is becoming a serious concern in the context of export banana production. They cause blemishes and reduced the cosmetic value of the fruit. Polythene sleeves impregnated with 0.1% Chloropyrifos + paraffin oil + adjuvant controlled the thrips attack by 25-30%. Bell injection (flower bud injection) immediately after shooting with Imidacloprid 0.001% has controlled the rust infestation to a greater extent. Scarring beetle (*Besilepta subcostatum*) is serious only in North-Eastern and Eastern states. The fruits affected by this pest have poor market acceptability. It can be controlled using 0.05% Monocrotophos sprays. Survey and identification of effective new bio-control agents and their effective utilization in controlling banana pests needs immediate attention.

Table – 7: Banana insect pests, distribution, symptoms and control measures

S.No.	Pest and Scientific Name	Areas of occurrence	Symptoms	Susceptible cultivars
1.	Rhizome weevil *Compolites sordidus*	Kerala, Assam, Maharashtra, Bihar, Andhra Pradesh	Galleries of network in the Rhizome	Nendran, Poovan Malbhog
2.	Pseudostem Borer *Odoiporus longicollis*	Andhra Pradesh, Bihar, Assam, Karnataka	Exudation of plan sap and drooping of faecal matter from the holes	Nendran, Kunnan, Poovan, Rasthali
3.	Scarring Beetle *Besilepta subcostatum*	Bihar, Assam, West Bengal	Fingers have full of scars	All cultivars
4.	Aphids *Pentalonia nigronervosa*	Kerala, Tamil Nadu, Karnataka	Bunchy appearance of crown and plant is unproductive	All cultivars
5.	Mealy bugs *Icerya aegyptiaca*	Southern States and North Eastern states	Fruit looses consumer appeal	Pisang Awak and its ecotypes
6.	Thrips *Thrips florum*	All banana growing regions	Fruits have brown patches with scraped look	Cavendish group, Plantain group, Silk and Monthan

Nematodes

More than 36 species of nematodes are affecting banana, of which four species namely *Radopholus similis, Pratylenchus coffeae, H. multicinctus and Meloidogyne incognita* are of global importance. Nematodes cause yield losses ranging from 30 to 50%. Nematodes are usually controlled by using Carbofuran, which has high residual toxicity. So, focus is now on the development of eco-friendly management strategies like use of neem based formulations like Nimbicidin and Econeem @ 30ml / plant. Bio-control agents like *Pseudomonas fluorescens*. *Paecilomyces lilacinus, Verticillium chlamydosporum, V. lecanii, Baccillus subtilis, Trichoderma harzianum and T. viride* has been effectively used for the management of banana nematodes. Use of VAM (*Glomus fasiculatum* and *Glomus mosseae)* at planting and after 3 months effectively reduced the infestation of nematodes and increased the growth of the plants. Use of AMF (Arbuscular Mycorrhizal Fungi) are obligate symbions colonizing in roots and know to reduce the effect of impact of soil borne pathogens. Though mechanism of action is

still debated but induced resistance is demonstrated. Some non-pathogenic Fusarium oxysporum entophytes have shown the ability to reduce pathogen population both in controlled and field conditions.

Table –8 : Major nematodes and their distribution in India

S.No.	Nematodes	Distribution	Susceptible cultivars
1.	Root knot nematode *Meloidogyne incognita*	Tamil Nadu, Bihar, Andhra Pradesh, Karnataka	Nendran
2.	Burrowing Nematode *Radopholus similis*	Kerala, Bihar, Maharashtra, Andhra Pradesh, Karnataka, Gujarat, Tamil Nadu	Robusta, Nendran, Poovan, Rasthali, Karpuravalli
3.	Root lesion Nematode *Pratylenchus coffeae*	Kerala, Tamil Nadu, Andhra Pradesh, Karnataka, Gujara	Almost all commercial cultivars
4.	Spiral Nematode *Helicotylenchus multicinctus*	Kerala, Assam, Bihar, Maharashtra, Tamil Nadu	Almost all commercial cultivars
5.	Cyst Nematode *Heterodera oryzicola*	Kerala, Karnataka, Assam	

Fungal diseases

Among the fungal diseases, *Fusarium* wilt and Sigatoka leaf spot complex are quite serious and *Erwinia* rot is gaining significant importance in tissue culture plants of Cavendish group. *Fusarium* wilt is serious in cultivars Rasthali, Karpuravalli, Pachanadan and Virupakshi. Foc race 1 is more widespread than race 2 while tropical race 4 only affecting the Cavendish clones which is not yet reported in India. Though chemicals and other cultural methods have been reported to control the disease, current emphasis is on bio-control agents and botanicals. Fusaric acid detoxifying strain of *P.fluorescens*, *T.viride* and *Bacillus subtilis* @ 10g / plant each at the time of planting, 3rd and 5th MAP reduced the wilt incidence.

Fungicides such as Propiconazole, Mancozeb and Bavistin have been found effective in controlling the leaf spot diseases during winter period. Bio-control agents like *T.viride* and *P.fluorescens* and botanicals such as Solanum, Emblica and Jatropa effectively controlled the pathogen. Options available for the control of Fusarium wilt are limited and developing resistant cultivars is the sustainable options. The recent release of genomic sequence of *Fusarium oxysporum* fsp. l*ycoperscii* is expected to aid in gene discovery and functional analysis.

Sigatoka leaf spot complex

Mycosphaerella leaf spot diseases are the biggest constraint in commercial banana production throughout the world. The three main causal agents are *Mycosphaerella musicola* (Sigatoka disease, also known as yellow Sigatoka), *Mycosphaerella fijiensis* (black leaf streak disease, BLSD, also known as black Sigatoka) and *Mycosphaerella eumusae* (eumusae leaf spot disease). These species are closely related and have very similar morphology. These three major species attack all commercial varieties of banana with species specificity. At the global level, Black Sigatoka or referred as Blask Streak Disease is very serious on Cavendish clones and in the export oriented western farms, 40-45 sprays are undertaken to control the disease. Petroleum oil, Dithiocarbamates, Chlorothalonils are the major chemicals used to control Sigatoka along with Propiconazole. But strategic resources like disease forecasting models, logistics, inoculum management curative effects using carrier and adjuvant and post pathogen sensitivity studies will help to control the Sigatoka in a more sustainable way.

Septoria leaf spot (*Septoria eumusae*), eye spot (*Drechslera* sp.) and pitting disease have been recorded for the first time in India. Erwinia rot is becoming a serious problem especially in tissue culture plants of banana for which two effective bacterial antagonists have been identified.

Table-9: Important diseases and their distribution

S.No.	Disease	Symptoms	Susceptible cultivars
1.	Fusarium wilt (Panama wilt) *Fusarium oxysporum f.sp. cubense*	Symptoms appear only 5-6 months after planting, yellowing of older leaves. Splitting of pseudostem at base	Silk, Ney Poovan Pisang Awak, Pome, Bluggoe and Monthan
2.	*Sigatoka leaf spot* *Mycosphaerella sp*	At earlier stage, small lesions appear on the leaves which become pale yellow or greenish yellow streaks	Cavendish and Mysore group
3.	Heart rot *Erwinia carotovara*	Planted suckers start rotting and emit off-odour. In older plants rotting appears at the collar regions and leaf base. Base of pseudostem gets swollen and split at later stages	Tissue cultured Cavendish, Robusta, Grand Naine
4.	Cigar end rot *Verticillium theobromae, Gloeosporium musaram*	Black necrotic rot appears at the tip of fingers and extends towards whole arrears of fruits	Bluggoe group, Nendran, Ney Poovan
5.	Anthracnose *Colletotrichum musae*	Black lesions on fruit skin	Cavendish and all varieties

Viral diseases

In the recent years, knowledge on these viruses has expanded but some aspects on the fundamental epidemiology were unanswered. Five viral diseases have been reported in India and among them BBTV, BBMV, CMV and BSV are considerably important. Occurrence of BBTV wiped out large area under hill banana cultivation and has been recorded even in wild bananas of Arunachal Pradesh. BBTV isolates of North Eastern states and lower Pulney hills exhibited more than 90% similarity which indicated its wide prevalence in many parts of the country. Now BBTV indexed hill bananas for large scale sucker multiplication and supply to the hill banana growers are done at NRC Banana.

Although management of BBTV is effective thrust a strategy of reintroduction of planting material and internal quarantine. But internal quarantine has some of the hurdles like constitution of quarantine protecting individual liberties has hindered the introduction and enforcement of quarantine regulations. Earlier cv. Gros Michel was thought to be tolerant but later proved to be due to slow expression of symptoms. In nature there is no immunity for BBTV. Development of resistant plant through genetic engineering seems to be the only the possible option.

Banana Bract Mosaiv Virus (BBMV) is another devastating viral disease affecting plantain and many important commercial varieties. In Robusta and Ney Poovan, application of higher dose of fertilizers (150%) increased the yield in BBMV infected plants. Often Bract mosaic virus is confused with sugarcane mosaic strain of Abaca. It might have alternate hosts in its epidemiology.

CMV occurs in almost all banana growing states. Control can be achieved only through effective legislative measures and quarantine procedures.

Banana Streak Virus (BSV) is present in every banana-producing region worldwide (Jones, 2000). BSV infections can lead to severe decline in yield especially in Poovan varieties. BSV is the main constraint for germplasm movement, breeding and tissue culture of *Musa acuminata* x *M. balbisiana* interspecific hybrids and species due to the presence of infectious BSV endogenous para retrovirus (EPRV) sequences in the genome of *M. balbisiana* (Harper *et al*., 1999; Ndowora *et al*., 1999). Tissue culture techniques trigger the activation of infectious BSV EPRV in such interspecific hybrids and species, giving

rise to infectious viral particles (Dallot *et al.*, 2000). Therefore meristem tip culture, which was widely adopted for generating virus free germplasm from infected plant material, cannot be used safely for generating virus free hybrids.

Furthermore, the presence of infectious BSV EPRVs in the B genome limits the use of B-rich genotypes for creating much needed new banana hybrids although they confer resistance to major pests and diseases, highly female fertile and contribute to cross compatibility with other cultivated varieties. Therefore, screening *M. balbisiana* resources for germplasm free from BSV EPRVs has become a pre-requisite for any classical *Musa* breeding programme. This endogenous badna virus has long association for more than million years and sequence has integrated with both A & B genomes. This is normally latent but active only in B genome.

ELISA based techniques have been developed for the detection of BBTV and CMV. Polyclonal antiserum has been produced for the Indian strain. This has facilitated the development of effective diagnostic kits to check the disease spread in tissue cultured banana. Diagnostic kits are currently available for all the four banana viruses and are being used commercially. PCR technique has been developed to simultaneously detect two (Duplex PCR) or three banana viruses (Multiplex PCR) i.e., BBTV, BSV and BBMV. But worldwide genuine identification of BSV is reported to be y IC-PCR and multiplex IC-PRC will be able to detect other strains of BSV in one go. Genomes of BBTV and BSV have been completely characterized while those of BBMV and CMV have been partially characterized. These would facilitate the development of PCR based markers for the detection of viruses at early stages in the nursery.

Two new virus Banana Mild Mosaic Virus (Ban MMV) and banana virus X (BVX) have been reported from the west. There is indirect evidence that Ban MMV is transmitted between plants in the field but no vector is identified. But Ban MMV is expected to have synergistic effects with other viruses.
Currently, protocols have been developed to detect viruses even in vectors. This would be helpful to study the epidemiology of banana viruses.

POST HARVEST TECHNOLOGY

Banana being a highly perishable fruit and the post harvest losses are estimated to be 8-9% at farmer's level, 20-25% at whole seller's level and 15% at retailer's level. Physiological loss in weight, spoilage and fruit drop are the major factors contributing for the loss. As far as the post harvest diseases are concerned anthracnose, crown rot and cigar end rot are the three major diseases affecting banana fruits. Propiconazole is recommended for the control of the post harvest diseases. Similarly bio-control agents like *Trichoderma viride*, *Pseudomonas* sp. and botanical *Solanum torvum* have been found effective against post harvest pathogens. Spraying of Bavistin (0.2%) and bunch covering at shooting, gave protection from insect pests, improved the quality and appearance. Usually, bunches are harvested at 90% maturity for the local markets and 75% maturity for distant markets. Hydro-cooling, use of ethylene absorbent, waxol treatment and packing with polythene wrapping increased the green shelf life. Combination of heat shock, modified atmosphere packaging, storing in CFB box in cold storage at 13.5^{o}C extended the storage life up to 126 days in Rasthali and 136 days in Robusta. The cold stored fruits ripened normally after treatment with Ethrel (500ppm).

Banana can be processed into different value added products. The NRCB, Trichy has developed protocols for more than 20 value added products and 4-5 products have been commercialized already. Aseptically packed pulp has high demand for export. Banana puree has maximum application in dairy products, bakery, beverage and baby food. Blending of banana (70%) with pineapple (30%) juice recorded maximum organoleptic value. Banana flour is also becoming popular. Banana flour based functional foods like Chapathies, bread and health drinks are found to control the blood sugar level on par with other diabetic food available in the market.

Plantains are usually processed into chips. For every ton of chips produced, 3-4 quintals of raw banana peel is generated as waste. A technology has been developed at NRCB to convert the waste into pickle of acceptable quality. Preparation of pickle from male bud of banana has been standardized. This technology has been transferred to several entrepreneurs for commercialization.

Post Harvest Handling

Banana has an impressive ascending track record of productive yields, ironically including the statistics on post harvest losses. Pre-harvest factors influence the post harvest losses to a greater extent. On plant protection of bunches from external injuries like attack of pests and diseases, exposure to direct sun causing sun burn etc. lead to the development of blemishes which eventually reduce the consumer acceptability. Pre-treatments for post harvest diseases have been recommended. Spray of Bavistin 0.2% and bunch covering at shooting is shown to protect from insect pests and to improve the quality by better appearance. Methods of safe handling, storage and transport of banana have been worked out but require being refined for specific purposes. The bunches are harvested at 90% maturity for the local markets and 75% maturity for distant markets. Hydro-cooling, use of ethylene absorbent, Waxol treatment and packing with polythene wrapping increased green shelf-life. Though hand packing is in vogue trend is slowly shifting towards the hand packing and cartoon transportation. Individual hands are packed in HMHDPE bags and packed in CFB boxes. Transportation with padded structures is expected to reduce abrasion during transportation. Storage and transport at $12^{o}C$ also improved the shelf-life. Slow ripening at 22-$26^{o}C$ and the use of ethylene helped in timely ripening and the development of uniform colour.

Banana can be processed in different forms, aseptically packed pulp has high demand for export and plantain is processed as chips. Banana puree has maximum application in dairy products, bakery, beverage and baby food, its commercial production has been taken up by the Jain group, Jalgaon, Maharashtra. Banana flour is also becoming popular. Use banana rhizome and pseudostem as animal feed which is popularly utilized by the rural folk requires to be worked out. More than 20 value added products of banana are awaiting commercialization.

Banana supply and marketing in India

Organizational structure:

This has well defined marketing dimensions which differs with respect to variety and other factors. Majority of banana supply and marketing is governed by the private sector except in some cases where co-operatives handle the marketing in some states. Perishable nature of the banana forces the markets to be short lived and fresh transactions are effected with everyday new arrivals. Unlike in other commodities, cash marketing is most common where money payment is done immediately after every transaction.

In India fruits have special marketing yards and banana is no different. Banana markets are specialized markets located in all big cities and most of the marketing functions are followed in a yet to be regulated manner.

Of late, entry of marketing giants like Safal, Reliance, Trinetra etc has brought in a change in banana marketing scenario. Companies like Safal has a network of farmers catering to their technical needs and with 'Farm Gate Buy Back Schemes' Minimum support price is fixed which cushions the farmers against over production and market glut.

MAJOR BANANA MARKETING CHANNELS IN INDIA

Cha-1	Grower	>	Co-operative	>	Secondary wholesaler in transit market	>	Tertiary wholesaler in terminal market	>	Retailer	> Consumer
Cha-2	Grower	>	Primary whole seller	>	Secondary wholesaler in transit market	>	Tertiary wholesaler in terminal market	>	Retailer	> Consumer
Cha-3	Grower	>	Primary wholesaler	>	Secondary whole seller			>	Retailer	> Consumer
Cha-4	Grower	>	Pre-harvest Contractor	>	Primary whole seller	>	Secondary wholesaler	>	Retailer	> Consumer
Cha-5	Grower's Association	>	Primary whole seller	>	Secondary wholesaler			>	Retailer	> Consumer

Government support to Storage Facilities

Storage is another important marketing operation where bunches are stored for a short span of time just before selling to the consumers. At farm level, the concept of zero energy chambers has been introduced. A cold storage facility for banana is slowly getting popularized against the inherent problem like chilling injury. National commission on Agriculture has recommended the Co-operatives and public sector undertakings to take up initiatives for providing cold storage facilities in production sites and terminal markets.

Agri-Bioinformatics

To fix up fair prices for bunches irrespective of the markets and places, National Horticulture Board (NHB) is trying to develop good market information through market intelligence services and market news. The prices are regularly aired through All India Radio and Television. NHB has developed a database for horticultural including banana from the information network received from a number of state and central government agencies to provide an overview and analyze the inherent problems in marketing.

With all this back up, to protect the farmers from distress sale and ensure better returns channelling and marketing is facilitated by some of the organizations at various central, state and producers levels.

* Marketing Institutions facilitating marketing in India:
* Some of the important institutions in the general field of agriculture marketing are
* State Trading Corporation (STC),
* Food Corporation of India (FCI),
* National Agricultural Co-operative marketing Federation (NAFED),
* Directorate of marketing and Inspection (Govt. of India),
* Agricultural marketing Departments and Agril. Marketing Boards,
* State and Lower level Co-operative marketing Societies and
* Consumer Co-operative Stores.

Of all these, Co-operative marketing Societies contribute a lot to set right a number of market anomalies. These organizations are the associations of producers for collective marketing of their produce with a capitalistic approach. Maharashtra Banana Growers Association, Gujarat Growers Association has proved successful in terms of better marketability of fruits throughout the country with reduced marketing cost and margins. Some Co-operatives extend the annual credit facilities to the growers whose pay backs are monitored either at harvest or at marketing. With a better networking, upto date market information is made available to the farmers. At required places, Co-operative societies act as government agents for procurement of bunches from its members for further distribution.

National Agencies involved in data collection and development of Horticultural database

Directorate of Agriculture

State Agricultural Universities and Private sectors

Database on Horticultural crops in India

Directorate of Horticulture

Agricultural produce market committees of wholesale markets

Regional office of NHB

Directorate of economics and statistics

7. STRATEGIES TO PROMOTE BANANA EXPORT

Factors favouring export of banana

Out of total production of 88.2 million tonnes of banana 12.5 million tonnes are exported to non-producing countries. Latin America, Africa and Caribbean islands account for major export. In Asia and Pacific regions, Philippines account for major export to Japan although good volume of fruits are also exported by Taiwan, Malaysia and Indonesia. Although India is the largest producer of banana in the world but its share in global trade is negligible. The meager export affected in recent days has been with respect to cultivar Nendran and its products to cater to the needs of our own people in Arab countries. In past, export of banana from India was tried through Banana Federation but it could not succeed.

Apart from promising selections, adoption of varieties and cropping pattern has led to the spread of many devastating diseases like Sigatoka. The cultivation of susceptible Cavendish clones is restricted to dry areas with low humidity due to Sigatoka leaf spot diseases, eventually reducing the cost on plant protection. Availability of fruits through out the year, spread over of harvesting season for selected varieties over different agro-climatic conditions can facilitate the fruit supply chain through out the year with reduced risk factors. Apart from these, high productivity in some states, integrated network of technical support to the grass root levels, entrepreneurship among the farmers and government policies are favourable for banana export. The global scenario presents the export of 20 per cent of the total banana produced. Limited production season and selected varieties along with labour unrest are becoming serious issues in various banana growing countries.

Fig-7: Major Banana & Plantain Expoting Countries

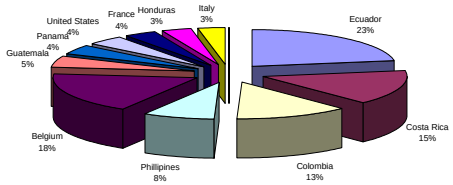
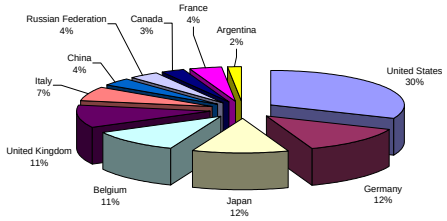


Fig-8: Major Banana & Plantain Importing Countries



BANANA-BASED SMALL SCALE INDUSTRIES

In a study conducted by INIBAP in nine countries, less than 5% of dessert bananas, about 24% of plantain and 30-40% of cooking bananas are processed for national and international markets. Several of these processing enterprises were micro business based with a single product. These products include chips, dried sweet bananas beer, wine, juice, sauce, baskets and mats from banana fibre. The prominent banana processing business in India is chips followed by figs, puree, powder and pickles.

Commercialization

Several processing technologies have been standardized at NRCB and some of them, especially the products, have been commercialized by training and transfer of technology to entrepreneurs and traders. Some of the products like pickles from banana flower and fruit, fig, and juice have been successfully commercialized.

Supply chain

Presently the main players in the marketing of banana are farmers, commission agents, wholesalers and retailers. The management link between these players is weak as there is no systematic demand-supply based production system and buy back arrangement between the producers and the traders. The markets are highly volatile with prices fluctuating based on the arrivals, seasons and other occasions like festivals. With emergence of super market and entry of corporates like Reliance, Bharathi and ITC into retailing, there are possibilities for better linkages between producers and consumers resulting in better price realization for the producers.

CROP INSURANCE

The small and marginal farmers with extremely limited resources are cultivating more than 90% of the bananas in India. Hence, they are unable to bear the risks of crop failure due to devastation by diseases, pests or natural calamities. The schemes are being implemented with the governmental support. The schemes are available to all states/ union territories covering all farmers including tenant farmers. Basically, it is an all-risk insurance covering losses or damages due to natural and non-preventable risks.

GOVERNMENT INTERVENTIONS

Indian government has a number of projects being supported to address the problems specific to banana production. One such was FAO assisted Technical Co-operation Project entitled “Improvement of banana production for small scale growers” was implemented in Tamil Nadu and Andhra Pradesh. The idea of the project was to address the constraints and bridge the gaps in banana production emphasis with on quality planting material. The project also aimed at human resource development and capacity building of the farmers as well as field extension staffs. This enabled them to gain expertise in banana cultivation. The farmers in those two states were trained on the selection of quality planting material, adoption of improved production technologies and efficient post harvest handling methods so as to meet the export standards. The technological infusions have greatly improved the production and productivity of small-scale farmers in the adopted states.

Similarly, Government of Tamil Nadu had launched Hill Banana Rejuvenation project co-coordinated by NRCB, State department and State Agric. University (TNAU) to improve the deteriorating status of cv. Hill Banana in Pulney Hills of Tamil Nadu. There are many more projects being supported and implemented by regional organizations.

The International Linkages

The International Co-operation has been operating through the MoUs/Work Plans signed with various countries/international organizations with ICAR/DARE as the Nodal Department, signed by the Department of Agriculture and Co- operation as Nodal Department. In addition, Ministry of Science and Technology has developed Programmes of co-operation with various countries and international organizations in which ICAR/DARE is the participating agency in agricultural research. The Joint Commissions/Working Groups constituted by the Ministry of External Affairs and the Ministry of Commerce have the component of agriculture/ agricultural research in which DARE participates directly or through the Department of Agriculture and Co- operation.

The ICAR has close collaboration with CGIAR system, World Bank, UNDP, FAO, SMRC, SAREC, CABI, ACIAR and Swedish Academy for Research co-operation among developing countries.

Collaborating Global Programmes

India has successfully coordinated a number of Global banana programmes like International *Musa* Testing programme (IMTP) of Bioversity International-France and evaluation programme of improved varieties through IMTP of Bioversity-Philippines, through BAPNET. NRCB was also involved in BIOVERSITY funded projects on 'Collection and documentation of bananas from NE India'. Tamilnadu Agricultural University collaborated with University of Reading, UK to study nematode resistance and germplasm evaluation.

Recently, India has been identified for the recipient of several externally funded programmes like from the Global Biodiversity Trust. For example, Safe regeneration of *Musa* germplasm, Cryo-conservation of *Musa* germplasm for use in eternity and 'Screening of *Musa* germplasm for drought resistance for use to the resource poor farmers'.

India is also a partner of '***Global Musa Genomics Consortium'*** where it is expected to contribute in terms of developing mapping populations, improvement through mutagenesis, Genetic transformation, development of markers for specific traits etc. Apart from these India could serve as Human resource development centers in the areas of genetic characterization, Breeding tissue culture, genetic transformation, molecular markers, virus indexing, bio-control etc.

What needs to be done under BAPNET to improve banana research

Supporting a strong Asian Banana breeding programme

Keeping in view of the diversity available in the continent and the polyclonal requirement of the region necessitates a good Asian breeding programme. It can have a co-ordinating center and multiple breeding centers in each country. The commom programme can facilitate the easy movement of germplasm and utilization of intermediary breeding material to advance breeding work in each country. It can be something similar to a CGIAR system.

To develop joint Asian programmes for external funding

Although some programmes are being supported by BAPNET, major problems like viruses, drought, upcoming problems like Fusarium wilt tropical race 4, pseudostem weevil etc need to be given special attention. We have witnessed the amount of importance and thrust shown by the international community for Xanthomas wilt. Similar war footing needs to be taken up fro the emerging problems to contain them before they become alarming.

Strengthening of Genetic conservation programmes in Asia.
Asia is one of the major centers of origin for banana and the diversity that exists is vast. Shifting system of cultivation is a way of life in most of the Asian countries. Now there is an urgent need to support project on awareness creation, *in-situ* conservation, developing alternate production systems for the nomadic communities are priorities.

Regular human resource development programmes within Asia
Although BIOVERSITY- France and Philippines are supporting some of the international training programmes, it further needs to be strengthened. Asian laboratories need to be identified for specific training programmes and regional collaborations may be intensified.

INDONESIA

BANANA SITUATION AND RESEARCH AND DEVELOPMENT IN INDONESIA

Yusdar Hilman, Director
Indonesian Center for Horticultural Research and Development
Catur Hermanto, Researcher
Indonesian Tropical Fruit Research Institute

INTRODUCTION

Indonesian banana production reached five millions ton in 2006, supplied 31.15% of national fruit production, and ranked sixth among the banana producing countries. Most of the production is produced in the backyard and small holder mainly in Java, Sumatera and Sulawesi Islands (Appendix 1), and only very few produced by commercial banana companies.

These productions were mainly used for domestic consumption and only few were exported (0.09%) (Table 1). The table also shows that Indonesia paid 4.2 times to import a kilogram of banana than the export was. Low in quality may be the main factor resulted in low export quantity and price unit.

Table 1. Situation of Indonesian banana, reflected in 2006

Situation of Indonesian banana	Value
Production (A)	5,037,472,000.00
Import (B)	124,243.00
National consumption (C)	1,621,100,000.00
Export (D)	4,443,188.00
Rest (A+B-C-D)	3,412,053,055.00
Rest percentage on A+B	67.73
Import value (USD)	168,408.00
Export value (USD)	1,407,542.00
Import price per kg (USD)	1.355
Export price per kg (USD)	0.317
Ratio import/export price	4.279
Availability (kg/capita/year)	21.6
Consumption (kg/capita/year)	7.54
Percent of consumption/availability	34.91

Potency of banana development in Indonesia is supported by the following resources:

High genetic diversity of banana since Indonesia is one of the centre of origin where banana evolution has occurred. This resource possible Indonesia to do selection and generate new variety to cover market demand,

Table 2. Land availability for banana development in Indonesia

No.	Province	Wide (ha)	No.	Province	Wide (ha)
1.	Riau	1,584,667	7.	South Kalimantan	293,569
2.	North Sumatera	554,670	8.	East Kalimantan	5,168,321
3.	South Sumatera	455,656	9.	South Sulawesi	355,035
4.	Bangka Belitung	433,520	10.	Maluku	1,332,796
5.	West Kalimantan	1,773,801	11.	North Maluku	1,644,053
6.	Central Kalimantan	2,226,188	12.	Papua	9,943,353

Source: Pusat Penelitian dan Pengembangan Tanah dan Agroklimat (2000)

Those banana potentials appropriate to support three core programs of Agricultural development in 2005 – 2009, namely: 1) increase food security, 2) agribusiness development, and 3) increase farmer welfare. In the other hand, banana development in Indonesia is threatened by pest and disease complex, low distribution and adoption of technology by the farmers, the high competitiveness among banana producing countries. Due to these high potency and constraint threatening banana production, handling of this crop should be conducted more seriously, that should be equal attention given to rice.

In other hand, national banana consumption ranked the first among the fruit consumption, as many as 14.21 kg per capita per year, occupied 30% of fruit consumption although this among still far below the average world banana consumption as many as 31.51 kg per capita per year. The per capita consumption of fruit in Indonesia is only 50 kg. The bad news is that banana consumption in Indonesia is halved from the total banana consumption in 1990. Since banana is significantly support nutrient and medical functions for human, this issue should be paid more attention.

CURRENT BANANA RESEARCH AND DEVELOPMENT

Banana research in Indonesia is done by Indonesian Agency for Agricultural Research and Development (IAARD) cq. Indonesian Tropical Fruit Research Institute (ITFRI), universities, and private companies, while development program is guided by Directorate General for Horticulture, local government/ autonomous regions and private companies.

In house research and development

By 2009, NARS-funded banana R&D at ITFRI is being focused to compose package technology to support the establishment of banana standard operating procedure. Research and development that have been conducted within the period of 2005 – 2009 are:

- Germplasm management; to support sustainable germplasm management and supply genetic materialto improve existing commercial varieties and to establish more productive, rapid yielding, and pests' resistant varieties.
- Varietal improvement and the control of major banana pests and diseases; to solve the main constraint of banana production caused by pests and diseases.
- Development of banana cropping system in swamp area of Kalimantan
- Integrated crop management; to formulate and assess the existing technologies into one complete of technological package.
- PRIMA TANI; a core program of IAARD that consequently become the program of Ministry of Agriculture. Banana contributes significantly to the program due to the high farmer demand banana

information and technologies. It is happened because of the important role of banana for food and income security.

Aside from those NARS-funded activities, ITFRI has also conducted some research collaborations with other agencies, namely:

- Diagnosis and management of banana wilt diseases in Indonesia, Indonesia – ACIAR bilateral project no. CP 2004/034. The project is objected to improve the understanding of the epidemiology and biology of banana wilt diseases, evaluate of management options (biocontrol, soil treatments, elicitors) for wilt diseases, and extents of best practice management practices for banana wilt diseases.
- Mitigating the threat of banana fusarium wilt disease: understanding the agroecological distribution of pathogenic forms and developing disease management strategies; multilateral project no. CP 2005/136; aim to collect and characterize *Foc* and expand the reference collection with representative isolates, to establish pathogenic relationships between VCGs and various banana cultivars, to develop and validate disease management tactics, and capacity enhancement and training:
- Utilizing rhizobacteria to improve the quality of banana plantlet and its tolerance to fusarium wilt disease; research collaboration with Bogor Agricultural University under KKP3T (IAARD-funded research collaboration with universities)

Finding

Collection of 190 banana accessions; Kepok Tanjung and Raja Kinalun was released in 2007

Within the last two 'five-year periods', ITFRI resulted in three candidates of banana variety, coded as INA-01, INA-02 and KPK 05.04. Those candidates are mainly to improve existing commercial varieties, namely Kepok, Ketan and Pisang Awak. Improvement is mainly addressed to their productivity and resistance to fusarium wilt disease.

Solarization/solar heating increased soil temperature until 10^{o}C above the control, reduced *Fusarium* sp. propagule in the soil, reduced fusarium wilt incidence and increased the agronomic performance of the banana. The technique is appropriate to dilute pathogen population in the infected soil.

Application of Gliostar (formulated *Gliocladium* sp.) either single on combined with M-RIF (nutrient enriched organic matter) reduced *Fusarium* sp. propagul in the soil. However, fusarium wilt incidence was not significantly different among the treatments.

Banana has having good performance in swamp area giving opportunity to utilize huge swampy land in Kalimantan. Application of combined amelioran and 450 kg K2O/hectare/year positively affected plant growth.

Access to 15 provinces in Indonesia (Fig. 2) on Identification of pest and disease complex, banana potential and banana farmer's performance. Banana wilt disease incidence, both for fusarium and bacterial wilts, in banana production centre of the fifteen provinces were ranging from 4.88 to 60.38%.

Seven *Foc* VCGs were collected during the survey distributed among the provinces and banana varieties. BBTV and Erwinia wilt disease is found to be the next threat of banana production in Indonesia after blood disease and fusarium wilt.

FUTURE BANANA RESEARCH AND DEVELOPMENT

For this reason, banana research building should be comprehensively established, integrated, and focus in a **national commercial based research** system. This research building will support the final goals of agricultural revitalization, namely: 1) establish industrial agricultural system, 2) settle food security,

3) establish job opportunity for the farmers, and 4) alleviate poverty through income security. Banana R&D program is mapped into SWOT analysis (Table 3).

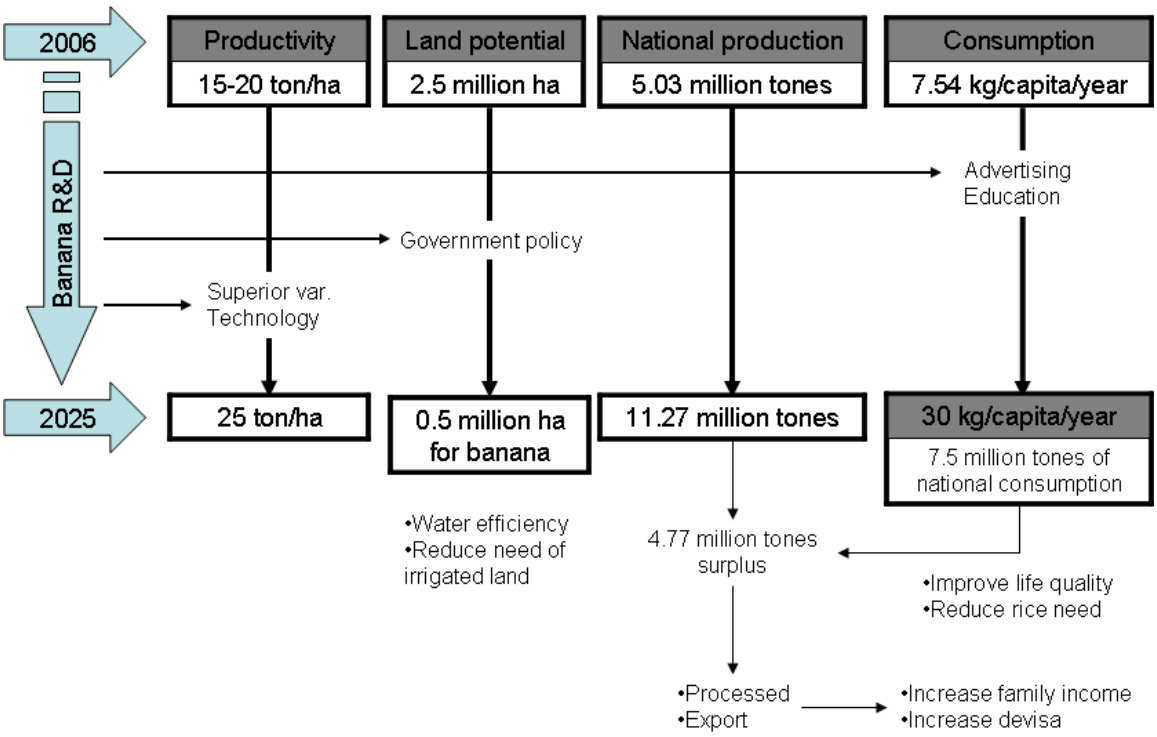
Table 3.SWOT analysis of banana research and development

	Strengths Best banana genetic resources in the world Huge land suitable for banana	**Weaknesses** Funding depends on national budget (NARS) Un focus R&D Slow transfer of technology
Opportunities Indonesia's population as a potential market Banana is the commodity of the people in Indonesia	Utilization of genetic resources and Involvement of the users in process of technology establishment	Triggering and supporting self-funding sufficiency Establish 'Banana Research Institution" closely to the farmer/ producer and user Direct supply materials, equipments, and information to the users
Threats Global competition and un fairness Food insecurity and poverty	Increasing the production quantity and quality Supporting growth of small holder and banana companies	Establishing national and international network Pushing food diversification through promotion

Banana R&D in 2009-2014 is objected to:
Escalate product quality and quantity, per capita consumption, and banana export. Increase banana contribution in poverty alleviation, food security, and ensure sustainable natural resources management.

STRATEGIC PLAN

Utilizing the existing resources, strategic plan of banana research and development is addressed to support three core program of agricultural development through **fruit quality improvement, increase of production, consumption, and export**. Goals of the strategies are projected in the following scheme (Figure 1). The scheme is addressed to the final goal in 2025 as it was proclaimed by The President of Indonesia in 2005 about 'Agriculture, Fisheries, and Forestry Revitalization'. By 2025, targeted national banana production is 11.27 million tones. The escalation of this production should be escorted by fruit quality improvement to reduce yield loss and increase export opportunity, and escalation of banana consumption.



Research and development of each target is composted in the following strategies:

1. Production escalation

Research

Research to support production increase should be done on-farm through varietal improvement, improvement and adaptation of production technology, and off farm on post harvest and improvement of banana agribusiness profile.

Development

a. Expansion

Production escalation through land expansion is widely opened due to huge land availability suitable for banana production. Land availability of some provinces is listed in the following table:

b. Intensification and farmer orchard renovation

Most of current national banana production is resulted from farmer orchards, either from backyards or small holder orchards. Consequently, product quantity and quality are only appropriate for family need, local and domestic consumption. Farming renovation and cultivation improvement are the ways to raise banana production quantity and quality.

c. Varietal shifting

National banana productivity reaches 15 – 20 ton per hectare that can be fulfill by 15 kg produced variety. Existing banana accession shows several varieties producing more than 20 kg yield per bunch. Selection, utilization and development of those high yielded varieties will significantly increase banana productivity.

Consumption escalation

Research

Increasing consumption will be suported by study on nutrient content, appropriate product, product qualility, and consumer preference to each of banana variety. Study of the product diversity will also be needed to expand consumer choice of the banana dessert and product.

Development

In the side of development, raising consumption rates can be done through the following steps:

- Increase society awareness and understanding on the nutrient content and function of banana through intensive publication/advertisement in electronic media,
- Collaborate with nutritionist, pediatrician association, and related organization in society nutrient fulfillment to promote banana as nutrient source. 'Posyandu' and elementary school are appropriate media to change the dietary habit and eventually increase national consumption.
- Implement banana-based product and food diversification.

Increase of export

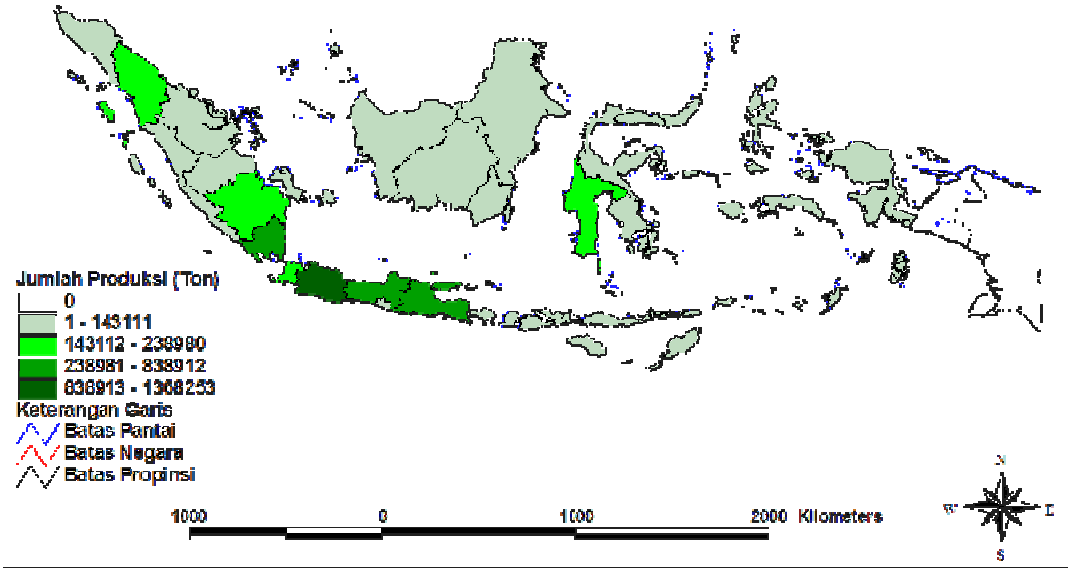
Research

To support fresh and processed banana, research will be addressed on study of foreign market standard quality (usually specific of each country), improvement of fruit quality through pre and post harvest handling, product diversity of specific variety.

Development

Raising export can be facilitated by market information supply (volume, standard quality of product, and target country), implementation of standard quality of domestic product to the banana producing farmers, and facilitating storage and post harvest processing equipments.

Appendix 1. Map of Indonesia banana production in 2006

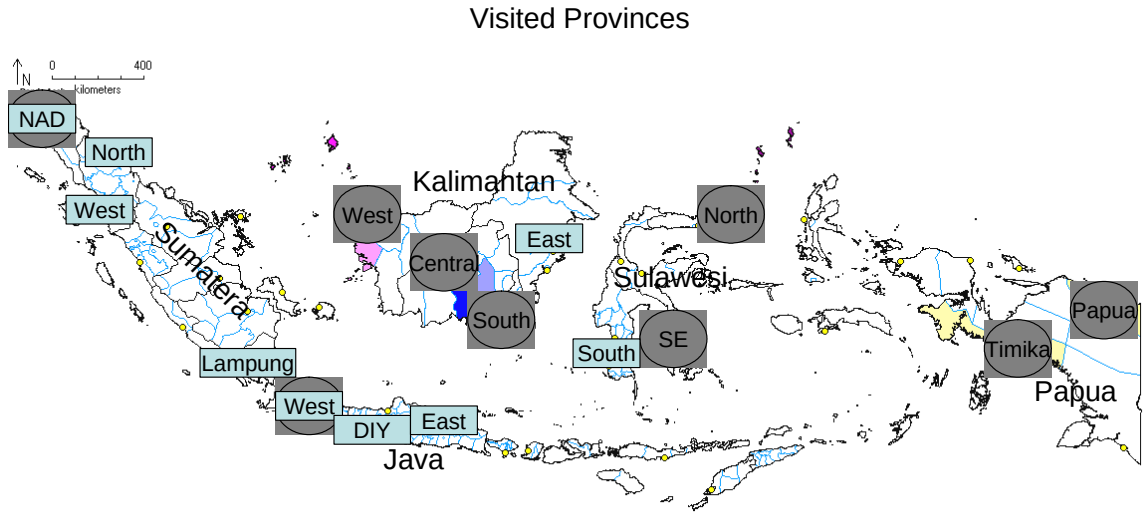


Source: http://ditbuah.hortikultura.deptan.go.id//index.php?option=com_content&task=view&id=70&Itemid=141

Appendix 2. Performance of Barif-0025 (Ketan, female parent), KPK-05.04 (the hybrid), and Barif-0130 (Calcuta, male parent).



Appendix 3. Provinces under the survey ot the two banana project collaboration. Area with square sign were visited by CP 2004/034 while round sign were accessed by CP 2005/136.



Appendix 4. *Foc* VCGs on banana varieties

Source: Hermanto, et al. 2008

Fusarium VCG	VOT	*M. schizocarpa*	Barangan	Rajasere	Rajabulu	Ambon Putih	Ambon Hijau	Ambon Kuning	Siem	Pulo (ABB)	Raja	Nangka	Kepok	Manurun
01213/16	O		√		√	√					√		√	
01218	I			√			√		√			√	√	
0123	I			√				√	√					
0120	O			√		√								
0124/5	I									√				
0126	O	√				√							√	√
01219	O												√	

R & D Updates of Banana in Malaysia

Nik Masdek Hassan, Ting, A.S.Y., Suhana O., Al-Hetar, M.Y., Yang, C.Y. and Syarifah Aisyafaznim, S.A.R.
Malaysian Agricultural Research and Development Institute

Introduction

Banana still remains an important fruit crop in Malaysia over the years. It is the second most widely cultivated fruit crop. The Third National Agricultural Policy has listed banana as one of the 15 fruit types prioritized for commercial production. The popular dessert cultivars are Cavendish, Pisang Berangan, Pisang Mas and Pisang Rastali and the cooking cultivars are Pisang Tandok, Pisang Nangka, Pisang Raja, Pisang Awak, Pisang Abu Nipah and Pisang Kapas. Banana is a traditional crop in Malaysia and its production has been dominated by smallholders. The production system are characterized by small farm size, not well organized, low inputs, poor quality planting materials, thus resulting in poor yields and low fruit quality.

Malaysia produces more than 500,000 metric tons of bananas per year from a production area of more than 31,000 hectares. The banana production statistics is quite stabilized around these figures. In line with the population growth, efforts are being undertaken to increase production and action are being taken to increase the area under banana production, enhancing production technology and agronomic practices through cultivar improvement, higher density planting, fertilizer management and through enhancement in pest and disease management practices.

The objective of this paper is to update on the research activities being conducted to upgrade the banana industry.

Banana research and development activities

Selection of superior cultivars

Pisang Raja: Growth performance of selected accessions and reaction to Fusarium wilt

Pisang Raja is a popular banana cultivar and used for both as a fresh eating banana as well as a cooking variety. The objective of this study is to identify improved cultivars of this variety of banana. Pisang Raja accessions were collected from around the villages across the country. A total of 144 accessions were collected and planted and the agronomic performances as well as reaction to Fusarium wilt were evaluated.

The performances of the top 15 accessions were presented in Table 1. Accession 51B stands out as the superior accession in terms of highest bunch weight. The rest of the accessions give moderate yields ranging from 14 to 18 kg. The number of days to shooting was only 235 days for accessions 51B. The length of time to shooting for other accessions ranges from 270 to 452 days. Four accessions had survived up to 3 harvests and the rest of the accessions only survived up to 1 or 2 harvest before succumbing to Fusarium wilt. Accession 51B has the best overall performance among the accessions evaluated.

Table 1: Agronomic characters of 15 selected Pisang Raja accessions

Accession No.	Days to shooting	Plant height (cm)	Bunch wt. (kg)	Reaction to Fusarium wilt
51A	301	303	16.2	Good
51B	235	280	23.4	Good
54B	324	300	16.2	Moderate
55A	327	329	16.8	Good
55B	270	282	15.5	Good
66A	323	302	14.0	Poor
66B	308	300	15.2	Poor
70B	298	333	15.6	Moderate
70C	284	300	15.5	Moderate
71A	285	324	14.8	Moderate
72B	308	340	14.0	Moderate
72C	298	333	18.0	Moderate
78C	296	292	14.8	Moderate
91C	270	326	14.2	Moderate
106B	452	322	14.0	Moderate

Reaction to Fusarium wilt:
Good: Survive for 3 harvests
Moderate: Survive for 2 harvests
Poor: Survive for 1 harvest

Genetic stability and agro-ecological performances of selected banana varieties

Several local and introduced cultivars brought in from various countries through INIBAP are being evaluated for their performances under different agro-ecological zones or environments. The cultivars being evaluated were GCTCV 106, GCTCV 119, GCTCV 215, GCTCV 247, FHIA-21, FHIA-25, CRBP-39, Montel, Williams, BITA-3, cv. ROSE, P. Berangan, P. Tanduk and P. Embun. The agro-ecological zones selected are in the Northern Zone (Bukit Tangga), Eastern Zone (Jerangau), Central Zone (Serdang) and the Southern Zone (Kluang). These studies will determine the stability of growth performance, fruit quality and disease resistance on the selected banana clones and will identify promising varieties to complement current fresh and cooking varieties.

Management of Fusarium wilt disease

Fusarium wilt of banana caused by *Fusarium oxysporum* f. sp. *cubense* (Foc) remains as one of the most serious and devastating disease of banana affecting many commercial plantations and smallholders farms throughout the banana growing regions of the world. In Malaysia this disease still causes huge economic losses to the banana industry. Despite the numerous control strategies attempted, no effective methods are available to control the disease. The search for remedies continues and research efforts are aimed at understanding the disease and looking for potential and effective methods of managing the disease.

Use of plant growth promoting rhizobacteria

Bacteria isolated from the root and rhizosphere have the ability to colonize roots, stimulate root development, increase water and nutrient absorption resulting in stimulation of plant growth and showed potential in disease reduction. A rhizobacterial isolate was shown to inhibit the growth of Foc Race 4 in vitro resulting in hyphae malformation by vacuole formation, swelling and thickening of hyphal strands. In glasshouse studies, the rhizobacteria was able to delay the infection process. Similarly, soil application of the biocontrol agent also delayed the infection process.

Use of endophytes from wild bananas

As Malaysia is also part of the centre of origin for bananas with abundance of wild bananas and their observed status to be free from Fusarium wilt infection. Wild bananas have been shown to be an interesting and potential source of endophytes. Initial studies have established the beneficial properties of endophytes isolated from wild bananas such as their antagonistic properties, their ability to induce host defense mechanism and improved plant growth and vigour. In vitro screenings for antagonistic properties against Fusarium oxysporum f. sp. cubense Race 4 revealed a much lower percentage of endobacteria with antagonistic activity compared to 100% of the total fungal endophytes showing varying degrees showing antagonistic inhibition.. Selected endophytic isolates inoculated onto healthy banana plantlets resulted in a positive host-endophyte association. Endophytic infection resulted in improved vegetative growth, and caused an increase in inducible compounds such as peroxidase, polyphenoloxidase, phenylalanine ammonia lyase, total soluble phenols and lignothioglycolic acid assayed from the root tissues. Pre-treatment of Fusarium wilt susceptible banana plantlets showed delayed onset of foliar symptoms, and lowered the percentage of disease incidence, disease severity and epidemic rate. Glasshouse studies had showed better results but field evaluation resulted in plants succumbed to Foc infection by week 28.

Plant species as host for endophytic microorganisms

Realizing the usefulness of endophytic microorganisms as potential biocontrol agents, source of novel metabolites and model systems for host-parasite interaction, the search for endophytic microorganisms on other plant species as host continues. An evaluation of 54 different plant samples comprising fruits, ornamentals, weeds and medicinal species indicate the distribution of endophytes from the various plant species. Results indicated that ornamental plants and weed species can host more endophytes and higher number of endohytes can be isolated.

Defense-associated genes in banana genotypes

A study was conducted to screen for defense-associated genes in various genotypes of tissue cultured 'Rastali Wild Type', 'Rastali Transgenic', Rastali Mutiara' and Pisang Jari Buaya. Molecular detection on defense-associated gene was conducted using Polymerase Chain Reaction and DNA extracted from the stem of each genotype. Results showed that 'Rastali Wild Type' lacks some defense-associated genes compared to the other 3 banana genotypes which explain its susceptibility to Fusarium wilt in the field.

Fungicidal activity of chitosan

Chitin is a biopolymer structurally related to cellulose and is found in the shells of crabs and shrimps. Chitosan is generally prepared from chitin by N-deacetylation with alkali and now is available commercially. The antifungal activity of chitosan was tested in vitro against Foc Race 4. Chitosan can reduce 75% of the hyphal growth of Foc Race 4 at 8mg/ml on potato dextrose agar. Similarly, the sporulation of Foc was inhibited exceeding 96% at 8mg/ml and spore germination inhibition reached 100%. Morphological deformation of the hyphae also occurs at concentration of more than 1 mg/ml.

Plant parasitic nematodes of banana

Distribution of plant-parasitic nematodes of banana and molecular characterization

A study was carried out to determine the distribution of nematodes from untreated soil of different banana varieties. The studies cover 14 localities in six different states in Peninsula Malaysia. The plant-parasitic species recovered were *Helicotylenchus* spp., *Hoplolaimus* spp., *Macrophostonia* spp., *Meloidogyne incognita, Paratylenchus* spp., *Pratylenchus coffea, Radopholus similis, Rotylenchulus reniformis, Tylenchida* spp., *Tylenchus* spp. and *Tylenchorynchus* spp*. Meloidogyne incognita* is the most prevalent in all the localities surveyed. These nematodes will be further evaluated for their genetic diversity and to determine the intraspecific and interspecific genetic variations. Thus, these nematodes will be further subjected to molecular manipulations, cloning and sequencing.

Interaction of Foc Race 4 and Nematodes

A preliminary study was conducted to observe whether there was a possibility of an interaction between Fusarium wilt incidence and severity with nematode infestation. The farm surveyed was a 40 hectares banana farm previously planted with Cavendish banana for 5 years. This area has been seriously infected with Fusarium wilt disease. Samples were taken from 45 locations and brought for extraction. Forty-one locations were infested with one or more of the nematode species. Ranking of the nematode in order of frequency of occurrence is as follows: Rotylenchulus sp. (34 samples), Helicotylenchus sp. (16 samples), Meloidogyne sp. (11 samples), Macrophostonia sp. (6 samples), Aphelenchus sp. (5 samples) and Pratylenchus sp. (4 samples). Rotylenchulus sp. is not only frequently recovered but also present in high population. There may be interaction between the presence of nematodes and the severity of the occurrence of Fusarium wilt of banana. However, further studies must be conducted.

New disease report

Incidence of Moko disease was first observed on banana in 2007. The disease was first observed in the southern state of Peninsula Malaysia. The disease was observed on the fruit of Pisang Rastali, Pisang Nipah and Pisang Kapas.

Other activities

Ms. Kathy Grice, plant pathologist from Australia, visited Malaysia in May, 2008 en route to CIRAD, France. She visited banana farms at MARDI and several other banana farms in the surrounding areas to study the foliar diseases of banana.

Alex Markham (assisted by Dr. Richard Markham) spent a month in Malaysia to conduct part of his final year research project. His research project involve isolating endophytic microorganisms from wild bananas as possible biocontrol agents against *Fusarium oxysporum* f. sp. *cubense* Race 4.

PAPUA NEW GUINEA

Research and Development Activities on Bananas in Papua New Guinea

Rosa N. Kambuou, Principal Scientist

National Agricultural Research Institute

Introduction

Banana is a major food crop in Papua New Guinea (PNG) and is the dominant staple crop in most farming systems in the lowland areas of the country and ranks second in importance after sweet potato in terms of production and consumption. PNG is an important 'centre of genetic diversity' of wild and cultivated bananas, with the greatest number of *Musa* species. The great diversity in the cultivated diploids (AA) has made PNG the only country in the world where diploid bananas are of significance in agricultural food production (Stover and Simmonds, 1987).

Cooking bananas is often distinguished from sweet or dessert bananas, although this is somewhat an artificial distinction. In PNG, more cooking bananas are produced and consumed than dessert types. Well over 80 percent of bananas produced are cooking types and are grown mainly for household consumption while less than 20 percent are dessert types grown by semi-commercial farms run by institutes or private growers for urban fresh fruit markets (Molina et al. 2003). The diploid cultivars are mostly cultivated in wet lowland areas of the country, including the islands. The triploids ABB groups, are harder and are grown mostly in dry lowland areas, along the Papuan coast and the Markham/Ramu valleys.

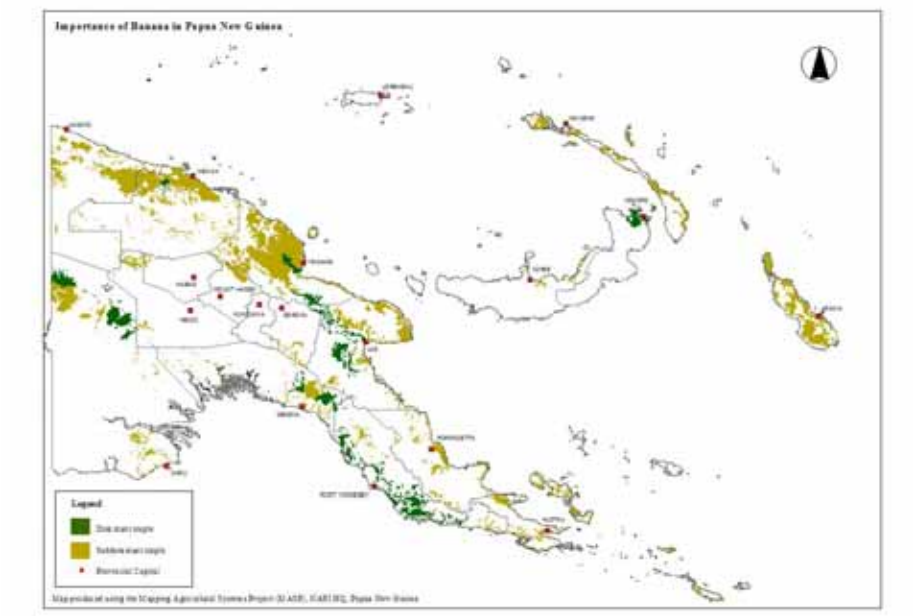


Figure 1.

The other triploid group, the AAB, are grown mostly in the highland areas of the country
The importance of banana as a dominant and sub-dominant staple crops in different areas of the country is shown in Figure 1 above.

This report will briefly discuss the banana Research and Development (R&D) work currently being implemented in the country and the recommendations from the National Stakeholders on the Banana Agricultural Science, Technology and Innovation Systems (ASTI) in Port Moresby, PNG.

2.0 Brief on Banana Production, Consumption & Marketing in PNG

Banana production

All banana produced are consumed in the country. The subsistence production is mostly for household consumption and the surplus is sold in urban markets for cash. There are few semi-commercial growers who grow dessert varieties for the urban fresh fruit markets in Port Moresby and Lae. There are no recent national level data on banana production for PNG. However, the nation-wide household consumption survey that was carried out in 1996 as part of the World Bank Poverty Assessment Project, gives some estimates of household production. Gibson (2001) reported an estimate of 4.1 thousand tonnes of bananas produced in 1996. The FAO estimates for banana production for PNG in the same year were 6.7 thousand tonnes (Waterhouse et al 1999). However, the report by Bourke and Vlassak (2004) stated that the annual production of banana was estimated at 4.4 thousand tonnes, second only to sweet potato with 2.9 million tonnes.

It is a mammoth task to undertake a study on banana production in PNG because of its subsistence nature. Small farmers throughout the country are growing bananas in mixed cropping system and in isolated areas not linked by roads or market infrastructure. Under subsistent farming banana suckers are planted in mixed cropping matter with other food crops usually at very high densities of over 400,000 plants/ha. Generally farmers use sword suckers as planting materials, but farmers in Central Province sometimes plant fully-grown banana plants with tops cut off. Banana grows in any kind of soils, but does well under loamy clay soils with sufficient retention of soil moisture and good organic matter. The diploids would take up to seven months to mature while the triploids take up to nine months.

Banana consumption

Gibson (2001) reported that each person in PNG was consuming around 83kg of bananas in 1996 with the rural areas consuming the highest quantity of 90kg per head. The FAO estimates imply average banana consumption in PNG of 84kg per head in 1998 (Waterhouse et al 1999). The FAO estimates closely related to the findings of the PNG Household Survey conducted in 1996. Interestingly the household survey showed high consumption of bananas (47kg/person/year) compared to other major staple food crops in the urban areas of PNG as shown in Table 1. The importance of banana as a food crop is again apparent in providing 6.9 percent of the national calories and 7.4 percent of the rural household calories (Gibson 2001). The numbers in the brackets in Table 1 are percentage of total calories provided by different staple food crops from the 1996 PNG household survey.

Table 1: Household consumption and total calories (%) by major staple food crops in 1996

Major staple food crops	Quantity consumed (kg/person/year) and total calories (%) provided by staple food crops		
	PNG	Urban	Rural
Sweet potato	260 (26.7)	299 (30.1)	42 (4.7)
Banana (cooking & dessert types)	**83 (6.9)**	**90 (7.4)**	**47 (3.9)**
Taro & Chinese taro	62 (6.6)	68 (7.3)	23 (2.2)
Yam	28 (2.4)	31 (2.6)	9 (0.7)
Cassava	25 (2.8)	27 (3.1)	9 (1.0)

Source: Gibson, J. 2001. The Economics and Nutritional Importance of Household Food Production in PNG. p 37

Marketing and distribution of bananas

Large production of banana in the country is still in the hands of the subsistence farmers. There is no formal market infrastructure provided by the government for bananas or other food crops. In banana growing areas of the country, which includes the Central, Morobe, East New Britain and Madang provinces, the small farmers take initiatives themselves to transport the produce from the rural areas or farm sites to urban markets for sale. Prices for bananas are set by the farmer/sellers themselves according to the varieties, the urban centre where it is sold and supply and demand of the crop at that time. It is expensive to buy dessert bananas from markets in Port Moresby than from other centres in PNG. A hand of naturally ripened Cavendish banana would cost around US$1.5-3.5 (K5-7) and a bunch of diploid (five hands) bananas would cost around US$1 (K4) in the Port Moresby markets.

There is some informal transportation of bananas from the highland centres of Goroka and Mt. Hagen to Lae and Port Moresby. Private enterprises and local business groups initiate the transportation of fresh produce from the production areas in the highlands to the main urban centres of Port Moresby and Lae. The two main actors involved in the transportation and marketing of fresh produce in large quantities in Port Moresby are wholesale companies the Alele Ltd and the Green Fresh. The Fresh Produce Development Authority (FPDA) is a semi- government agency that is also responsible for the post-harvest handling and transportation of fresh produce in PNG. These organizations are currently responsible for the transportation of fresh produce from the highlands to Lae and Port Moresby using road and sea routes, which is cheaper than the air transportation.

3.0 Banana Research Activities

The PNG National Agricultural Research Institute (NARI) is responsible for all food crops research in the country including research activities on bananas.

3.1 National Banana Germplasm Collection

NARI is the custodian for the genetic diversity of PNG bananas. Over the years NARI and the Department of Agriculture & Livestock (DAL) have collected the genetic diversity of bananas in the country and assembled them in *ex situ* field collection at NARI Laloki, 25K out of Port Moresby. Working collections of less than 30 cultivars are maintained at other NARI Programme sites at Keravat, Bubia and Aiyura. The current collection has 217 accessions and landraces from PNG and some international breeding lines and varieties. The collection comprised of 81 diploids, 115 triploids, 11 tetraploids and 7 accessions are unclassified. The original collection had wild species including; *Musa balbisiana*, *M. acuminata* ssp. *banksii*, *M. schizocarpa*, *M. maclayi* ssp. *maclyi* var. maclayi, *M. boman*, *M. lolodensis* and *M. ingens* and three Fei'i bananas but these bananas did not establish well under *ex situ* set up and died.

The National Banana Collection is not fully characterized and evaluated. Work is continuing on the descriptors of male buds and fruit bunches. Lately, the curator is not sending or entering any data into MGIS because of non-availability of the revised version of MGIS. Work on collecting data on the National Banana Germplasm Collection has temporary halted this year until assistance is sorted from INIBAP. The NARI Genetic Resources Programme has engaged an in-country consultant to look at developing a PNG PGR Information Management System. Once this system is established, data and information on banana collections would be properly stored and documented.



Plate 1: PNG National Banana Germplasm Collection



Plate 2: J. Paofa characterizing male buds

3.2 Current Banana Research Projects

PNG through NARI collaborates with regional and international organizations on banana R&D programmes, and these organizations include; Banana Asia-Pacific Network (BAPNET), Pacific Agricultural Plant Genetic Resources Network (PAPGREN) and the Australian Centre for International Agricultural Research (ACIAR).

Banana Sigatoka Resistant Study

The BAPNET collaboration in PNG is currently looking at varieties of bananas that are resistant to Sigatoka leaf disease (*Mycosphaerella fijiensis*) and the study on the survey of the *Fusarium* wilt (*Fusarium oxysporium*) disease of bananas. Over 16 varieties of common international banana varieties and breeding lines resistant to Sigatoka leaf diseases from IMTP were introduced to PNG in the early 1998. This is an international collaborative project between the INIBAP member countries. These materials were tested under irrigated conditions at Laloki, outside Port Moresby. The study identified five varieties showing high resistance to Sigatoka disease and good bunch weights ranging from 15-38 kg/bunch. These five varieties are now tested under on-farm conditions at PAU and later this year they will be tested under high rainfall and atoll environments in the country. Sigatoka leaf disease complex is present in PNG and can cause up to a 40 percent yield reduction in banana production, especially in high rainfall areas. The immediate output from this research collaboration with PAU will directly contribute to boosting the dessert banana production by PAU for the local fresh fruit markets in Port Moresby. The cost of production in relation to chemical control will be minimized as resistant varieties are planted. Recommendations on suitable varieties resistant to Sigatoka will also be made available to local banana producers for production. The overall outcome will contribute to increase national production of dessert bananas for the domestic fresh fruit markets in PNG.



Plate 3: Sigatoka Resistant Study planted next to Cavendish Commercial block at PAU



Plate 4: Hybrid FHIA 23





Plate 5: Bunches of Hybrid SH3436

Banana Fusarium Wilt Study

The *Fusarium* wilt study is another BAPNET collaborative project with PNG/NARI, Indonesia and Australia and is funded by ACIAR. Again NARI is the PNG collaborator in this project. Currently the PGR Programme of NARI is working in close collaboration with the PNG/National Agriculture Quarantine Inspection Authority (AQIA) in undertaking surveys in strategic locations throughout the country, especially along the PNG-Indonesian border. *Fusarium* wilt 'race 4' is the most destructive race and is present in Irian Jaya Province of Indonesia. Research work in PNG is basically to investigate the presence of the disease in PNG and what contentment measures to take should the disease come to the country. Surveys were undertaken along the PNG-Indonesian border from Sandaun to Western Provinces and in the Morobe and Eastern Highlands Provinces of the mainland PNG and the island provinces of East New Britain, North Solomons and Manus Provinces. Results from the surveys so far showed no signs or presence of *Fusarium* wilt in these areas. The main diseases seen throughout the survey areas were Sigatoka complex and *Marasimiellus* rot (*Marasimiellus inoderma). Fusarium* wilt attacks mostly the triploid 'ABB' group of bananas. These bananas are tough and most suitable for growing under prolong dry conditions. They contribute significantly to the daily food requirements of the rural households who live in the drier areas of the country like the coastal areas of Central Province and the Markham/Ramu valleys of Morobe Province. Food security for the rural households in the drier areas of the country would be at risk if *Fusarium* wilt comes to PNG.

The surveys have been carried out and currently the PNG team is multiplying sufficient planting materials for a Varietal Evaluation at Laloki, looking at 10 commonly consumed cultivars of bananas in PNG.



Plate 6: Dr T K Lim & Dr A Molina having discussions with the PNG Fusairum Project

Banana Fruit Fly Study

Apart from the diseases, insect pests also attack bananas. Major entomology studies conducted on bananas is on the control of banana fruit flies (*Bactrocera musae* spp.). This is another collaborative project between PNG NARI and Australia and is funded by ACIAR. The project is looking at managing and controlling banana fruit flies in PNG through the application of Male Annihilation Techniques (MAT) and fruit bagging as control agents against fruit fly infection. The combination of MAT techniques and fruit bagging appears to produce promising results on the commercial planting of bananas at PAU at the moment which results in the production of undamaged and clean banana fruits for the urban markets.

On-farm Conservation Study

The other project implemented by the NARI Genetic Resources team is the On-farm Conservation Project funded by PAPGREN. This project has received a one-year funding and commenced in August this year. The project has initially taken inventory of the food crops inter and intra-specific diversity existing in farmer's fields, the traditional diversity and the introduced diversity, the importance of these food crops species in the livelihoods of these people and also assess 'genetic erosion' over a five year period. The study is executed by interviewing farmers through questionnaires/surveys. The reassessment of the status of diversity is carried out every 2-3 months to capture the 'drivers' of change and erosion that is taking place. This study is conducted at Pinu village 80kg away from NARI Laloki where farmers are following the banana-yam-cassava based farming systems practices. Preliminary findings have shown that farmers in Pinu village are maintaining 24 distinctive banana cultivars or landraces. The farmers also mentioned that they lost some of their traditional cultivars mainly through floods and damage by wild animals. The study continues to 2012 to see what happens to the current diversity and whether new crops/cultivars are introduced and accepted by the people and to identify the 'drivers' of genetic erosion on-farm.

3.3 Banana Projects/Activities in the Pipe Line

Two project/activity on bananas have been approved and are in the pipeline for implementation as soon as the procedures are put in place.

Caroteniod Content Analysis Study

This project is to address the micronutrient deficiencies in urban and peri-urban populations in West and Central Africa through *Musa*-based foods. PNG NARI is collaborating with Bioversity International Commodities for Livelihoods' Programme in the project by providing the orange flesh banana accessions from the PNG National Germplasm Collection for the caroteniod analysis study. Currently the national curator is going through the collection to identify 20 accessions that will be used in the study. The project is funded by the HarvestPlus Challenge Programme.

Pacific Region Banana Collection

The last Pacific Regional Banana Meeting was held in South Johnston Research Station, Innisvalle, Australia and the decision was made for the Pacific Regional Banana Collection to be established there. The island member countries were asked to go back, select the unique accessions such as the Maoli, Popoulu, Iholena and Fei'i groups of bananas from their national collections and deposit them as 'duplicates' with the Regional Field Gene-bank at South Johnston Research Station. The selected accessions will be sent with passport, characterization and evaluation data. Work on this activity has commenced in PNG and hopefully the accessions will be sent towards the end of the year.

4.0 Banana Development Activities

Banana production in the country is in the hands of small subsistent farmers. Few individuals and organizations are involved in growing bananas specifically for sale. One such organization is PAU growing bananas on commercial scale for the Port Moresby market. They are growing Cavendish variety and are costing them lot of money in terms of fungicide application in controlling Sigatoka leaf disease. The screening of Sigatoka resistant hybrids/varieties on-farm at PAU showed impressive results especially the performance of hybrid SH3436. The international hybrids and varieties including; FHIA02, FHIA23, SH3436 and Pisang Ceylan still showing resistance to Sigatoka and produce very impressive fruit bunches. However, all of them are showing some symptoms of Black cross and Cordana. The observations so far on the PAU study showed hybrid FHIA17 to be affected by Sigatoka leaf disease (Plate 10). The PAU planting is the 6th time these varieties are grown in the field from when they were first introduced as tissue culture plantlets to PNG. The planting materials for the study were taken from the field multiplication block and therefore they were not clean materials.

A Mini-Field Day on Bananas was organized jointly by NARI and PAU farm for the local banana growers and stakeholders who are involved in the Banana ASTI system in and around Port Moresby. The banana growers and visitors were impressed with the growth and performance of the hybrids and immediately requested for planting materials to try out on their farms. The visitors also had the opportunity to taste the different hybrids as fruit when ripened and as food crop when cooked (boiled with skin) and as drinks and smoothies. Findings from the Taste Panel showed over 50% of the 30 tasters graded hybrid FHIA02 as very sweet, but most of them like variety Pisang Ceylan in the banana smoothie recipe. Over 76% of the tasters favored (like a lot) hybrid SH3436 as dessert or ripe banana. The comments received for hybrid SH3436 is that it is sweet, has firm and attractive skin color, excellent shape and size for the dessert banana industry in PNG. According to the taste panel study, the tasters preferred hybrids FHIA23 and FHIA02 when boiled with skin.

Banana suckers and planting materials are available from different sources in the country. Small subsistence farmers maintain their own planting materials in old gardens, which are later transferred to new garden sites. Those growing bananas for the local and urban markets also supply their own planting materials from their farms. PNG NARI is responsible for multiplication of small quantity planting materials of the superior banana cultivars and improved varieties or hybrids for distribution to farmers, who also include backyard gardeners in the urban and peri-urban areas. Variety Dwarf Cavendish is in high demand by the backyard gardeners in the Port Moresby area.

PNG NARI is currently working on introducing superior accessions and landraces back to farmer's fields, especially the ones that are tolerant to dry conditions and saline conditions for the atoll environment. The accessions that are high yielding with orange flesh from the National Germplasm Field Collection are being selected and eventually would be introduced back to farmer's fields.

Some small subsistence farmers and community groups are collaborating with PNG NARI in establishing "Resource Centres" where planting materials of NARI released food crops and animal species and other technology releases are channeled through to the farmers. Sufficient banana planting materials are disseminated through the established 'Resource Centres' for further distribution to farmers in their area.

There are two types of 'Resource Centres' operating in the southern region of the country; the Community-based Resource Centres (CBRC) and the Institutional-based Resource Centres (IBRC). The CBRC is set up by the local communities on their own land and PNG NARI provides technical assistance, planting materials, publications and advice whenever the needs arise. The original materials and publications are provided by NARI and the Community takes over and run their own Resource Centres. NARI continues to provide technical assistance and advise when needs arise. The IBRC is set up by organizations, Government agency, NGO groups or Church groups. They provide the land and the resources to maintain and run the "Centres" and PNG NARI only provides the initial planting materials and publications and also technical assistance and advise.

5.0 Banana Innovation Systems

The agricultural science and technology innovation (ASTI) systems approach is essential for any agricultural development. In this context, the innovation system is defined as the process by which farmers, agro-entrepreneurs and other agricultural entities including research and development organizations master and implement the designs or use the skills, techniques and knowledge that are new to them to produce goods and provide services, irrespective of whether these designs, skills, techniques and knowledge are new to their competitors, their country or the world.

For innovation to take place there must be continuous learning and this depends on the extent and rate at which information and knowledge are generated, disseminated and utilized. The opportunities to learn, access and share information depends very much on the degree and type of interactions between and among 'actors' in the system as well as the behaviors of the appropriate institutions

Background

PNG was introduced to the formal innovation systems approach to research and development in agriculture in 2004. The ASTI system's methodological framework is a tool to analyse various agricultural sub-systems used in the country. The previous study looked at the ASTI system of Rice in PNG and this was followed by a study on the Farmer Experimentation and Innovation as a strategy for strengthening the agricultural innovation system.

This report is on the innovation systems framework approach looking at the banana agricultural system in PNG. The framework involved the review of appropriate policies, which included the Agriculture White Paper; the National Agricultural Development Plan (NADP); the White Paper on Higher Education, Research, Science and Technology; the National Agricultural Research Institute Strategic and Implementation Plans 2006-2010; Trade Facilitation Policy and Policies on Credit Schemes. The key actors in the banana system were identified and inventory developed for main clusters of national, regional and international actors involved in the banana ASTI system. The key functions were identified for each cluster of actors and how they are linked within and between clusters.

Surveys were carried out for various key actors especially the small subsistent farmers who are the main producers of bananas in PNG. Other actors interviewed included entrepreneurs involved in post-harvest storage and handling, transporters, marketers, middle men who buy and sell banana and consumers (urban workers, rural families and institutional messes).

The key actors in the Banana ASTI systems in PNG were invited to a national stakeholders workshop to discuss the findings and to re-affirm the results of the surveys and to approve and endorse the set of recommendations put out by the Banana ASTI Systems Study team.

Objectives of Banana ASTI System Study

The overall objective is to investigate banana innovation system in PNG using the ASTI systems framework approach. The purpose therefore is to identify gaps, deficiencies and bottlenecks in the banana ASTI system that prevents generation of knowledge including new technologies and hinders information flow and uptake of improved knowledge, technologies and skills. The study also identified the 'key actors' involved in the agriculture food crop sub-sector in PNG with special reference to the banana system. The outcome of the study may also be used in exploring other crops in the agricultural systems and to assess and recommend policy interventions.

ASTI System Methodology

The study was undertaken using two main methods; the Desktop research and the Actor Survey. The desktop research method was undertaken to review the appropriate policies that impact on agriculture and science and technology. The identification of key actors in the banana ASTI system and the main functions these actors play in the system were also looked at.

Two survey questionnaires were used, one for the small farmers and the other for the organizations, large growers and entrepreneurs. The survey questionnaires comprised of five main components from which the data were collected. The components included (1) Demographics, (2) Manpower and Specialization, (3) Financing, (4) Collaboration and Networking and (5) Performance of the System.

Surveys were carried out using two methods; through personal interviews over the telephone and face-to-face interviews. For telephone and most of the face-to-face interviews, prior appointments were made with the respondents some days or a week before the actual interviews took place. For small farmers in isolated areas, the project team visited them on site and conducted the interview without prior appointments

The surveys were conducted in selected areas in Central, Morobe, Madang and East New Britain provinces where banana is grown as the dominant staple food crop in the farming systems. The survey data were then collated and analyzed through general Excel and the results were presented at the National Stakeholders workshop for their deliberation and comments.

Brief Summary of the Findings from Banana ASTI System Study

The desktop policy review revealed that while there are adequate policies formulated for agriculture sector and general science and technology, there is no specific policy on Agricultural Science, Technology and Innovation Systems. The current agricultural policies are adequate, but are yet to transpire into any tangible and sustainable development realities. Similarly, the policy in science and technology sector remains in a generic framework and yet to be fine-tuned into specific policies such that it can facilitate greater interactions with other sectors.

The field survey showed critical weaknesses in interactions between main actor groups in the banana ASTI system. It also showed strong collaboration between smallholder farmers themselves. The main areas of collaboration were in exchange of information and experiences while the least areas where respondents collaborate, were in exchange of planting materials, personnel and publications.

The study revealed that generally actor's competency level was low for the smallholder farmers. It is believed that absence or minimal educational level may have contributed to this low competency.

The actors in the Diffusion sector may not disseminate information or communicate with actors in other sectors due to lack of knowledge on the needs of these actors. The case study found that actor's ignorance of what main functions are performed by various actor groups is a real problem. Because of this ignorance they are unable to communicate or collaborate with each other. No clear policy directive is also a contributing factor to this ineffective communication linkage by the formal government service

delivery. DAL Provincial Support Services Division and the DPIs of the various Provincial Governments are responsible for delivering services to the farming communities and rural areas in the country under the Organic Laws of PNG. This policy has not been effectively supported and implemented by the concerned authorities.

Innovations by farmers was minimal, only up to 25% respondents having acquired new information and improved technologies including new products, improved crop varieties and farm implements.

Information flow and access between smallholder farmers is very strong. This is expected because of the traditional values of sharing with others. Access and flow of information between the R&D organizations and other sectors exists, but not as strong and effective. During the survey, the farmers were asked if they receive any information or technologies on bananas from any service providers and their response was hardly any government service providers visit them and advise them on agricultural production. However, the commercial banana producers, the PAU mentioned that they are using the information package put out by NARI on the control of banana fruit flies. At the stakeholders meeting, the PAU participants mentioned that they found the NARI released fruit fly control information package was very useful and have contributed to production of good quality bananas for the fresh fruit markets in Port Moresby.

The survey results showed that information aired through radio reached the highest proportion of the respondents, but in terms of its usefulness, the respondents rated that as inadequate. General agricultural information is aired through the radio, no specific programme on bananas.

While agriculture is the backbone of PNG economy where 85% of the population in the rural areas depends on, the ineffective linkages in the innovation systems as revealed by the study raises a grave policy concern for the government. The Banana ASTI System Case Study put forward a set of recommendations that are considered and endorsed at the National Stakeholders workshop. These recommendations are given below.

Recommendations

The study recommends the Government of PNG or its appropriate agencies:

- To explore and apply ASTI System as an integrative developmental tool that addresses social, economic, political and environmental issues in the agricultural sector to help improve and promote food production, processing, marketing and export.
- To develop a National Research and Development (R&D) strategy on ASTI Systems of major staple food crops especially on bananas in PNG .
- To support the work of the relevant R&D organizations and interested private sector in the development of the Banana Industry in PNG.
- To support and develop formal Post-harvest infrastructure including storage, packaging, transportation with cooling facilities and marketing of highly perishable staple food crops like bananas.
- To rigorously support agriculture sector with appropriate policies for effective and continuous implementation, evaluation and monitoring of agricultural programmes, projects and activities operating under varying social and economic environments.
- To implement agricultural sector policies in a cohesive and collaborative manner while adhering to individual organization's mandates.
- To proactively and critically study the provisions of the various trade agreements in order to gain maximum benefits from exports of non traditional commodity crops like bananas, while protecting domestic industries and indigenous biodiversity.
- To support, develop and strengthen the basic communication, infrastructure and transportation network to facilitate interactive collaborations between various actors in the agricultural

innovation system.

- To enhance capacity of human resources involved in the ASTI Systems, to contribute towards improvement of literacy levels especially in rural areas.
- To support and enhance capacity of appropriate authorities like NAQIA to development 'Internal Quarantine' regulations to safe guide movements of plants and animals within the country.

It is strongly believed that these recommendations are targeted towards addressing vital developmental issues in the country for achieving sustainable livelihoods for Papua New Guineans

Summary

Banana is still a small farmer crop in PNG, but it ranks second only to sweet potato as a staple food crop in the country in terms of production and consumption. The national household survey conducted in 1996 showed that a person in PNG consumes around 47kg of bananas in a year. Banana provides 6.9 percent of the national calories and 7.4 percent of the rural household calories. Although PNG farmers are mostly producing cooking types of bananas, R&D activities have given some focus on dessert types as well. Through collaborative research projects, PNG NARI is currently evaluating some international banana hybrids/variety resistant to Sigatoka leaf diseases in farmers' fields and is also undertaking studies in *Fusarium* wilt surveys and Banana Fruit Fly Management in PNG. The Fusarium wilt surveys so far showed no presence of the disease in the areas surveyed included the border provinces of Western and Sandaun, the Eastern Highlands and Morobe in the mainland PNG and the island provinces of East New Britain, Manus and Bougainville. The recommendations from the Banana ASTI Systems study clearly stated that Banana Industry has to be developed in the country because of its importance as a staple food crop and the domestic fresh fruit markets in the main urban centers like Port Moresby. The banana ASTI Systems study also recommended the development of R&D strategies on ASTI Systems of major food crops especially bananas in PNG.

References

Bourke, R.M & Vlassak, V. 2004. Estimates of Food Crop Production in Papua New Guinea. Land Management Group, The Australia National University, Canberra.

Gibson, J. 2001. The Economic and Nutritional Importance of Household Food Production in PNG. In: R.M. Bourke, M.G. Allen and J.G. Salisbury (eds). Food Security for Papua New Guinea. Proceedings of the Papua New Guinea Food Security and Nutrition 2000 Conference, Papua New Guinea University of Technology, Lae.

Moline, A.B. et al. 2003. Advancing banana and plantain R&D in Asia and the Pacific. Vol.II. Proceedings of the 1st BAPNET Steering Committee Meeting held in Los Banos, Laguna, Philippines, 7-10 October 2002. International Network for the Improvement of Bananas and Plantains.

Stove, R.H & Simmonds, N.W. 1987. Bananas. London. p.468

Waterhouse, D., Dillion, B. & Vincent, D. 1999. Biological Control of the Banana Skipper in Papua New Guinea. Cost-benefit analysis of an ACIAR project. Report, CIE, Canberra & Sydney.

PHILIPPINES

Banana R and D Updates: the Philippines Country Report

Dr. Jocelyn E. Eusebio and Dr. Edna A. Anit
Philippine Council for Agricultural, Forestry, and Natural Resources Research and Development
Dr. Carmencita Kagaoan
Department of Agriculture—Bureau of Agricultural Research

Introduction

Banana is an important fruit crop widely grown in the country and has maintained its position in both domestic and export markets. In 2007, banana occupied 436,762 ha producing a total volume of 7.48 M metric tons. Out of the area planted with banana, only 10-15% are managed as commercial banana plantations, mostly producing the Cavendish cultivar. The remaining 85-90% is backyard and small-scale farms producing local banana cultivars (Saba, Lakatan, Latundan, Bungulan and others). Despite the relatively small land occupied, the commercial banana plantations produce more than 40% of the country's total production, which are mainly exported. In 2007, the country exported about 2.2 M metric tons of fresh fruits valued at US$ 396.3 M and about 31.86 metric tons of chips valued at US$ 39.32 M. The other products being exported are banana blossom, leaves, flour, dried banana, and ketchup (Table 1).

Table 1. Volume (metric tons) and value (US $, F.O.B.) of exported banana products, 2007 (BAS, 2008)

Product	Volume (metric tons)	Value (US$)
Banana, fresh,	2,199,321	396,279,318
Banana, dried,	310	597,796
Flour, meal and powder of banana	83	50,890
Banana blossoms	12	28,336
Banana leaves	715	618,119
Banana chips or crackers	31,866	39,316,341
Banana ketchup	3,302	2,234,367
TOTAL	2,235,608	439,125,167

About more than 90 cultivars of banana are being cultivated in the country (Valmayor *et al*, 2002). However, the most popularly grown cultivars are Lakatan, Latundan, Saba, Bungulan, and Cavendish. With an average volume of production over five years of about 6.32 M metric tons, Cavendish had 40% share followed by Saba with 35% (Figure 1). Lakatan, Latundan and Bungulan had minimal share of 12%, 8%, and 3%, respectively. The production volume of the local cultivars is very low, hence, adoption of appropriate management technologies must be done by smallhold growers in order to enhance the productivity and increase the income of banana growers.

Figure 1. Average %share of production by volume of different banana cultivars, 2003-2007 (BAS, 2008)
Average volume (5 yrs): 6,317,000MT

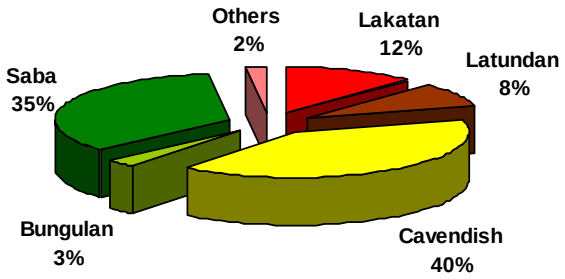
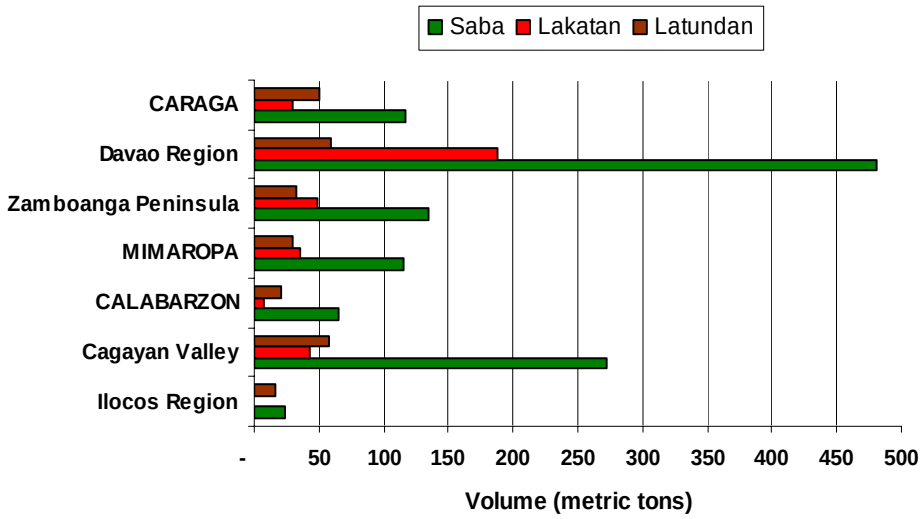


Figure 2 presents the performance of Saba, Lakatan, and Latundan in terms of production volume in selected regions of the country. In most regions Saba performed best with the highest production in Davao Region followed by Cagayan Valley with production ranging from 23 to 480 thousand (T) metric tons. Production of Lakatan ranged from 1 to 187T mt with Davao having the highest followed by Cagayan Valley & Zamboanga and the least in Ilocos Region. On the other hand, Latundan production ranged from 16 to 59 T mt with Davao Region and Cagayan Valley as the highest.

Figure 2. Volume of production (metric tons) of Saba, Lakatan, and Latundan in selected regions , CY 2007 (BAS, 2008)



Salient Accomplishments of Research & Development Activities

Several R&D projects implemented were focused on major concerns such as pests and diseases, cropping systems, postharvest handling, packaging and socio-economic on Lakatan, Latundan and Saba.

The project on "Distribution and Evaluation of Improved *Musa* and Popular Local Varieties to Rehabilitate Local Banana Industry in the Luzon Areas (Bioversity/PCARRD)" that was implemented in 2002-2007 had successfully introduced the use of disease-free planting materials in some selected sites in Ilocos Sur, Ilocos Norte, La Union, Cavite, Mindoro Oriental, Quezon, Batangas, Quirino, and Isabela. Moreover, the nursery management protocol for TC plantlets was employed by the respective implementing agencies inasmuch as meriplants were bought from Lapanday and DOLE Musatech in Davao. However, the project introduced the different FHIA varieties which have shown good performance in terms of reaction to BBTV and good yield parameters. FHIA 17 and 18 were the most acceptable among the improved cultivars introduced. The significance of this project is the introduction to smallhold farmers the use of TC plantlets and the management practices in small scale farms.

Another project on the "Introduction, Evaluation and Adoption of Improved Landraces of Banana for Food and Income Alleviation (DA-BAR-Bioversity/IPB/BPI-DNCRDC) had also contributed to the increasing knowledge of smallhold banana growers to the use of disease-free planting materials. This project on the maintenance of banana germplasm was implemented by the two repository centers in the country strategically located in Mindanao, the BPI-DNCRDC and in Luzon, the IPB-UPLB from 2004-2007. The following are the major accomplishments of the project:

In vitro and in vivo maintenance and multiplication of improved and superior cultivars of banana

A. *In vitro* maintenance

Collections maintained as shoot cultures:

23 introduced hybrids/landraces

7 local cultivars serve as source of materials for multiplication and distribution

Serves as source of materials for multiplication and distribution



B. *In vivo* maintenance

14 introduced and 6 local cultivars maintained as foundation stocks

Planted in plastic pots (# 14) and kept inside the greenhouse

Monitored for somaclonal variation and incidence of pests and diseases




C. Multiplication and Distribution of selected banana cultivars

The following tables shows the distribution of the various banana cultivars during the implementation of the project.

Table 3. Total plantlets distributed of selected banana cultivars.

Source	**Plantlets Distributed**		**Total**
	In vitro	**Established**	
Introduced	6,759	5,660	12,419
Local	2,412	3,628	6,040
Total	9,171	9,288	18,459

Table 4. Distribution of planting materials by institution/unit

Institution/unit	**No. of Plantlets Distributed***
SCUs	5,608
Farmers	4,364
DA and other gov't agencies	3,075
LGU	1,257
Others**	3,975
Total	18,459

* *In vitro* or established plantlets
** e.g. Private institutions, Research projects

Table 5. Number of in vitro plantlets and established plants distributed per cultivar

Cultivar	Number distributed		Total
	In vitro	Established	
FHIA 17	2,383	1,224	3,067
FHIA 23	499	1,179	1,678
FHIA 21	909	674	1,533
FHIA 02	535	662	1,197
FHIA 18	495	185	680
FHIA 01	150	442	592
Lakatan Davao	1,041	1,867	2,908
Cardaba	420	1,259	1,679
Quarenta dias	509	110	617

In 2004, an integrated program dubbed as the "S&T Anchor Program for Banana (Lakatan, Latundan, and Saba)" was funded by the Department of Science and Technology (DOST) and the Philippine Council for Agriculture, Forestry and Natural Resources Research and Development (PCARRD), and to be implemented until 2009. It has three major components such as research and development (R&D) interventions, technology promotion and utilization and socio-economic/ policy studies.

Moreover, this integrated program actually evolved from the earlier projects wherein the locally grown cultivars (Saba, Lakatan, and Latundan) were focused in the various project components that were implemented. The following are some notable findings of the program:

On the management of bacterial wilt/moko and bugtok disease of banana, survey in four provinces of Luzon (Pangasinan, Aurora, Nueva Vizcaya and Isabela) covering 39 towns revealed no serious incidence of the disease. A total of 34 putative *Ralstonia solanacearum* isolates were collected. A commercial disinfectant was also tested for its effectivity to inhibit and control the growth and spread of *R. solanacearum.* Survey in other banana growing areas in Luzon and confirmation of moko incidence in Mindoro is still in progress.

On the identification, characterization and management of Fusarium wilt of banana (Saba, Lakatan and Latundan), mapping of Fusarium wilt incidence was conducted in areas surveyed in Luzon provinces of Nueva Vizcaya, Isabela, and Quirino. A total of 22 endophytic fungi from healthy banana plants were isolated for antagonistic study against *Fusarium oxysporum* f. sp. *cubense*. Moreover, a total of 25 isolates and 12 diseased materials is undergoing strain identification using VCG analysis.

The work on insect vectors (mealybugs/aphids): survey, biology and potential biocontrol agents,' the biology (including developmental stages, duration of each stage, fecundity, longevity, mating behavior and other habits) of mealybug, *Dysmicoccus neobrevipes,* was completed. The protocol for the plastic cage rearing method of black earwig, *Chelisoches morio*, the potential biological control agent was also improved. Stock cultures of mealybugs, aphids, predatory mites and earwigs are being maintained. To incorporate the effects of environmental factors in mealybugs/ aphids, population dynamics of pest were monitored.

To enhance the production efficiency of Saba, Lakatan and Latundan cultivars in different cropping systems,' the performance of meriplants grown using biofertilizers, Bio-N and Mykovam, were field-tested following varying fertilizer rates. Preliminary results revealed that suckering and size of pseudostem were improved with the use of combination of inorganic and biofertilizers. The nursery management protocol for Lakatan, Latundan and Saba cultivars inoculated with biofertilizers was also established. Another set-up in farmers' field , Infanta, Quezon using monthly planting of Lakatan was conducted to assess what particular month is most ideal for planting Lakatan in relation to typhoon occurrence and damages in the area.

On the regulation of ripening and disease control in Lakatan and Latundan bananas,' the ripening schedule of Latundan using ethephon was determined. The optimum concentration and sequential treatment of ethephon and 1-methylcyclopropene were also studied to achieve a consumer acceptable even delayed ripened Latundan. The efficacy of using ethanol and ethephon in reducing the incidence of fingerdrop and its effect on the physico-chemical and sensory attributes of Latundan were also evaluated. On the other hand, using Hot water treatment (HWT), Lakatan at 55 ^{o}C dipped for 5 min and 60^{o}C dipped for 1 min ripened after 10 days and are even fit for consumption even after 14 days. The efficacy of using ethanol and ethephon in reducing astringency in Latundan as well as the characterization of the physiological disorders and the control of common postharvest diseases of banana using heat treatment will be further studied.

The development of appropriate and innovative packaging for banana products also forms part of the integrated program. Several meetings cum farm visits to Lakatan growers in Cavite, Isabela and a farm in Mindanao were conducted to assess the existing handling and distribution of fresh banana from farm to market. Development of shelf stable ready to eat boiled banana was done. It was found that boiled Saba with high total soluble solids of 27-29% was highly acceptable in terms of flavor and odor. The appropriate degree of ripeness for shelf stable ready to eat/use boiled saba was found important during the process. The use of edible film and PE coated paper as a substitute for the currently used paper in pinasugbo-making was also tested. It was found out that pinasugbo in edible wrapper has higher acceptability.

The socio-economic studies had initially set policy advocacy instruments, marketing and entrepreneurial strategies and determined the factor conditions on which to improve the smallhold banana sub-industry in Luzon areas.

The project on "Banana Investment Package Project for Micro-Small- and Medium Enterprises (PCARRD/ CvSU/QSC/LGU)" has demonstrated the performance of tissue-cultured Lakatan on a bigger scale under coconut and in the open-field in farmer cooperators farms in Cavite and Batangas. This project came up with a Banana Production Module for Lakatan in Luzon Areas.

Taking off from the information, protocol, and technologies developed from the S&T Anchor Program for Banana and previous researches on banana, PCARRD deemed it necessary to utilize and disseminate relevant information and technologies on banana to a wider scope and area. Based on various consultations with the stakeholders in the different regions through the PCARRD Regional consortia and its member-agencies as partners, and six regional consortia indicated banana as their focused commodity. Hence, the National Integrated Banana R&D Program for CY 2009-2011 was packaged in

collaboration with the partners and stakeholders in the region. This program aims to meet the goals of the industry as embodied in the Philippine Agenda 2020, that is, to increase the year-round production and supply of high quality fruits by adopting the recommended production and post production practices and to enhance the global competitiveness of fresh and processed bananas by improving the handling systems, providing the policy and regulatory environment and enhancing the quality and safety of products for the international markets.

With various technologies developed in growing Lakatan, Saba, and Latudan and the launching of the Techno-Gabay Program of PCARRD which is a mechanism to showcase technologies derived through Science and Technology (S&T), several S&T- Based Farms (STBF) on Banana Production were established all over the country. These STBFs were managed by the Magsasaka Siyentista (MS) or progressive farmer in the different sites to disseminate the improved technologies for adoption by smallhold banana growers within the community. The STBFs are implemented through the Farmers Information and Technology Services (FITS) centers of the regional consortia. Figure 4 presents the 17 different sites of S&T Based Farms on banana production in the Philippines.

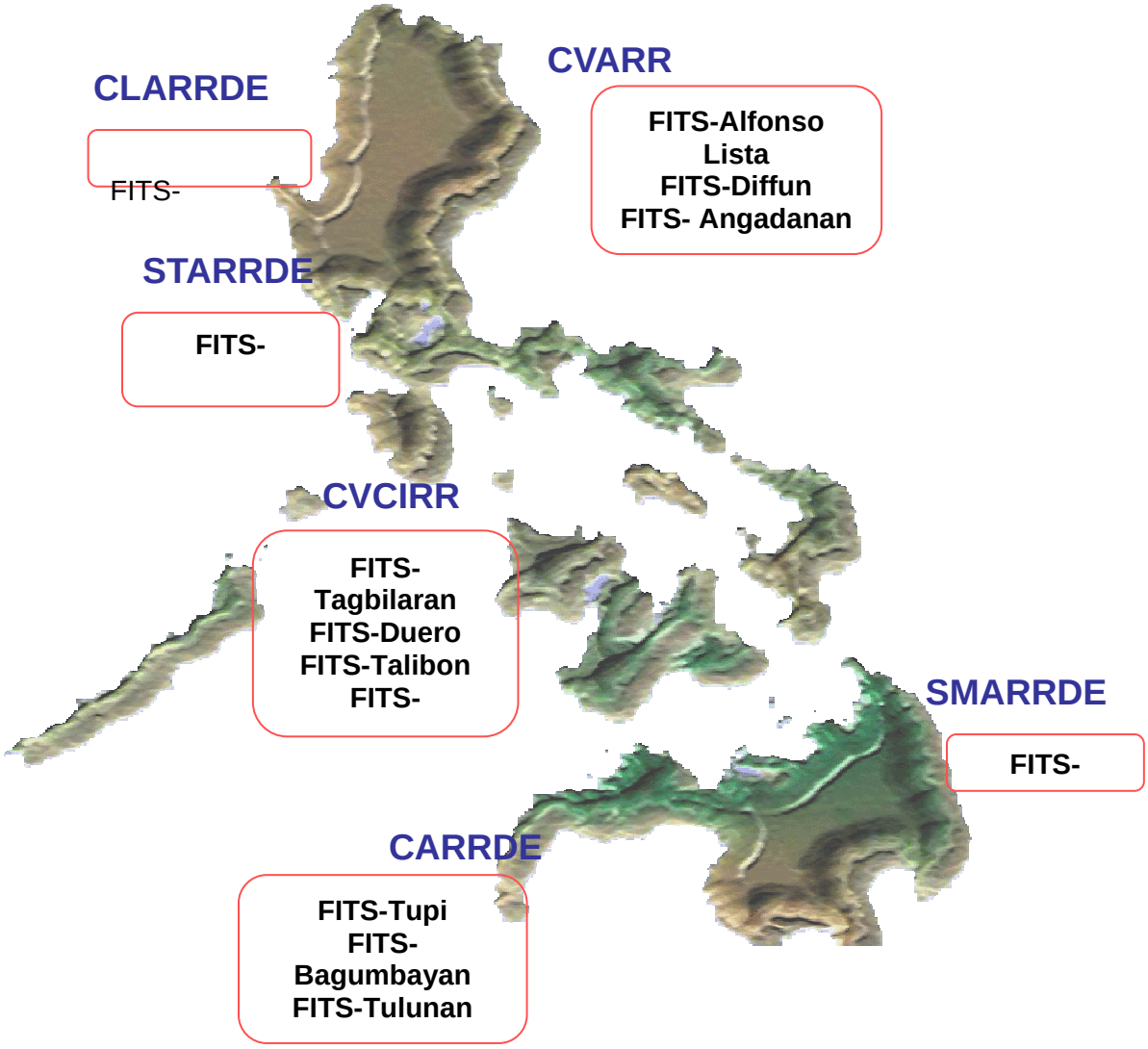


Figure 4. S&T- Based Farms on the production of banana established as of October, 2008

In summary, the various R&D activities on banana are shown in Figure 5 which actually presents the banana roadmap from 2002-2011. The programs/projects implemented and for implementation with their respective outputs and deliverables were reflected.

2002	2003	2004	2005	2006	2007	2008	2009	2010-2011
Distribution and Evaluation of Improved *Musa* and Popular Local Varieties to Rehabilitate Local Banana Industry in the Luzon Areas (Bioversity/PCARRD)			***This project was implemented after the launching of BAPNET in 2002 that introduced the use of tissue cultured banana plantlets in smallhold growers***					
	Introduction, Evaluation and Adoption of Improved Landraces of Banana for Food and Income Alleviation (DA-BAR-Bioversity/IPB/BPI-DNCRDC					***This project introduced the promising cultivars***		
	S&T Anchor Program for Banana (DOST-PCARRD)						***R&D on Disease Management, Post harvest Handling and Packaging; Socio-economic studies***	
			Banana Investment Package Project for Micro-Small- and Medium Enterprises (PCARRD/ CvSU/QSC/LGU)			***To test the effectivity and profitability of the use of tissue-cultured plantlets and the component technology in both nursery and field management of banana in smallhold farms***		
Adoption of the enhanced technology of growing banana in the smallhold growers				**Establishment of Science & Technology Based Farms on Banana (PCARRD-DOST, Consortia, LGUs)**				
Adoption of the enhanced technology of growing banana in the smallhold growers							**National Integrated Banana R&D Program (DOST-PCARRD, Consortia)**	
Adoption of the enhanced technology of growing banana in the smallhold growers							**S&T Based Farms on Banana & Cacao under Coco-based Farming Systems (PCARRD-DOST, FFF, SLSU, QAES, LGU)**	

References:

Distribution and Evaluation of Improved *Musa* and Popular Local Varieties to Rehabilitate Local Banana Industry in the Luzon Areas (Bioversity/PCARRD)

S&T Anchor Program for Banana (DOST-PCARRD), 2008 Annual Report

Introduction, Evaluation and Adoption of Improved Landraces of Banana for Food and Income Alleviation (DA-BAR-Bioversity/IPB/BPI-DNCRDC). 2008 Annual Report.

National Integrated Banana R&D Program (DOST-PCARRD, Consortia), 2008 Program Proposal

Banana Investment Package Project for Micro-Small- and Medium Enterprises (PCARRD/CvSU/QSC/LGU). 2007 Annual Report.

Valmayor, RV., RRC Espino, and OC Pascua. The Wild and Cultivated Bananas of the Philippines. Los Baños, Laguna. PARFFI and DA-BAR. 2002. 242 pp.

Bureau of Agricultural Statistics, 2007

Food and Agriculture Organization

STA

Annual Reports of the different projects

BANANA ACTIVITIES IN THE PACIFIC: SECRETARIAT OF THE PACIFIC COMMUNITY

Dr. Mary Taylor
Regional Germplasm Centre Advisor, Secretariat of the Pacific Community

Introduction

The Secretariat of the Pacific Community (SPC) is an inter-governmental organization with a membership of 22 Pacific Island Countries and Territories, which range in size from small atolls to islands like Papua New Guinea with a land area of 462,840sq.km. The Land Resources Division is based in Suva, Fiji and has the mandate for all agriculture activities, including genetic resources. Within the Land Resources Division, there is a specific Genetic Resources programme, consisting of the Centre for Pacific Crops and Trees (CePaCT), and the Pacific Plant Genetic Resources network (PAPGREN). It is the Genetic Resources programme, which implements banana activities in the SPC member countries and territories.

In the last 12-18 months, the main focus of work has been the development of a Pacific banana conservation strategy. A number of countries (Fiji, French Polynesia, New Caledonia, Papua New Guinea, Pohnpei (Federated States of Micronesia), Samoa and Solomon Islands) have banana collections, which vary in size, associated information and diversity. The main purpose of these national collections is the provision of planting material. Importantly there is rich banana diversity in the Pacific, some of which is unique to the Pacific, namely the Pacific plantains and the fe'i type. Some of this diversity can be found in existing collections, but these collections are relatively vulnerable to losses from changing commitments from donors, governments and supporting institutes, pests and diseases, and limited resources. The development of a Pacific banana conservation strategy recognizes the important diversity that exists within the Pacific and the threats that exist to that diversity, and what is required to optimize the use of that diversity.

The funding for developing the Pacific banana strategy and implementing some of the activities has been, and will be provided by the Global Crop Diversity Trust. The components of the strategy were agreed at a planning meeting held in Suva, Fiji in November 2007, and then followed up by a second meeting in Cairns, Australia in July 2008. At the planning meeting the participants, mainly banana curators, agreed that any regional banana collection should focus on fe'I, Maoli Popo'ulu and Iholena diversity, and that the components of the conservation strategy would be collecting, conservation, providing access to clean planting material, sharing germplasm and providing information to promote use.

Components of the Conservation Strategy

Collecting

Several countries have identified the need for collecting missions in areas believed to contain unique diversity either currently absent from formal or community collections, or under severe risk of being lost because of remoteness of site, market influences, pests and diseases, and changing cultural habits.
Since the planning meeting in November 2007, and the training workshop in July 2008, Solomon Islands have started collecting through their Planting Materials Network (Kastom Gaden Association). Collecting in Vanuatu will commence in January 2009. Funding is currently insufficient to address all collecting needs.

Conservation

Fiji, French Polynesia, New Caledonia, Papua New Guinea, Pohnpei (Federated States of Micronesia), Samoa and the Solomon Islands have banana collections, while Vanuatu and Palau are keen to establish national collections. With the exception of Papua New Guinea, countries' accessions have not been duplicated and are at risk of being irretrievably lost. In Papua New Guinea (PNG), banana accessions have been provided to the *in vitro* collection at the International Transit Centre (ITC-managed by

Bioversity International at the Katholieke Universiteit Leuven, Belgium) and to QDPI, and lost accessions may be repatriated. However, PNG accessions duplicated in Davao, Philippines, have been effectively lost through disease.

The main purpose of national collections is in the supply of planting material to producers, and as such, national institutes may not be best-positioned to guarantee the long-term conservation of accessions. The Pacific conservation strategy revolves around ensuring long-term access to genetic diversity, establishing adequate measures for safety duplication, and enabling rationalization of Pacific diversity to take place. The regional collection will consist of unique accessions (that is, representative accessions of indigenous cultivars that appear to be found nowhere else), and will be maintained *in vitro* at SPC and ITC (cryopreserved) and as a field genebank. The field genebank will be established for the purpose of evaluation, in depth characterization, other comparative research, training and a site for field verification and replacement (regeneration) of the *in vitro* collections of ITC and SPC. The proposed size of the collection will be at least 100 accessions of which 70 will be cryopreserved at ITC

Providing access to clean planting material

Black leaf streak disease, Banana bunchy top virus and Fusarium Wilt race 4 are present to varying degrees in different islands. Nematodes are also a persistent problem throughout the region. Training in PCR methodology for virus testing bananas will be conducted in the region, mainly with SPC staff so that the regional banana collection can be disseminated free of known viruses to both ITC and the community at large. SPC can also within the limits of available resources, virus test material at the request of countries. This "clean" material can then be multiplied for dissemination back to the countries. Training will also be conducted to raise awareness as to the occurrence of banana diseases and the importance of clean planting material.

Sharing germplasm

Five of SPC member countries have ratified the International Treaty on Plant Genetic Resources for Food and Agriculture (ITPGRFA). Others have made significant progress towards ratification. The recent Heads of Agriculture and Forestry Services (HOAFS) and Ministers of Agriculture and Forestry (MOAF) meetings in Samoa (September 2008) approved and endorsed the following recommendations;

> That countries yet to ratify the International Treaty on Plant Genetic Resources for Food and Agriculture(ITPGRFA) progress with ratification
>
> SPC and the Secretariat to the Treaty progress with the establishment of an agreement to place the *ex situ* collections of the Centre for Pacific Crops and Trees (CePaCT) into the Multilateral System (MLS).

However there still remains a limited understanding of the MLS and how it works and the conditions to which countries must adhere to, once they have ratified the Treaty. Therefore developing awareness and capacity in this area is very important. Information must also be made available so that Island governments can make informed decisions with regards to the ITPGRFA.

Providing information to promote the use of genetic diversity

The availability of characterization data on banana genetic diversity in the Pacific is limited in quantity and quality. A significant and coordinated effort is required to improve the information available on Pacific bananas from the gathering of data to its publication and dissemination. A number of activities will be implemented to ensure there is a greater wealth of information on Pacific bananas, such as the use of common (minimum) descriptor lists with standard protocols for field experiments, and the use of reference accessions for comparison and training.

Progress to date in implementing the Pacific banana conservation strategy

A training workshop was held at the Queensland Department of Primary Industries (QDPI) South Johnstone Station in July 2008. 15 participants, (7 women, 8 men) representing 13 Pacific Island countries attended the three day workshop, which consisted of lectures and practical hands-on sessions. The aim of the workshop was to provide the necessary skills with which the participants could characterize the bananas in their national collections. Participants were briefed in the use of photos for identification and introduced to the concept of minimum descriptors. To facilitate the use of the photo guidelines, all participants were provided with cameras.

The workshop focused on the unique Pacific bananas – Fei, Maoli, Popo'ulu and Iholena, and a range of topics were covered, to include the basics of identification, minimum morphological descriptors – how to go about measuring/distinguishing these and taking appropriate photos to augment them, using cameras in the field to record minimum descriptors and banana genebank management

The next steps in implementing the strategy will be establishing the actual regional collection. To this end countries will have to identify which accessions from their national collections are "unique" according to what was discussed at the training meeting and make these accessions available to the SPC for establishment in tissue culture.

Conclusion

The establishment of a Pacific banana collection is an important step, and one that is much-needed. With the impact of climate change, the risks to the diversity of any crop have increased, emphasizing the urgency with which collecting must be carried out and the conservation strategy implemented.

SRI LANKA

Banana Research & Development activities in Sri Lanka

Dr. Indra Jinadarie de Zoysa, Director,
Horticultural Crops Research and Development Institute

Introduction

Banana is the major fruit crop in Sri Lanka. The fruits are available throughout the year and apart from the many uses (nutritional, commercial) it has a high cultural value being indispensable at the cultural ceremonies of all ethnic groups.

In Sri Lanka banana is cultivated in about 50,000 ha which is about 50% of the major fruit extent and contributes to 70% (378336 mt) of the major fruit production (538744 mt) (Agstat Vol IV, 2007). Majority of the fruits are consumed locally and a small quantity is exported. There is a very high potential for export.

As such, high priority is given for banana in research and development (R & D) activities. Banana R & D activities are carried out mainly at the research stations attached to Horticultural Crops Research and Development Institute of the Department of Agriculture (DOA). In addition, some research activities are done at universities and to a lesser extent by the private sector. Provincial Departments of Agriculture are mainly responsible to undertake extension activities.

Research Activities

Development / Identification of varieties with high yielding good quality fruits and pest & disease resistance.

Collection, characterization (morphological & molecular), conservation and improvement of available germplasm were given high priority in research.

Characterization, Conservation & Evaluation

Characterization

Genetic diversity of this crop in Sri Lanka is rich with the presence of two wild ancestral species viz *Musa acuminata Colla, AA* (Unel) and *M. balasisiana* Colla, BB (Etikesel (Chandraratne & Nanayakkara 1951). There is a record that wild bananas had been consumed by prehistoric people, over 12,000 years ago (Deraniyagala, 1992). Most of the wild populations had been found in Matale, Kandy, Nuwara Eliya, Ratnapura, Matara and Kegalle Districts (Samarasinghe et at.2008). It had not been possible to locate some of the populations at present which had been identified by Chandraratne & Nanayakkara in 1951. The reduction of wild banana populations had been attributed to deforestation, urbanization, expansion of agricultural lands, climate changes, wild animal damage etc. Those populations had been found in protected as well as in unprotected areas, which are under threat of declining. *In situ* conservation of these are being carried out by Plant Genetic Resources Centre (PGRC) which is facilitated by conservation of Crop Wild Relatives through Enhanced Information project.

Characterization of the two wild banana species morphologically had been carried out and found that they possess quite distinct morphological characters between the species but not within the populations of the same species. In contrast, molecular characterization of the populations within a species using simple sequence repeats (SSR) primers showed distinct genetic variation (Samarasinghe et al 2008). This indicates the occurrence of natural cross pollination and the value of conservation of the wild species which could be used in banana improvement programme effectively.

Further characterization of 27 Musa germplasm had been carried out using morphological and molecular

traits with SSR primers. *M. balbisiana* showed some similarity to Sri Lankan cultivars while *M. acuminata* showed less similarity (Samarasinghe et al.2008).

DNA typing of 23 silk banana (kolikuttu, AAB) accessions (collected based on morphological variations, tolerance to Fusarium Wilt and tissue culture origin) had been carried out using six SSR primers and found five different genotypes. (Samarasinghe & Pushpakumarie 2008)

Conservation

Most cultivars including wild spices are being conserved *in-vitro* at the Plant Genetic Resource Centre (PGRC), Sri Lanka. In addition the cultivars are being conserved in field gene banks at the Horticultural Research Stations and Research Farms.

Evaluation

a) Evaluation for high yield, good quality and adaptation to different agro – ecological regions

A National co-ordinated varietal trial (NCVP) is being conducting at 08 locations with 07 selections for selection of best varieties to recommend for commercial cultivations.

b.) Screening for pest & disease resistance

i) **Fusaruim wilt (Panama disease) caused by *Fusarium oxysporum* f.sp. *cubebnse***

Variety Embul (Pisang Ceylan AAB) was known to have high resistance to Fusarum wilt and successfully cultivated in the areas where high incidences of this disease occur.

Two hundred fifty one (251) apparently symptomless plants of popular cultivars collected from highly infected fields had been screened in the green house and symptomless plants had been tested again in the field sick plots with very high inoculum levels and 125 plants (22 Ambun, 12 Anamalu, 26 Seeni Kesel, 50 Kolikuttu and 15 Ash plantain) had been found tolerant to Fusaruim wilt (Rajapaksa et al 2005). Further screening revealed that only one Amban, two Anamalu and two Seeni Kesel accessions were tolerant to Foc.

ii). **Virus Diseases**

Evaluation of popularly grown varieties for resistance to Banana Bract Mosaic (BBrMV), Banana Bunchy Top (BBTV), Cucumber Mosaic (CMV) and Banana Streak Virus (BSV) had been carried out in the field and found that the variety Ambun had been resistant (Ekanayake et al.2002).

iv). **Banana Weevil**

Studies are being carried out to find the resistant germplasm.

Crop Improvement

A crop improvement programme is being carrying out using mutation breeding and somaclonal variations in tissue cultured plants. The main objectives of this programme are to find varieties with pest & disease resistance (mainly for fusarium wilt, virus diseases and banana weevil), high yield and good quality.

Rapid propagation methods for production of high quality planting materials.

Lack of planting materials of popular varieties in large quantities is an obstacle in expansion of popular varieties of banana.

Tissue culture of banana at cottage level : A booklet had been published (Premathilaka & Hettiacachchi 2007) describing technology, planning of mini tissue culture laboratory, expected problems, measures for prevention and solutions for the problems, estimated cost and returns. Guidelines for banana tissue

culture had been prepared (Premathilake et al. 2008 unpublished) for researchers and private sector producers to minimize the problems encountered specially somaclonal variations.
Other Rapid Propagation techniques (Weerasinghe 2008, unpublished data)

Cutting of the Pseudostems of the suckers (1.2 – 1.8 Kg) in to 3-5 pieces and growing in a nursery yielded minimum of 3 plants from one sucker.

Harvested pants were decapitated at the ground level . The mother corm is split in to 04 sections by inserting a sharp knife without uprooting the corm. Thereafter 1.5 liter of 1% urea solution is applied to the corm through the split surface to induce the dormant buds. In this technique 3 – 5 vigorous suckers which are ready for field planting could be obtained in three months time.

Development of nuclear stocks for mother plants
Establishment of mother plant orchards are being carrying out at different locations to avoid spread of pest and diseases and to provide high yielding and good quality planting materials to government and private sector.

Pest & Disease Management
1) Fusarium wilt caused by *Fusarium oxysporum* f.sp *cubense* (Foc)
A Survey had been carried out in 10 Districts (Viz. Anuradhapura, Matale, Kandy, Kegalle, Gampaha, Colombo, Rathnapura, Galle, Matara and Hambantota) and severe Foc incidences were observed in silk banana (AAB) cultivations at Ratnapura and Anuradhapura Districts and in Ambon (AAA) cultivations at Kandy & Kegalle Districts. (Rajapaksa et al 2005). Research work on Biological control of Foc using *Trichoderma* spp.are in progress

2) Virus Diseases
Molecular Methods for detection of banana viruses
(a). Molecular methods viz. Polymerase Chain Research (PCR) and Immuno capture polymerase chain research (IC - PCR) had been compared to distinguish episomal banana streak virus (BSV) from integrated chromosomal BSV and found that IC – PCR method was more effective than PCR method in diagnosing episomal BSV and IC – PCR had been successfully used for virus indexing during tissue culture process in order to produce BSV free planting material (Gunasinghe et al 2008).

(b). The major constraint in molecular level detection of RNA virus is difficulty of RNA extraction. This is primarily due to the high degradation of RNA by the contamination of RNAses during the process. This can be easily overcome by using the RNA extraction kits. But the problem is those kits are very expensive. A novel method was practiced to extraction of RNA in viruses. Main feature of this methodology was use of guanidine thiocianate for inactivation of RNAses and trapping of RNA by fractionated silica.

Samples were crushed with lysis buffer and then mixed with fractionated silica to absorb RNA. After several washing steps adsorbed RNA was eluted to deionized water which was subsequently used as the template for reverse transcription. For BBrMV reverse transcription was done using oligo dT primer and followed by PCR which was done using primer Bract F1 and Bract R1. The expected amplification product of 324bp was obtained. In the case of CMV, reverse transcription was done using primer CMV 3' and the PCR amplification was done using primer CMV3' and CMV 5'. The expected product of 500bp in size was successfully amplified.

3).Post Harvest Diseases
Anthracnose (*Collectorichum musae*)
Crown rot (*Lasiodiploidia theobromac, c.musae, Fusarium sp.*)
Freckle disease (*Phyllosticta musarum*)

These three diseases are most common post harvest diseases in Sri Lanka. Application of Gibberellic acid (100ppm) at bunch emergence and bagging reduced crown rot and freckle disease but infection of

M. anthracnose remained similar to that of the control treatment (Ikiriwatte 2008)

4) Banana Weevil

Non chemical methods for eradication of banana corm weevil (Cosmopolitus sordedus) *(Weerasinghe 2005)*

Cold water treatment.

Immersion of the corm in clean water for 48 hours eradicate all the stages of life cycle of corm weevil within the corm. As an additional advantage plant can withstand for 2 weeks without irrigation since it has absorbed enough water.

Hot water treatment.

Dipping the cormal part of the sucker in boiling water for 30 – 40 seconds easily can be used to eradicate the corm weevil within the corm. In addition, the temperature of hot water kills the nematodes, bacteria and fungi other than *Fusarium oxysporum* f.sp. cubense.

Post harvest & Processing

Banana Sandwich spread (Sarananda 2008 unpublished)

Sandwich spread was prepared using ripe "Ambul" banana with butter and spices. Ripe fruit pulp was blanched with the above other ingredients and the pH was adjusted to 4.2.The prepared spread was bottled and kept in a freezer (-18 ^{0}C) for 3 days. After 3 days the bottles were stored at refrigerated temperature. Microbiological properties of the spread were at acceptable levels. Sensory evaluation showed that the product was highly acceptable up to 3 months at refrigerated storage.

Varieties suitable for Fried chips

For fried chips Seeni Kesel (AAB) , FHIA 03 (Pulathisi), FHIA 02 and FHIA 25 were better thant the other varieties (viz. SH 3640, FHIA 14, Embul and Anamalu) tested. (Ekanayake 2008 unpublished)

Ekanayaka and Ranawana 2008 showed that at the preparation of banana fried chips pretreatment (dipping the slices) with 0.1 % citric acid +0.1% Potassium meta bisulfate (KMS) + 2% NaCl resulted in low enzymatic browning.

Varieties suitable for preparation of banana leather

Varieties Anamalu (AAA), Seeni Kesel (AAB) and Ambul (AAB) were tested and found that variety Anamalu was the best for preparation of banana leather (Ekanayake 2008 unpublished).
Use of 1000 ppm KMS at the preparation of banana leather enhanced shelf life up to one year.

Development of different banana based products

Development of bio wrappers for food items with leaves.

From four months after planting up to bearing stage each alternate leaf was trimmed and leaf lamina was taken. Different curing techniques; steaming, hot water treatment and oven drying, were identified as different techniques for curing banana leaves. Cured banana leaves were introduced as a wrapping material for food items which fetchs an additional income for the farmers.

Bio plates with leaves.

Torn, ripen or spotted leaves and the leftovers can easily be molded and fabricated into plates. An additional income of Rs. 350,000/ha could be obtained. (Weerasinghe *et.al* 2008)

Fibre extraction

Pseudostems of commercially grown banana varieties are profitably be used to extract fibres . Ten kg of psuedostem yields one kg of fibre on dry weight basis. These fibre are used to produce different industrial items successfully.

Banana as staking material for *Diascorea faciculata*

Diascorea faciculata is a commonly growing yam species in Sri Lanka and its staking cost accounts 20% to the total cost of cultivation. Hence, a cooking banana variety Prasad (ABB - *pisang awak*) was tested as a staking material for *Diascorea faciculata*

The mean tuber yield of 0.98 – 1 kg/vine and the mean bunch yield of banana 12 kg/bunch had been obtained when banana was used as staking material. This had been compared with a control in which glyricidia was provided as staking material. In control treatment tuber mean yield of 1 kg and mean bunch of 12.5 kg in banana were obtained. Therefore, banana can be used as a staking material for *Diascorea faciculata* without affecting yields of both crops. (Weerasinghe 2008 unpublished)

Utilization of Banana pseudo stem for Oyster mushroom (*Pleurotus ostreasus*) Cultivation

Pleurotus mushrooms were cultivated in three substrates namely conventional sawdust (SD), banana pseudo stem (BS) and a combined substrate of BS and SD mixture (1:1 ratio) to ascertain the feasibility of using banana pseudo stem as a potential substrate to cultivate oyster mushrooms. Assessments were based on the spawn run time and the mushroom yields obtained from each of the three substrates. Significantly higher ($P < 0.05$) mushroom yields and short spawn run duration were observed in banana pseudo stem amended saw dust substrate. Based on the above observations banana pseudo stem amended sawdust substrate had been identified as a better substrate than the conventional saw dust based compost mixture for Oyster mushroom cultivation. (Weerasinghe 2008)

Development Activities

Banana Dedicated zones

Establishment of banana dedicated zones with popular varieties are in progress. This project was started in 2007 and up to now several zones had been established (map).

References

AgStat 2007 Pocket book of Agricultural statistics, Department of Agriculture, Peradeniya

Chandraratne MF and KDSS Nanaakkara 1951 cultivated varieties of banana in Ceylon. Tropical Agriculturist 107:70-91.

Deraniyagala S 1992 Prehistory of Sri Lanka Archaeological Department Sri Lanka 1:5-10

Ekanayake EMDSN, WLG Samarasinghe and I Ariyarathne 2002 Collection, Identification, characterization, evaluation and conservation of Musa genetic resources in Sri Lanka Proceedings of Global conference on Banana & Plantation 28 – 31.

Ekanayake S & C K Ranawana 2002. Study on product development of banana. Proceedings of the 58th annual sessions of Sri Lanka Association of the Advancement of Science 56p.

Gunasinghe WADSK, WKA Madushani, EM Dassanayake and NM Ubeysekara 2008.A suitable methodology to detect banana streak virus (BSV) in tissue cultured banana. Annals of the Sri Lanka Department of Agriculture 10:37-44

Ikiriwatte CJ 2008. Effect of Preharvest treatments of Gibberelic acid and bagging on quality and shelf – life of banana (CV. Embul) In M. Phil degree thesis in Post harvest (Plant Sciences) PGIS, Peradeniya, Sri Lanka.

Premathilake DP, A Hettiarachchi 2007 Tissue Culture at cottage level. Publication by the Sri Lanka Department of Agriuclture (In singhala)23 pp.

Rajapakshe RGAS, SMIK Sakalauriya, J. Kahawatte, RV Sumanapala & ERSP Edirimanna 2005, Annals of the Sri Lanka Department of Agriuclture, 7: 225-232

Samarasinghe WLG, SLD Jayaweera, MRP Kurukulasooriya, ASU Liyanage & KVWDharshana 2008. Occurance, characteristics and diversity of wild banana *Musa Acuminata* and *Musa Balbisiana* in Sri Lanka. Annals of the Sri Lanka Department of Agriculture 10:165 - 176

Samarasinghe WLG, ALT Perera, IP Wickramasinghe and AM Nafees 2002, Molecular characterization of Musa spp. by simple sequence Repeats (SSR) Tropical Agricultural Research 14:1 – 10.

Samarasinghe WLG, HWL Pushpakumari 2008 Dissertation for the B Sc degree in Agriculture. University of Ruhuna, Sri Lanka.

Weerasinghe SS. Management of banana weewil.2005 AGTEC Newsletter Department of Agriculture Sri Lanka 7(3).2

Weerasinghe SS. K H Ruwanpathirana, D Epa, S. Chamara, DT Wanniarachchi and LS Gunasekara 2008 Permormance and economic returns of leaf oriented banana cultivations in two agro ecological regions.

TAIWAN

Current Status of Banana R&D in Taiwan

Dr. Chih-Ping Chao, Acting director and Researcher
Taiwan Banana Research Institute

Summary
The total volume of Taiwan banana exported to Japan is estimated less than 0.8 million cartons in 2008. Tai-Chiao#5, a new somaclone variant with moderate resistance and similar traits to the widely cultivated cultivar, "Pei-Chiao", has been released to banana growers in 2007. FHIA-01, -02, and -25, similar enough to GCTCV-119, showed high resistant reaction to Fusarium wilt, caused by *Fusarium oxysporum* f. sp *cubense* race 4, whereas Pisang Jari buaya, SH-3436-9, FHIA-18, and Williams had moderate resistance in Taiwan. Adventitious buds maintained on MS medium amended with TDZ+PP333, and then rotated to MS+BA could enhance the multiplication of bud initiation. MS+BA and MS+PP333 in solid medium, respectively, can also increase the quantity and size of the regenerated plantlets. Application of vaporized chlorine dioxide weekly can significantly decrease the contamination in the TC incubation room. When 3 out of 5 diagnostic approaches such as severe type symptom, PCR and RT-PCR, ELISA, SEM, and mealybug transmission showed positive reaction, the indexed clone is considered infected by severe type of BSV. Consecutively, 8-year organic banana plantation has relatively lower Fusarium wilt incidence, when compared to the conventional management. All banana exported to Japan can be traced for their safety and management through the internet established by Taiwan agricultural unit.

Introduction
Cavendish banana is the number one export tropical fruit crop in Taiwan since 1960s, and Japan is always oriented as the major foreign market for Taiwan banana to export. At present, Taiwan banana, famous for its superior eating-quality especially in spring and autumn seasons, still retains the highest offered price normally ranging between CIF $11-20 per carton (12Kg/carton), in Japan market. However, the record low volume, only 0.5-0.6 million cartons of banana available from February to October this year, were exported to Japan (Fig1).

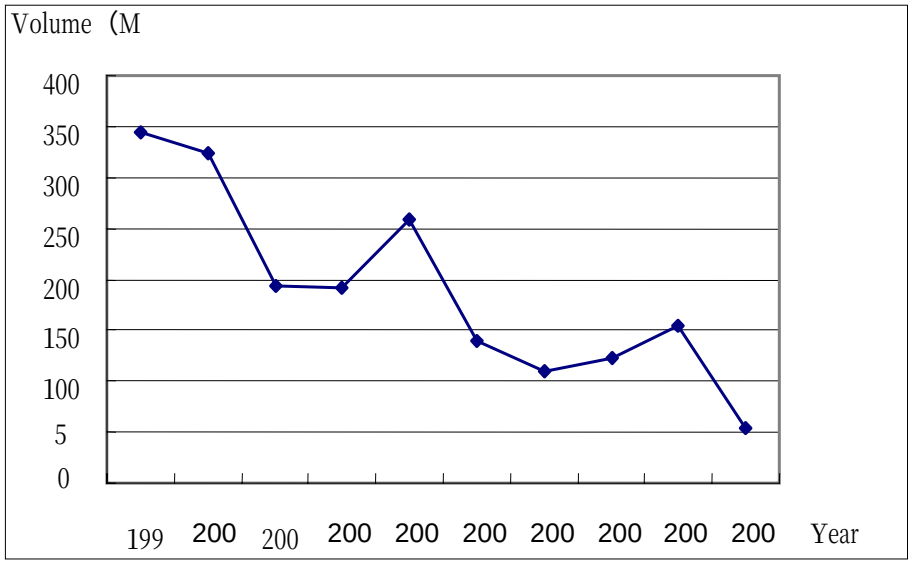


Fig 1. The dynamic of Taiwan Cavendish banana exported to Japan in recent ten years

There are several factors associated with the drastic decline of Taiwan banana available for export in 2008. Firstly, the impact of two consecutive typhoons on banana plantation on the fall of 2007, when most of the banana plantations reached shooting stage , reduced the yield of banana plant seriously. Secondly, the soaring-up of banana grower's high annual cost of production, 7,300US$ /Ha without the count of extra labor hiring, is another constraint. Thirdly, the fact that 15-20 % banana plants in average infected in each banana plantation by the Fusarium wilt epidemic, especially the race 4 of Fusarium oxysporum f. sp cubense （FOC）, leads to the target yield capacity, 35-40Ton/Ha, hard to be reached.. Regretfully enough, in order to establish the market connection in Japan, few new Taiwan banana export sectors who only supplied " Pei-Chiao" fruit to Japan, misled Japanese importers the belief that fruit quality of "FORMOSANA", a somaclone derived from "Pei-Chiao" and released in 2001 with high-yield capacity and resistance to FOC race 4, is inferior to that of "Pei-Chiao" at the beginning of export season in 2007. In 2007 and 2008, only very limited volume of "FORMOSANA" banana can be accepted for export to Japan even the information collected by the government through the post-harvest quality survey on "FORMOSANA" in Japan clearly showing that actually not much difference of post-harvest quality between those two cultivars could be detected. .

Variety improvement

To stabilize the sustainability of Taiwan banana for local and domestic needs, "Tai-Chiao#5", a new somaclone variant, TC-1035, which was selected in 1999, with moderate resistance to FOC race 4 (Fig2, 3) and horticultural traits similar to those of "PEI-CHIAO" (Table1), has been released as a new cultivar in 2007. Currently, more than 300 Ha plantations has been established with TC plantlets of this new clone in Taiwan, and the post-harvest quality (Table 2) of this cultivar is quite well accepted by domestic and Japan market.

After the quarantine inspection on some listed diseases and pests such as banana streak and bract mosaic for three years, thirty tissue culture plantlets of each 19 ITC accessions obtained from Australia in 2004 , partially overlapped with clones for IMTP III test, were planted in a FOC race 4 (probably VCG1213/1216, tropical race 4) infested plot in 2007 to obtain information about the growth pattern and specifically reaction of those clones to FOC race 4 in Taiwan. Affected by two consecutive typhoons since fall of 2007, six ITC clones such as Williams and Gros Michel were severely damaged. Even though the first crop data was not completed yet, it appeared that most clones evaluated took more than 10 months to reach the shooting stage (Table 3). Three FHIA clones, FHIA01, FHIA02, and FHIA25, expressed high resistance as that of the check cultivar, GCTCV-119, to FOC race 4 in Taiwan. Clones including Pisang Jari Buaya, SH-3436-9, FHIA 18, and Williams showed moderately resistant reaction to FOC race 4 whereas10 other evaluated clones including FHIA 3, FHIA 17, FHIA 21, FHIA 23, TMBX 1378, TMBX 5295-1, Cachaco, Gros Michel, Pisang ceylan, and SH3640 showed high susceptibility to FOC race 4. The evaluation on accession CRBP39 was not engaged because of the failure in recovery from the tissue culture stock maintained at TBRI.



Fig2. Banana plants of a new Cavendish cultivar, Tai-Chiao #5, showing moderate resistance to Fusarium wilt of banana（Left）; Pei-Chiao plants severely affected by Fusarium wilt in a same plantation（Right） in Taiwan.



Fig3. The outlook of a Tai-Chiao #5 plant at shooting stage, showing the good configuration of fruit fingers

Table 1. Regional evaluation of Tai- Chiao #5 on its growth rate and yield potential

Clone	Cultivar	Days to harvest	Height (cm)	Girth of Pseudostem	Hands /plant	Bunch weight	Resistance reaction
Tai-Chiao#5	Tai-Chiao#5	394 a	257 a	69.2 a	7.9 a	20.6 a	MR
Pei-Chiao	Pei-Chiao	384 a	278 a	72.0 a	7.9 a	19.7 a	HS

Table 2. Flavor evaluation for fruit of Tai-Chiao #5

Cultivar	Grey Relation Coefficient			Coefficient Average	Ranking
	Aroma	Firmness	Sweetness		
Tai-Chiao#5	0.667	1.001	0.728	0.799	1
Pei-Chiao	0.667	0.809	0.697	0.725	2

Table3. Preliminary evaluation of 19 ITC accessions in Taiwan

Accession (Genome)		Days to shooting	Days to harvest	Plant height	Girth of pseudo-stem(cm)	No of hands	Bunch weight (kg)	Fusarium wilt incidence (%)
I-1	**Pisang Jari Buaya(AA)**	309		306.7	54.0	8.3		16.7
I-2	FHIA-01(AAAB)	388.8		232.5	63.5	10.7		0
I-3	FHIA-02(AAAB)		417	206.6	62.2	7.6	7.5	0
I-4	FHIA-03(AABB)			293	76	5.0		50.0
I-5	Williams(AAA)							25.0
I-6	Cachaco(ABB)							50.0
I-7	Gros-Michel(AAA)							91.7
I-8	Yangambi KM5(AAA)							58.3
I-9	FHIA-17(AAAA)							66.7
I-10	FHIA-23(AAAA)							63.6
I-11	SH-3436-9(AAAA)	307		317	77	9.0		16.7
I-12	TMBx 1378(ABBB)	321	431	263	71	8.0	10.9	44.4
I-13	TMBx 5295-1(AAAB)			309	72	8.0		58.3
I-14	SH-3640(AAAB)							100
I-15	FHIA-18(AAAB)			240	73	10.0		20.0
I-16	FHIA-21 (#68) (AAAB)			289	79	15.8		45.5
I-17	CRBP 39(AAAB)	-	-	-	-	-	-	-
I-18	FHIA-25 （AAAB）	337		276.5	92.5	15.8		0
I-19	Pisang Ceylan(AAB)			268.5	61.0	8.7		58.3
Ck	GCTCV-119(AAA)			358	71	9		0

Commerical micropropagation of banana plantlets

The banana micropropagation system was set up in 1983 to combat the spread of Fusarium wilt. After 25 years of service to banana farmers in Taiwan, a total of over 50 million plantlets have been produced. In recent years, the average supply of plantlets was around 3 million per year. The market demand of plantlets have been greatly influenced by the market price of bananas. This system has also served the purpose of rapid promotion of new cultivars.

Improvement included culture medium formulations, techniques in subculturing, regeneration of tissue culuture plantlets of banana , and screen house transplanting. The adventitious bud multiplication efficiency is achieved by amending Thidiazuron (TDZ) and Paclobutrazol (PP333) ingredients into MS medium, and alternated with MS medium with traditional BA growth regulator. BA+MS solid medium also has higher regeneration effect, compared to MS medium with active charcoal. More larger plantlets per flask can be expected after a new regeneration formulation, MS+PP333, is applied.

During the rainy season, the mass propagation system occasionally suffered 10-15% air-borne mold and bacteria contamination, leading to the unstable supply of TC plantlet to banana growers. It was found that regular vaporization of TC incubation room by 300-1,000ppm chlorine dioxide solution can significantly reduce the risk of TC flask materials contaminated by fungal and bacteria contaminant (Table 4).

Table 4. Effect of chlorine dioxide on the control of contaminant in tissue culture incubation room of banana

Treatment	Colony of Contaminant on PDA					
	Check			After treatment		
	Fungi	Bacteria	Total	Fungi	Bacteria	Total
5%chlorine dioxide solution 300ppm	3.6	2.8	6.4	0	1.6	1.6
Chlorine dioxide tablet 1,000ppm	8.5	0	8.5	0.4	0.3	0.7

Eight chlorine dioxide bottles, 200ml/bottle, per 80-100 square meter per week

BSV severe strain and BBrMV indexing techniques

The banana streak, caused by banana Bandastreak Virus (BSV), and banana bract mosaic, caused by banana bract mosaic virus (BBrMV) , are presently listed as two quarantine diseases in Taiwan. To ensure the normal evaluation and utilization of banana germplasm collected before by TBRI researcher, it is a must to prove the clones kept in TBRI repository are free of the severe strain (the expressed type) of BSV, which incites the yellow streak symptom on the leaf, and negative for BBrMV indexing. Five diagnostic techniques, including symptom type, PCR+ RT-PCR, ELISA, Scanning Electron Microscopy, and transmission test with banana or citrus mealybug as BSV vector, are applied to check whether clones are infected by BSV severe strain. When the sample , analyzed by 3 out of 5 methods mentioned above, show positive reaction, the indexed clone is considered infected by severe strain of BSV and shall be eradicated. For positive confirmation of clone infected by BBrMV or not, the RT-PCR diagnosis and cotton aphid transmission trial have to been conducted.

Extension of organic banana production

After establishing a 8-year continuous organic banana plantation, the incidence of Fusarium wilt is significantly lower than that under conventional farming system (Fig 4). Soil in plot under long-term organic farming becomes mild alkaline (pH>7), has more than 2% organic matter per gram of soil, and the conductivity condition decrease (Table 5).

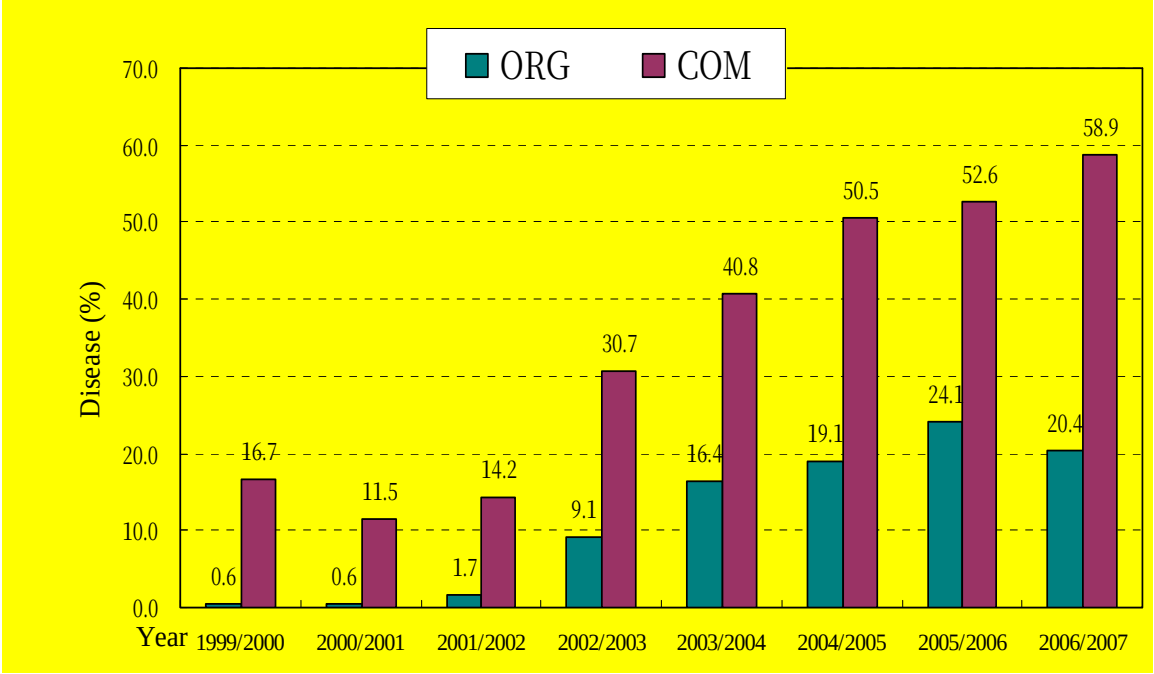


Fig 4. Comparison of Fusarium wilt incidence between conventional and organic banana farming

Table5. Comparison of the soil chemical conditions of banana orchard after harvesting under conventional and organic farming system

Peri-od	Farming	OM (g/Kg)	pH	Conduc-tivity (dS/m)	P	K	Ca	Mg	Fe	Mn	Cu	Zn
					(mg/Kg)							
98/99	ORG	21.1	7.5	0.37	85.7	155.4	3360	110.5	81.1	3.3	3.3	1.8
	CON	20.8	6.7	0.37	69.6	136.1	1515	99.5	181.5	2.6	3.8	0.7
05/06	ORG	42.9	7.5	0.91	112.5	617.0	2616	257	219.8	98.3	6.2	25.2
	CON	35.5	5.4	0.82	87.4	233.5	1175	117	469.7	51.5	4.9	15.4
06/07	ORG	34.1	7.6	0.66	142.1	721.0	2085	236	254.9	85.0	7.3	32.8
	CON	30.7	5.1	1.41	83.5	492.0	770	46	510.0	54.7	6.3	20.8

Banana traceability extension education

In total, more than 3500 banana growers belong to different banana farmer's association were lectured with management of high quality production of banana to ensure the safety and competition of Taiwan banana. All banana exported to Japan have to attach the traceability code in the carton, which can be referred and inspected by Japanese' customer through surfing internet "taftj.afa.gov.tw"

Country Report of Status and Research and Development of Banana in Thailand

Pitsawat Buara, director
Horticulture Research Institute, Department of Agriculture
Bangkok, Thailand.

Introduction

Banana are widely cultivated all over the country of Thailand, as a small farms, back yard trees and commercial plantation. There are numerous cultivars of Thai banana, the fruits of different cultivars are available all year round. It can be used as food, fresh, cooked, processed and feed. The fruit can be consumed as fresh or prepared as dessert or processed as banana chips of different type. Banana flower and immature fruit can be used for cooking in various dishes. The leaves are used to wrap up food and made into containers. The inside young stalk can be used as hog feed. The tougher outside or stalk sheet is torn into small strips and made into a durable type of string.

The survey of banana species and cultivars in Thailand during 1979-1981 reported that more than 50 varieties were found throughout the countries. There can be divided into 7 groups of different genomes, i.e., AA (Kluai-Khai, Kluai Leb-Mue-Nang), AAA (Kluai-Hom Thong), AAB (Kluai-Nak), ABB (Kluai-Hak-Mook, Kluai-Namwa), ABBB (Kluai-Teparos), BB (Kluai-Tanee) and BBB (Kluai-Leb-Chang-Kood). There are only three varieties mainly grown as economic fruits, because they have high potential for export and processing. These are *Musa* (AAA group)" Kluai Hom" , *Musa* (AA group) " Kluai Khai" and *Musa* (ABB group)" Kluai Namwa" Kluai Hom, meaning 'aromatic banana' has a special flavor and fragrance superior to most commercial cultivars of the 'Gros Michel' type grown in other banana-exporting countries. The meaning of 'Kluai Khai' is egg banana' of the Sucrier type, although similar to Pisang Mas of Indonesia and Malaysia, is very sweet and has special texture, flavor and aroma. The most common banana in Thailand, which is widely grown in the backyard of houses in the villages, is Kluai Namwa of the "Pisang Awak' type. It has firm, sticky fresh and can be eaten as fresh, cooked and processed of different type of snack. It is very nutritious and used for feeding infants.

Planting area and banana production

In 2007, The total planted area of banana was 113,165 ha with a total production of 1,565,817 tons, distributed into areas for Kluai-Namwa totaling to 85,660 ha having a total production of 1,151,937 tons. The area planted to Kluai-Hom was 15,856 ha with a total production of 246,834 tons while planted area for Kluai-Khai was 11,649 ha with a total production of 167,046 tons (Table 1).

Table 1. Planted area and yield of banana in Thailand in 2007

Variety	Planted area (ha)			Total yield (t)	Average yield (t/ha)
	Bearing	Non-bearing	Total		
Kluai-Namwa	83,210	2,450	85,660	1,151,937	13.84
Kluai-Hom	13,642	2,214	15,856	246,834	18.09
Kluai-Khai	9,329	2,320	11,649	167,046	17.91
Total	106,181	6,984	113,165	1,565,817	14.75

Source: Office of Agricultural Economics,2007

Market situation

The fruits of banana are mostly produced for domestic consumption. Only a small volume is exported. The supply chain for banana in Thailand is divided into 2 ways. The fruits are produced for exporting countries, has to certify in farm and travel directly to importing countries, so the fruit is generally of better quality. The fruits are produced for local market has to travel long distance from the production site to the wholesale market through collector agents and then sell to supermarket or open market, so the fruit is sometime low quality.

The export quantity of fresh bananas fruits of Kluai-Hom, Kluai-Khai, Kluai-Namwa and other varieties during 2006 – 2007 ranged between 19,662 – 20,110 tons with the value of 193.68 million baht and 170.62 million baht, respectively.The export quantity of bananas products (dried) were 1,426 and 2116 tons with the value of 91.85 and 105.13 million baht, respectively (Table 2).

The major market export of fresh Kluai-Hom, including processed products are Japan and China. The main market export of Kluai-Khai is Hongkong, China ,Loas and Japan.

Importing country for fresh banana

Bahrain, China, Hong Kong, Korea R, Malaysia, Australia, Switzerland, Saudi Arabia, Taiwan, Japan, Myanmar, United States, Laos Republic, and Netherlands.

Importing country for dried banana

Bahrain, China, Ireland, New Zealand, Singapore, Turkey, United States, Australia, France, United Kingdom, Japan, Netherlands, Denmark, Malaysia, Qatar, Hong Kong, Germany, Guam, Israel, Korea R, Switzerland, Philippines, Taiwan, India, Norway, and Portugal.

Table 2. Quantity and value of banana exported 2006 – 2007

Categories	2006		2007	
	Quantity	Value	Quantity	Value
Bananas,fresh	19,662	193.68	20,110	170.62
Sweet banana	2,100	55.0	2,960	46.00
Dainty banana	13,837	114.0	13,723	91.00
Kluai-Nam-wa and other bananas	3,725	24.68	3,427	33.62
Bananas,dried	1,426	91.85	2,116	105.13

Source: Department of Customs. 2008
Sweet banana : Kluai-Khai
Dainty banana : Kluai-Hom

Quantity: Metric ton
Value :Million Baht

Banana R&D activities

Banana research and development in Thailand is mostly undertaken by government agencies. There are many institutes involved such as Department of Agriculture, Department of Agriculture Extension, colleges, universities and other government organizations.

As banana is not the main export crop of the country, there are no immense R&D plans. Moreover, the financial support on research is very limited. Nevertheless, over the past few years, there are a number of projects concerned banana in various aspects including varietals improvement, propagation techniques, germplasm collection and conservation, plant protection, production technology, fruit quality improvement for export, post harvest handling and processing technology for new products, and etc. The followings are example of R&D activities in Thailand.

Germplasm collection and conservation

About 175 accessions have been collected and conserved under care of the Department of Agriculture, Department of Agriculture Extension and Kasetsart University. Most of these have been characterized on morphology and taxonomy. Some have been used for breeding programmes.

Varietals improvement

There is only few research works concern the improvement of banana variety. However, in the past few years, Kasetsart University has released the new banana variety called Kasetsart Banana 2. This new variety occurred from the mutation of callus that is initiated by radiation.

Production system

R&D on production systems are aimed to improve yield and qualities. The followings are the projects that have been done in the past few years:

- Development of production technology for improving growth, yield and qualities of Grande Naine.
- Effect of sucker size on growth of Grande Naine.
- Sucker-dividing effect on growth of Kluai-hom, Kluai-khai and Kluai-nam-wa.
- Effect of media on growth of Grande Naine seedlings.
- Effect of some foliar fertilizers on growth of Grande Naine seedlings.
- Study on growth of inflorescence and fruit of Kluai -hom-kom.
- Selection of saline-tolerant varieties through tissue culture techniques.
- Effect of number of genomes on propagation via tissue culture methods.
- Increasing of number of chromosomes of Kluai -leb-mue-nang using colchicines under aseptic condition.
- Study on the possibility of conservation of banana germplasm with liquid nitrogen.
- Study on the causal agent of leaf speckle symptoms and its control measures.
- Study on the effectiveness of some fungicides on the control of sigatoka disease of Kluai -hom, Taiwan variety.

Maintenance and distribution of *Musa* germplasm in Thailand

The project is introduced through International Network for the Improvement of Banana and Plantain (INIBAP). It was carried at Phichit Horticultural Research Center (PHRC), Department of agriculture. *In vitro* proliferating tissue of 23 banana accessions, ITC codes 0312, 0504, 0505,0506, 0570, 0643, 0712, 1122, 1123, 1264, 1265, 1282, 1283, 1296, 1297, 1307, 1319, 1332, 1344, 1418, 1441, 1442, and 1443 were received from INIBAP on February 21, 2003. They were cultured for plant multiplication in the medium of Murashige and Skoog (MS) Of 23 accessions, ITC. 1319 was contaminated and died. The rest was transferred to grow in the green house at PHRC. Later, the healthy young plants of the 22 accessions were selected and planted in the field at PHRC from September 2003 to January 2004. Randomized completed block design (RCBD) with 2 replications was used. Data was recorded such as number of days after planting to flowering, number of days after flowering to harvest, plant height, bunch weight, number of hands in bunch at harvest, number of fingers per hand and Sigatoka severity scoring.

The results showed that number of days after planting to flowering ranged from 175 to 218 days. ITC. 0570 was the earliest accession, which gave 175 days and ITC. 1332 was the latest accession, which gave 218 days after planting to reach flower. Number of days after flowering to harvest ranged from 94 to 124 days. ITC. 1297 was the earliest accession, which gave 94 days and ITC. 0570 was the latest accession, which gave 124 days after flowering to reach harvest.

Bunch weight ranged from 3.68 to 31.69 kg. ITC codes 0507 and 1442 gave the highest bunch weight of 31.69 and 28.76 kg, respectively. The lowest bunch weight was ITC. 0712, which gave 3.68 kg.

Number of hands per bunch ranged from 7 to 11 hands. The highest number of hands per bunch was ITC. Codes 1441, 0505, 0507, 0712 and 1442 which gave 11, 10, 9, 9 and 9 hands per bunch, respectively. The lowest number of hands per bunch was ITC. Codes 1297 and 1344 which gave 7 and 7, respectively. Number of fingers per hand raged from 14 to 21 fingers. ITC. Codes 0507 gave the highest number of fingers per hand 0f 21 fingers, respectively, ITC 0712 gave the lowest number of finger per hand of 12 .

Sigatoka severity scoring at harvest ranged from 1 to 3. ITC. Code 0505, 1307 and 1344 gave Sigatoka severity at the lowest scoring which were at 1, (<1% of lamina with symptoms). ITC. Code 0570, 0712 and 1442 gave the highest Sigatoka severity scoring of 3 (6 to 15% of lamina with symptoms).

Currently, all of them were planted at Phichit Horticulture Research Center and some banana plants were distributed to colleges, university and governmental organization for further study. Some important varieties are selected to grow at Royal Flora Ratchaphruck plantation, Chiangmai Province.

Production constraints

Kluai Namwa is the most popular variety in Thailand. It is grown and widely adapted to several areas in the country, i.e. the southern region, the central plain and the northeast region. In Thailand, it is founded that this variety is very susceptible to Fusarium wilt. The causal organism was identified as *Fusarium oxysporum* f.sp. *cubense*. The outbreak of this pathogen in some banana planting areas is due to disease-free suckers are not used as new planting materials and lack of quarantine and sanitation to prevent the spread of the pathogen to uninfected areas.

At present, Thailand has not yet serious problems of this wilt disease infection. The system of quality management: Good agricultural practice (GAP) for banana is established by Department of Agriculture to evaluate all registered banana farm, particularly in commercial production of large-scale farmers. The selection of disease-free suckers as new planting materials is a major step towards preventing the spread of Fusarium wilt to disease-free fields. There is the use of banana tissue culture plants as new planting materials to prevent Fusarium wilt in commercial production of Kluai Namwa. Acid soil is more conductive to Fusarium wilt. Amendment of soil with lime is recommended to lower the spread of the disease in the field. Severity of Fusarium wilt is also diseased with the application of nitrate form of Nitrogen fertilizer. Furthermore, sanitation of equipment management and tools and selection of diseased-free planting material play an important role in practices to prevent the introduction of *Fusarium* wilt into clean banana fields.

Survey, collection and characterization of banana *Fusarium* wilt

Survey of banana Fusarium wilt has been done in eleven provinces during October 2007-January 2008. Banana trees in each plantation were randomly selected and taken samples from pseudostem of suspected diseased plants. Three hundred and eighteen samples have already been sent to FABI, South Africa for characterization and VCG analysis of FOC. Some samples were identified in Thailand. It was reported that all samples were taken from Nhong Khai and Phichit have not been found *Fusarium* wilt infects. Number of sample were taken in each province and number of samples were found Fusarium wilt with a map of eleven provinces of survey areas are given as follow (Table 3).

Geographical maping of banana *Fusarium* wilt samples collected in Thailand :



Table3. Survey of banana *Fusarium* wilt of eleven provinces in Thailand.

Provinces	N0. of Sample	Kind of Pathogen	No. of sample was found *Fusarium* sp.
Nakorn nayok	15	*Fusarium* sp.	14
Singburi	7	*Fusarium* sp.	6
Chumphon	46	*Fusarium* sp.	30
Chanthaburi	9	*Fusarium* sp.	8
Petchaburi	75	*Fusarium* sp.	1
Nhong Khai	28	-	-
Chiangrai	40	*Fusarium* sp.	25
Chiang Mai	6	*Fusarium* sp.	6
Tak	29	*Fusarium* sp.	27
Phichit	50	-	-
Sukholthai	13	*Fusarium* sp.	3
	318		

References

Anupunt, P. 2002. Banana in Thailand. Advancing banana and plantain R&D in Asia and Pacific, Vol. 11. pp.149-154.

Bansiddhi, K. 2003. Current status and prospects of banana R&D in Thailand. Advancing banana and plantain R&D in Asia and Pacific, Vol. 12. pp.111-115.

Chandraparnik, S., C. Ditchaiwong and K.Bansiddhi. 2004. Comparison of Musa germplasm in Thailand. Advancing banana and plantain R&D in Asia and Pacific, Vol. 13. pp.131-134.

Kooariyakul, S. 2008. Survey, collection and characterization of banana *Fusarium* wilt pathogen in Thailand. 13p.

Office of agricultural economics.2007.Statistic data agriculture economics. Office of Agricultural Economics. Ministry of agricultural and Cooperative.Thailand.97p.

Silayoi, B. 2006. New variety, Kasetsart banana 2. Workshop on mass production of Kasetsart banana 2 by tissue culture. 29 May – 2 June 2006 at Central laboratory. Kasetsart University. 112p.

Vichitrananda, S.2007. Current banana research and development activities in Thailand. 8p.

STATUS AND MAJOR TECHNOLOGICAL SOLUTIONS FOR BANANA PRODUCTION IN VIETNAM

Dr. Nguyen Van Nghiem, Head
Fruit Crops Department, Fruit and Vegetable Research Institute

Introduction

Banana is one of the most important fruit crops grown in Vietnam. It ranks first in term of production area and in term of gross output. The plant has been cultivated there for thousands of year and has great socio-economic importance in most regions of the country.

Vietnam has favourable environmental conditions for banana production. However, both average productivity and production are still very low. In general, bananas are almostly grown in small gardens. Especially, fruits are mainly consumed in domestic market and their contribution to the export trade is negligible. Up to now, research efforts have been focused on standardization of production technology to increase the productivity and production of banana in varying agro-ecological conditions under different system of production.

In " The project of developing fruit crops to the year 2010, beyond the year 2020", The Ministry of Agriculture and Rural Development of Vietnam had identified to develop banana production in large scale for both domestic and export consumption. By the end of the year 2010, banana production for export will reach to one hundred thousand tons and the export turnover will be 35 million USD. In order to achieve the above goal, it is necessary to have centralized banana production areas with large scale for export. In these areas, technical procedure for banana production should be applied efficiently to increase productivity and to improve quality of fruit. Besides, banana growers need to apply Good Agricultural Practices VietGAP to have safe products, to protect environment and farmers heath. Also, research activities of banana need to pay attention to conserve and efficient using of genetic diversity of banana.

Status of banana production

Current fruit crops production

Vietnam's big products fruit-crops are banana, pineapple, orange, pumelo, mango, longan and litchi. In which, banana is a kind of fruit-crop which has biggest production scale. In the year 2007, banana production areas reached 106.2 thousand ha and the output is about 1.4 million tons, much higher than other fruit-crops (Table 1).

Table 1. Area and production of fruits in 2007

No	Fruits	Area		Production	
		Total (000 ha)	Rank	Total (000 tons)	Rank
1	Banana	106.2	I	1376.1	I
2	Pineaple	38.6	VII	529.1	IV
3	Mango	76.7	V	409.3	VI
4	Orange	86.7	IV	662.0	II
5	Pumelo	39.7	VI	296.4	VII
6	Longan	97.9	II	578.0	III
7	Litchi	88.9	III	428.9	V
8	Others	240.8	-	-	-
	Total	775.5	-	-	-

Source: Central Statistic Office, Hanoi, Vietnam 2007

From 2001 up to present, banana planting square all over the country is increasing and moving steadily from 105 to 110 thousand ha. The highest production area is 108 thousand obtained in 2006. The average productivity of banana in 2001 is very low, at 11.7 tons/ha. Since 2004 up to now, banana productivity has been increasing a lot, it is moving around 14.2 - 14.6 tons/ha. The increasing of banana production is as same as the increasing of banana productivity. Years of 2006 and 2007 have highest products which is about 1.4 million tons (Table 2).

Table 2. Banana production, period 2001-2007

No	Banana production	Year				
		2001	2004	2005	2006	2007
1	Area (000 ha)	101.1	101.9	104.7	108.1	106.2
2	Production area (000 ha)	92.1	92.4	93.9	96.2	94.7
3	Productivity (tons/ha)	11.7	14.6	14.3	14.2	14.5
4	Production (000 tons)	1080	1354	1344.2	1368.6	1376.1

Source: Central Statistic Office, Hanoi, Vietnam 2007

Vietnam is divided into 8 different regions according to their agro-ecological features. As banana can widely adapt to different climatic conditions, it has long been grown in all these regions. In the year 2007, the total banana square is about 106.2 thousand ha. The Mekong River Delta was largest region of 33.0 thousand ha, subsequence The Red River Delta of 16.7 thousand ha and North Central Coast of 15.6 thousand ha.

Table 3. Banana production in different regions in 2007

No	Regions	Production Aspects			
		Total Area (000 ha)	Production Area (000 ha)	Average Yield (tons/ha)	Total Production (000 tons)
1	Red River Delta	16.7	16.0	25.0	399.7
2	North East	9.2	7.3	12.7	92.9
3	North West	3.3	2.8	13.2	36.9
4	North Central Coast	15.6	14.3	9.1	130.2
5	South Central Coast	11.8	10.1	11.3	114.4
6	Central Highland	4.1	3.9	17.7	69.1
7	Southern East	12.5	11.6	15.4	179.0
8	Mekong River Delta	33.0	28.7	12.3	353.9
	Total	**106.2**	**94.7**	**14.5**	**1376.1**

Source: Central Statistic Office, Hanoi, Vietnam 2007

The average productivity of banana is still very low (14.5 tons /ha). The highest productivity is at The Red River Delta (25 tons/ha), and the lowest is at The North Central Coast (9.1 tons/ha). Total banana output in 2007 was about 1.4 million tons. The output of The Red River Delta was highest of 399,700 tons subsequence The Mekong River Delta of 353,900 tons.

Banana varieties

Vietnam lies in the centre of origin of banana and is the place which has favourable environmental conditions for banana production. There have been a lot of different varieties cultivated throughout the country. Below are some of popular varieties with high economical value.

- Chuoi Tieu (genome group AAA): Chuoi Tieu is a collective noun for the sub-group Cavendish, included dwarf Tieu (1.5-2.0 m), medium Tieu (2.0-2.8 m) and high Tieu (2.8-4.0 m). In the North, there had been some popular varieties such as Pink Tieu, Lao Cai Tieu and Phu Tho Tieu. Meanwhile in the South, there had been some famous varieties such as Gia Huong, Gia Cui and Gia Lun. Chuoi Tieu varieties are planted for internal comsumption and for export to China, South Korea and previously to Russia. These are strong growing varieties, high productivity, good smell and delicious especialy in the region with cold weather in winter.

- Chuoi Tay (genome group ABB): Chuoi Tay has different names like Chuoi Su, Chuoi Xiem, Chuoi Mat Moc. It has varieties such as Tay Hong, Tay Phan and Tay Su which are popularly planted everywhere. Its pseudostem is 3-4 m high, well grown and easy to plant on different kinds of land even on hot, dry land. Fruits are mainly used for consumption in domestic and local market. In general, Chuoi Tay is easier infected by FOC (Fusarium oxysporium f.sp. cubense) compared with Chuoi Tieu and other.

- Chuoi Bom (genome group AAB): This variety has a high tolerance to drought and is popularly grown in the South East and Central Highland region. Fruits are for fresh consumption or for drying.

- Chuoi Ngu (genome group AA): Chuoi Ngu includes Ngu Tien, Ngu Man. Its pseudostem is 2.5 – 3.0 m high. Fruits are small with beautiful bright colour and very good smell but low producivity. The

main regions to grow this kind of banana are Hai Duong, Hung Yen and Nam Dinh.

Besides, there are other kinds of banana like Chuoi Hot, Chuoi La and Chuoi Ngop... However, these varieties are not popularly grown and low economical value.

Banana production aspects

- Planting seasons: There are two main planting seasons in the Northern regions which are spring (from February to April) and autumn (from August to October). Meanwhile, the planting season in the South regions is mainly from the end of dry season to the beginning of rainy season.

- Planting materials: In the past, banana planting materials are mainly their bulbs and sucker. This was one of the disavantages in banana production in Vietnam, especially in large scale production for exporting because planting materials are not at the same level then harvest period is different from each other. The application of *in vitro* planting materials had been being in progress. Recent years, it is estimated that 500-800 thousand plantlets for two varieties Chuoi Tieu and Chuoi Tay are produced annually.

- Density of planting: Planting density is a very important factor which is directly effectted to banana productivity. In Vietnam, bananas are mainly planted in small gardens and intercropped with many other kinds of fruit-trees, thus density is not right. It is sometime too dense and sometimes is too thin. This almost depends on farmers experiences. Popular planting density is of 2000-2500 trees/ha for Chuoi Tieu and Chuoi Tay and is of 3000-3500 trees/ha for Chuoi Bom.

- Banana management: Bananas production in Vietnam is mainly small scales, mostly in farmers' garden and for internal consumption and for local markets. Thus, banana growing technology is based on personal experiences. Investment and technical care is not right so that productivity is very low, unstable and almost production has not reached exporting standards.

- Pest and disease: The serious banana diseases are Panama *(Fusarium oxysporium f.sp.cubsence)*, yellow sigatoka *(Mycosphaerella musicola)*, black sigatoka *(Mycosphaerella fijiensis)*, BBTV (Banana Bunchy Top Virus). There are some dangerous banana pets such as Scabmoth *(Basilepta)*, banana weevil borer *(Comopolites Sordidus)*.

Preharvest aspects

- Preharvest treatments to improve quality of Cavenfish banana in the North of Vietnam by using bunch bagging with semi-transparent and perforated polyethylene (PE) bags after fruit setting that effectively prevent fruit borer and sunburn damage.

- Development of Cavendish banana maturity indices, where the banana are recommended to harvest if have at least one of the following characteristics: time from the flower cutting reaches 80-85 day; total soluble solids (TSS) of flesh reaches 3.0-3.5 Brix; and titratable acidity reaches 0.20-0.25%

- Research and Development of combined postharvest flowchart (postharvest treatment, packaging, storage, and ripening) for Cavendish banana in the North of Vietnam that can ensure postharvest storage life of 42 days with total postharvest loss of 4.9%.

- Research and development of banana drying technology that ensures product diversification and provides more added value of banana industry.

Major technological solutions for banana production in Vietnam

Building centralized banana production areas with large scale for export

In Vietnam, bananas are planted all over the country, from the North to the South, from the delta to the highland but it is mainly under small scale or in the home garden. Fruits are mainly for local consumption. Ministry of Argriculture and Rural Development has pointed out 5 banana production regions for exporting which are Northern Mountains, Red River Delta, South Central Coast, Southern East and Mekong River Delta. However, in order to increase the banana production efficiency, in each region, it is necessary to build big enough scale areas of 400 to 500 ha... The soil of these areas must be rich in nutrition. Then, the ecological conditions are suitable for banana growing and having high productivity with good quality of fruits. On the other hand, it is important to choose the areas which have skillful labours and intellectual standards of local people meeting the market requirements. The

banana production regions for export are facilitated for transportation product.

Using banana varieties for export

The consumed markets of Vietnam banana production are identified China, South Korea and Russia.. The major agronomic characters of exporting varieties: the rate of fruit which meets exported standards is over 85%, fruits are longer than 16 cm and bigger than 3 cm in diameter, the flesh is bright yellow, sweet and aromatic.

Commercial banana varieties in the world belong to the sub-group Cavendish. In Vietnam, there had been some good varities such as Pink Tieu, Phu Tho Tieu and Lao Cai Tieu. They are all local varieties, high adaptive to different ecological environmental conditions of the country.

In the near future, research activities will be taken care:

Selecting good varieties from the existing Musa collection

Evaluating and testing introduced varieties in different regions

To identify suitable and valuable varieties for each region which produce banana for export

- To build intensive farming model of banana production for the varieties which have high productivity and the fruit quality are good.

Pay attention to intensive farming and bring advanced technology into banana production

Banana is shortterm fruit-trees and suitable with intensive farming. If the banana growers do not take care of investment or only base on the fertility of soil, the effect of production may be very low. On the other hand, in Vietnam the advanced technology of banana production had not been applied effectively. To overcome above weaknesses, research and apply activities need to focus on the following issues:

Using desease-free planting matarials with proper density

To apply organic fertilizer, mineral fertilizer combined with irrigation

To identify the process for prouction banana of winter harvested time

Applying production process Viet GAP (Good Agricultural Practices) to get safe and high value product.

Applying advanced posthavest technology

It is necessary for banana treatment for both prehavest and posthavest stages. Requirement is keeping fruits in the storage duration of over 40 days. The loss in storage duration is less than 5%. Quality and appearance match with exported standards.

Conserving and using Musa collection

Vietnam has been one of the chosen countries in Asia to be supported by the Musa conservation Trust Fund, to support the rejuvenation, and conservation of *Musa* national collection. This project is coordinated by Bioversity International.

Up to year 2007, there had been 84 accessions in the collection with 72 local and 12 introduced ones. This collection was added 6 accessions in the beginning of year 2008. It's very distinguished that it consists of accessions of all 8 genome groups: AA, AAA, AAB, AAB, AB, ABB, BBB and BB.

July 2008 Bioversity International and Fruit & Vegetable Reasearch Institute (FAVRI) had signed a Letter of Agreement (LOA) to implement the project "Regeneration and Safety Duplication of Priority Musa Collections". The duration of this project is from August 2008 to March 2011. The goal of the project is to establish and to conserve Musa national collection at FAVRI. The main contents of the project are to duplicate and to maintain 90 existing accessions in the field. Of which, 30 accessions will be multiplicated in vitro. In the duration of the Project, characterization and evaluation of 90 accessions are also pointed out.

The Musa collection at FAVRI has been setting up and keeping 54 accessions. According the timeline for the project activities, up to beginning of year 2009, the rest 36 accessions will be duplicated and added to Musa national collection at FAVRI. All the activities of the LOA had been going according to plan.

Agreements & Action Points

1: Priority Setting for Banana Research and Development (R&D)

The banana R&D priorities in Asia and the Pacific, in view of limited funds and existing national program priorities, were tackled by the representatives, including the review of BAPNET's relevance. The session agreed to create an action plan based on the urgency and relevance of issues to current times.

1A: In the wake of increasing reports of incidence of the Panama wilt in countries in the Asia Pacific, including China and the Philippines which are important countries in the banana export market, the representatives agreed that banana wilt is the most urgent threat to the regional banana industries, thus recognizing that national programs must continue to tackle these diseases and that a project covering the region on the subject of Fusarium and other wilt diseases will be formulated.

Action Points for 1A:

1) At country levels, all national programs will be initiated, and a regional project proposal will be developed.

2) Secretariat to follow-up on the completion of VCG analysis and mapping of current surveys conducted in the Region.

1B: The group recognised that utilizing clean planting materials is an important issue for all countries with the emergence of viral, wilt diseases, which are transmissible through planting materials; its health management is strategic for the success of banana in all countries and this needs utmost attention. It is therefore agreed upon that there should be an understanding of the current seed systems in each country in order to develop a comprehensive and effective regional seed system. It was also agreed upon that members of the network should share methodologies available in setting up their respective national seed systems.

Action Points for 1B:

1) Conduct survey for Asia-Pacific's seed systems on banana (status and profile) Performance survey documents be formulated in consultation with BAPNET SC members and Bioversity staff. Timetable: ABMolina will consult with Charles Staver and BAPNET members for a simplified and more comprehensive survey. ABM will look into the survey and simplify.

2)Secretariat will provide members with protocol of mass-production of suckers developed from other Regions. Timetable: ABMolina will send the survey form to members for comments and send back to ABMolina within the week (of receipt). Simplified format will be sent to SC Reps by mid-December.

1C: The Committee agreed on making a position regarding climate change, recognizing that it is a reality that is affecting agricultural systems all over the world including banana production systems.

Action Point for 1C:

Dr. HPSingh (Representative of India) agreed to provide a short note on BAPNET's position on climate change that will be uploaded on BAPNET's webpage; It was agreed upon that the BAPNET position on the issue will be a basis for future project development with donors.

1D: Group recognised that proper understanding of the cultivars used by farmers across the Region is important. It was agreed upon that member countries must develop profiles/descriptions of cultivars/varieties usable by growers in respective countries and consolidate it into a regional compilation of profiles using a standard format.

Action Point for 1D:

BAPNET Secretariat will provide the standard format (including agronomic traits, and uses of such cultivars, and pictures of important characters) for describing the varieties that will be used across countries. Secretariat will compile and publish a regional manual/compilation.

1E: The group recognised the importance of Musa conservation, characterization and exchange, the Region being the centre of Musa diversity. A strong linkage with, and support to, current Musa global conservation strategy is needed. It was agreed upon that BAPNET will continue to monitor and support the implementation of this program.

Action Point of IE:

Guidelines developed by the TAG will be made available to member-countries.

1F: During the discussions, while it has been stipulated in the previous BAPNET meeting that aside from fusarium wilt, foliar diseases (particularly Sigatoka) are also fast emerging banana concerns in the region, the representatives agreed to let national programs tackle the issue on foliar disease, but expects a national report on this efforts for the next BAPNET meeting.

Action Point for 1F:

Countries will provide Secretariat with information on different foliar diseases for compilation and consolidation for upload to the BAPNET webpage.

1G: The representatives recognised that there is a need for increased capacity building including assessment of training needs as well as provision of trainings. The group further agreed upon the need to train on diagnostics on bacterial wilt & fusarium wilt; training on seed systems, virus-indexing, and variety improvement

Action Points for 1G:

BWilliams and AMolina to follow-up proposal to AUSAID (on training on diagnostics) / Jakarta
ICAR and NRCB will come up with a training module/protocol.
ABMolina (with NRCB) will consolidate the training modules and communicate to steering committee representative for invitations.
Training module provided to Secretariat for submission to donors

1H: The representatives recognised that enhancing information exchange and communication among partners will improve the effectiveness of the Network. It was agreed upon that this will be achieved by supporting to the BAPNET Bulletin and other information exchange modes. The representatives agreed to submit, on a quarterly basis, news articles that will be featured in the BAPNET Bulletin. The representatives also agreed to that Secretariat must supply member countries with information from their (secretariat) end for publication in their respective information systems.

Action Points for 1H:

1) Representatives must give Secretariat (through MLJBarona) information/reports from respective countries. Regional Coordinator will supply information/announcement to partners.
2) Secretariat/MLJB will supply articles of interest; including announcements of meetings to national newsletters.
3) Posters will be consolidated and posted on BAPNET Page
4) MLJBarona will contact all networks and link the BAPNET page to the websites of member institutions. Full papers will be part of the proceedings.

2: Sustaining and strengthening BAPNET

2A: The representatives made a positive consensus on the relevance of BAPNET in advancing banana R&D in the Region; However there is need to understand the effectiveness and sustainability of

the Network. It was agreed upon that a survey among member countries will be conducted.

Action Point for 2A:

Secretariat to formulate the survey document and distribute to BAPNET members for their responses. Timetable: Secretariat will send final survey form on January 2009.

2B: Group recognised the need to enhance monitoring and follow-up system of actions decided upon during SC meeting.

Action Point for 2B:

Secretariat (through MLJBarona) sees to it that BAPNET mailing list is updated / get emails of assistants

2C: Network Executive Secretary ABMolina explained to the representatives that holding the BAPNET SC meeting is a big expenditure incurred by Bioversity every year. While the meeting is essential for the effective operation of the network, efforts should be undertaken to find complementary funding for its conduct. It was agreed upon that members must find ways to fund their expenditures incurred during attendance to the BAPNET meeting.

During the discussion, proposals were made for the next meeting: These are:

1. that a format for country reports must be developed
2. that the chairman will come from host-country and the Vice-Chairman will be from the next country host. Nominated Vietnam to host next meeting; Australia is second choice.

Action Points for 2C:

1) ABM will send letter to Vietnam steering committee member to signify the intention of next meeting hosting.
2) BWilliams to pursue proposal to Australia to fund next BAPNET meeting

3: Project Areas

3A: The representatives recognised that somaclonal selection is an effective alternative method of banana improvement in the advent of mass usage of tissue-culture. Effort should be made to make use of these methods in alleviating pest and disease problems. It was agreed upon that countries that have resources to do somaclonal selection to improve important varieties may carry on (with their somaclonal selections and tissue culture) with their activities .

Action point for 3A:

National programs to support activities to further select and improve somaclones from TBRI and other important varieties that are resistant to Fusarium wilt.

3B: The members recognised that soil health is an important R&D area for effective integrated pest management (IPM), which are being addressed by some member-countries. It was agreed upon that there is need to increase communication among members to avoid duplication of research work and enhance synergy.

Action point for 3A:

1.) Develop communication line among Taiwan-Australia-Indonesia-Cambodia
2.) Standardise format of soil information for mutual understanding and interpretation

4: Funds sourcing

4A:The members recognised that there is need to look for funds to finance projects. It was agreed upon that the Network must present a unified regional agenda can strengthen our position to donors.

Action point for 4A:

Representatives must identify project opportunities and sources of funds from respective countries, as well as agencies that tackle bilateral/multilateral relations who can be prospective fund sources for joint projects in the Region.

Closing

Bioversity International CfL Regional Coordinator for Asia and the Pacific and BAPNET Executive Secretary Dr. Agustin Molina thanked and congratulated the members of the plenary for their active and productive participation. Dr. Molina also thanked the hosts, and Dr. HP Singh for his role in the organization and conduct of the meeting and wished all SC representatives and guests a safe trip back to their respective countries. Papua New Guinea Representative and Pisang Raja Awardee Ms. Rosa Kambuou gave the vote of thanks, and expressed gratitude to the hosts, and to the organizers.

Annexes

Annex 1. Programme of the 6th BAPNET Steering Committee Meeting

Wednesday, 22 October			
	8:00-8:30 am	Registration	
	8:30-10:00	Opening Ceremonies	
		Welcome Remarks	*Dr. Mohamed Mustaffa* Director, NRCB
		Message	*Dr. Agustin B. Molina* Regional Coordinator, Bioversity International & Executive Secretary BAPNET
		Inaugural Message	*Dr. HP Singh*, DDG, ICAR (Hort.) Chair, BAPNET Steering Committee
		Plaques of Appreciation	*Dr. Agustin B. Molina*
	10:00-10:30	Coffee/Tea Break	
	10:30	Country Presentations	
	10:30-10:55	Australia	*Mr. Robert Williams*
	10:56-11:20	Bangladesh	*Dr. Abdul Hoque*
	11:21-11:45	China	*Dr. Yi Ganjun*
	11:46-12:10	India	*Dr. HP Singh*
	12:10 nn	Lunch Break	
	1:30-1:55 pm	Indonesia	*Dr. Yusdar Hilman*
	1:56-2:20	Malaysia	*Dr. Nik Masdek*
	2:21-2:45	Cambodia	*Dr. Preap Visarto*
	2:46-3:00	Coffee Break	
	3:01-3:25	Papua New Guinea	*Dr. Rosa Kambuou*
	3:36-4:00	Philippines	*Dr. Joy Eusebio*
	4:01-4:25	Sri Lanka	*Dr. Indra Jinadarie de Zoysa*
	4:26-5:00	Highlights	
	7:00 pm	Welcome cocktails /dinner	*Host-NRCB/ICAR*
Thursday, 23 October			
	8:00-8:25 am	Thailand	*Ms. Pitsawat Buara*
	8:26-8:50	Vietnam	*Mr. Nguyen Van Nghiem*
	8:51-9:15	Secretariat of the Pacific Community	*Dr. Mary Taylor*
	9:16-9:40	Taiwan	*Dr. Chih-Ping Chao*
	9:41-10:00	Coffee/Tea Break	
		Special Presentations	
	10:01-11:00	Highlights of Bioversity/BAPNET R&D Activities	*Dr. Agustin Molina*
	11:01-11:25	Highlights of Fusarium Research in India	*Dr. Tanggavelu*
	11:26-11:50	Overview of 2009 ISHS-ProMusa International Banana Symposium, in Guangzhou, China	*Dr. Yi Ganjun*
	11:50-12:20	BAPNET: Sustainability and Relevance of Musa R&D Networking	*Dr. Agustin Molina*
	12:20nn	Lunch Break	
	1:30-3:30 pm	Priority Setting/Project Identification -Brainstorming/ Planning Workshop	*Facilitator:* *Mr. Bob Williams*
	3:30-4:00	Coffee/ Tea Break	
	4:01-5:30	Continuation	
Friday, 24 October			
	8:00-8:30 am	Indian perspective on mechanisms of germplasm exchange in the framework of the International Treaty on Plant Genetic Resources for Food and Agriculture"	*HP Singh (to be confirmed)*
	8:31-9:00	The Musa Conservation Strategy	*Nicolas Roux*
	9:00-9:30	Presentation of TAG outputs	*Anne Vezina*
	9:31-10:00	Open Forum	
	10:01-10:30	Coffee/Tea Break	
	10:31-12:00	Priority Setting – Brainstorming/ Planning Workshop	*Facilitator:* *Dr. Nik Masdek*
	12:00 nn	Lunch Break	
	1:30-3:00	Continuation	
	3:01-3:30	Coffee/Tea Break	
	3:31-4:30	Presentation of Outputs of the Brainstorming Planning Sessions	*Dr. H.P. Singh*
	4:31-5:00	Closing Remarks	*Dr. Agustin Molina* *Dr. HP Singh* *BAPNET Steering Committee Chair*
	7:00 pm	Closing & Social Night	
Saturday, 25 October			
		Field Visits	*(To be coordinated by Dr. Mustaffa)*

Annex 2. List of 6th BAPNET Meeting Attendees

NAME	EMAIL ADDRESS
Dr. Robert C. Williams Science Leader, Queensland Department of Primary Industries and Fisheries, PO Box 20 Johnstone Qld 4859 Australia	bob.williams@dpi.qld.gov.au
Dr. Abdul Hoque Chief Scientific Officer, Bangladesh Agricutlural Research Institute, Joydebpur, Gazipur 1701 Dhaka, Bangladesh	dg.bari@bari.gov.bd director_hrc@yahoo.com
Dr. Preap Visarto Head, Plant Protection Group, Cambodian Agricultural Research & Development Institute Prateah Lang, National Road #3 Dangkor, P.O. Box 01, Phnom Penh, Cambodia	visarto03@cardi.org.kh
Dr. Yi Ganjun Director, Pomology Research Institute, Guangdong Academy of Agricultural Sciences, Wushan, Guangzhou 510640, China	yiganjun@vip.163.com
Dr. Yusdar Hilman Director, Indonesian Central for Horticulture Research and Development Jl. Ragunan 29ª, Pasarmingu, igar, Indonesia	yhilman@indo.net.id
Dr. Nik Masdek Senior Researcher Malaysian Agricultural Research and Development Instt. (MARDI), P.O.Box 12301. 50774 Kuala Lampur, Malaysia	nmasdek@mardi.my
Dr. Chih-Ping Chao Acting Director, Taiwan Banana Research Institute Chiuju, Pingtung, Taiwan, R.O.C.	cpchao_tbri@yahoo.com.tw
Dr. Rosa N. Kambuou Principal Scientist, National Agricultural Research Institute – Dry-Lowlands Programme – Laloki, P.O. Box 1828, Port Moresby, Papua New Guinea	rosa.kambuou@nari.org.pg narichem@dg.net.pg
Dr. Indra Jinadarie de Zoysa Director, Horticultural Crop Research and Development Institute P.O. Box 11, Gannoruwa, Peradeniya, Sri Lanka	dirhordi@yahoo.com
Mr. Nguyen Van Nghiem Head, Fruit Crops Research Dept., Fruit and Vegetable Research Inst. (FAVRI) of VAAS, Trau Qui, Gialam, Hanoi, Vietnam	nghiemvrq@yahoo.com
Dr. Mary Taylor Regional Germplasm Centre Advisor, Secretariat of the Pacific Community Private Mail Bag, Suva, Fiji	maryt@spc.int
Dr. Jocelyn Eusebio Director, Crops Research Division Philippine Council for Agriculture, Forestry and Natural Resources Res. And Development (PCARRD) Los Baños, Laguna 4030 Philippines	joycedee_5898@yahoo.com
Dr. Carmencita Kagaoan Head, Project Development Division Bureau of Agricultural Research Department of Agriculture, RDMIC Building Elliptical Road cor. Visayas Avenue., Diliman, Quezon City	ckagaoan@bar.gov.ph
Ms. Pitsawat Buara Director Horticulture Research Institute Bangkok, Thailand	pitsawat_hort@hotmail.com
Executive Secretary **Dr. Agustin B. Molina** Regional Coordinator Bioversity International CfL-AP 3/F Khush Hall, IRRI Laguna, Philippines	a.molina@cgiar.org
Maria Lizbeth J. Barona Communications Specialist Bioversity International CfL-AP 3/F Khush Hall, IRRI Laguna, Philippines	l.barona@cgiar.org

Annex 3. BAPNET Fusarium wilt RD&E regional strategy

County x Activities	Clean planting materia	Improved Varieties evaluation	Varieties Collections	Characterisation	Conservation	Banana genomics	Somaclonal	Improved Production practices	Soil health	Viruses	Fusarium	Sigatoka	Bacteria wilts	Nematode	Insect pest	BWB	Post harvest diseases	Supply chain	Active Quarantine	Value adding	Extension material	Banana R&D skills development
INIBAP																						
Australia	xxx	x	x	x	x	xx		xxx	xxx	xx	xx	xx		x	xx			x	xx		xx	xx
Bangladesh										xx												x
Cambodia	xx	xx	x	x	x			x		x	xxx	x		xx	x	x				x	xx	xxx
China	xxx	xx	xx	xx	xx	xxx	xx	x	xx	xx	xxx	x		x	x		x			xx	x	xxx
India	xxx	xx	xx	xx	xx	xxx		xx		xx	xx	x		xx	x	xx				xx	xx	xxx
Indonesia	x	x	xx	xx	xx			x	x	x	xx	x	xx							x	x	
Malaysia		xx				x					xx			x								
Myanmar																						
PNG	xx	xxx	xx	x	xx															xx	x	x
Philippines	xx	xx	x	x	x			xx	x	xx	xx	xxx					x	x		xx	xx	xx
Sri Lanka	xx	xx	xx	xx	xx			x		x	x					xx	x			x	xx	xx
Thailand		x	x	x	x						x									x		
Taiwan	xxx	xx	x	x	x		xxx	xx	xx	xx	xxx	x			x			xx	x		x	x
Vietnam	x	x	x	x				x		xx	x	xx								x		
SPC																						