Improved Varieties for Food and Income in Asia Pacific

Agustin B. Molina, PhD
Senior Scientist and Regional Coordinator
Bioversity International
Asia and the Pacific
World Banana Production by Region

- **Asia**: 32M tons (2M consumption, 30M production)
- **Latin America & Caribbean**: 11M tons (21M consumption, 0M production)
- **Africa**: 25M tons (1M consumption, 24M production)

FAOSTAT, 2008
Asia – Center of Musa diversity
Asia- Center of diversity of pests and diseases

- Fusarium wilt
- Viruses
- Sigatoka
- Nematodes
Important banana diseases in Asia

- **Fusarium wilt**
  - *(Fusarium oxysporum f sp cubense)*
  - Tropical Race 4

- **Bacterial wilt/Fruit rot**
  - Moko *(Ralstonia solanacearum)*
  - Bugtok *(Ralstonia solanacearum)*
  - Blood disease *(Pseudomonas celebensis)*

- **Sigatoka leaf Spot**
  - Yellow Sigatoka *(Mycosphaerella musicola)*
  - Black Sigatoka *(Mycosphaerella fijiensis)*
  - *(Mycosphaerella eumusae)*

- **Banana Bunchy Top Virus**

- **Freckle** *(Guignardia musae)*
• Established in 1991 (Asia Pacific Network)
• Relaunched in 2001 (BAPNET)
• Members: 13 NARS + 2 institutions
• Guided by Steering Committee
• Memberships and focus within APAARI
• Secretariat - Bioversity - Asia Pacific office
### Members of BAPNET:

<table>
<thead>
<tr>
<th>Countries:</th>
<th>Institutions:</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Australia</td>
<td>• Sri Lanka</td>
</tr>
<tr>
<td>• Bangladesh</td>
<td>• Thailand</td>
</tr>
<tr>
<td>• Cambodia</td>
<td>• Vietnam</td>
</tr>
<tr>
<td>• China</td>
<td>• Taiwan Banana Research Institute</td>
</tr>
<tr>
<td>• India</td>
<td>• South Pacific Community</td>
</tr>
<tr>
<td>• Indonesia</td>
<td></td>
</tr>
<tr>
<td>• Myanmar</td>
<td></td>
</tr>
<tr>
<td>• Malaysia</td>
<td>• Bioversity International CfL - Asia Pacific</td>
</tr>
<tr>
<td>• Papua New Guinea</td>
<td></td>
</tr>
<tr>
<td>• Philippines</td>
<td></td>
</tr>
</tbody>
</table>
BAPNET priority: Musa germplam conservation and use

- **The International *Musa* Testing Program (IMTP)**
  
  A global program to: evaluate worldwide elite *Musa* varieties produced by breeding programs as well as promising germplasm accessions from Bioversity ITC, Leuven, Belgium. To evaluate varietal resistance to major pests and diseases including their adaptability to local conditions.

  National programs may evaluate and promote use of IMTP varieties.
IMTP materials
IMTP in India
IMTP in Bangladesh

FHIA-01 & FHIA-02

Lakatan
Major adoption constraint

- The availability of *in-vitro* propagated materials for wide distribution and evaluation is limited by the capability of ITC to respond to the many requests for materials worldwide.

- The need for National Repository, Multiplication and Dissemination Centers (NRMDC)
NRMDC – established in BAPNET

• National Repository, Multiplication, and Distribution Programs – IMTP varieties were transferred to NARS for improved access to new improved hybrids and superior local varieties for national evaluation and adoption

MTAs were signed with all BAPNET members for the turnover of 26 virus-free IMTP improved varieties
Goals of NRMDCs

• improved access to new, improved hybrids and superior local varieties
• local multiplication for the provision of material to national programmes for more expanded evaluation activities
• local multiplication for adaption by farmers
• platform to launch improved production system: IPM, improved production practices, i.e. use of tissue culture, annual cropping
NRMDCs

*In-vitro* conservation in the NRMDC of the Malaysian Agricultural R&D Institute (Malaysia, left), and the Vietnam Agricultural Science Institute (Vietnam, right)
Musa Screenhouse-gene bank in China
FHIA 25 in Northern Philippines
FHIA 03 field evaluated in farmers field in Sri Lanka.
FHIA 21 – plantain type for banana chips NRCB - India

FHIA 17 – fresh-fruit variety Vietnam
Backyard grown
FHIA 03 in
Northern
Philippines
### Yield data of cultivars planted at the Banana Demonstration Field, CES, UPLB

<table>
<thead>
<tr>
<th>Variety</th>
<th>Bunch weight</th>
<th>No. of hands</th>
<th>No. of fingers</th>
</tr>
</thead>
<tbody>
<tr>
<td>FHIA 01</td>
<td>22.22 d</td>
<td>8.70 de</td>
<td>125.96 ef</td>
</tr>
<tr>
<td>FHIA 02</td>
<td>24.30 d</td>
<td>9.05 d</td>
<td>129.88 ef</td>
</tr>
<tr>
<td>FHIA 17</td>
<td>36.61 b</td>
<td>12.25 b</td>
<td>200.56 c</td>
</tr>
<tr>
<td>FHIA 18</td>
<td>21.38 d</td>
<td>8.42 de</td>
<td>133.17 e</td>
</tr>
<tr>
<td>FHIA 23</td>
<td>31.79 c</td>
<td>11.28 c</td>
<td>217.72 b</td>
</tr>
<tr>
<td>FHIA 25</td>
<td>47.49 a</td>
<td>15.03 a</td>
<td>277.86 a</td>
</tr>
<tr>
<td>Cuarenta Dias</td>
<td>8.51 g</td>
<td>7.24 f</td>
<td>110.00 h</td>
</tr>
<tr>
<td>Grand Naine</td>
<td>23.44 d</td>
<td>8.08 e</td>
<td>128.45 ef</td>
</tr>
<tr>
<td>Latundan</td>
<td>12.39 f</td>
<td>7.18 f</td>
<td>101.07 h</td>
</tr>
<tr>
<td>Cardaba</td>
<td>23.19 d</td>
<td>8.61 de</td>
<td>149.98 d</td>
</tr>
<tr>
<td>Lakatan Davao</td>
<td>17.24 e</td>
<td>6.84 f</td>
<td>115.71 gh</td>
</tr>
<tr>
<td>Lakatan Cavite</td>
<td>18.03 e</td>
<td>6.70 f</td>
<td>109.80 h</td>
</tr>
</tbody>
</table>

*Means in column of the same letter are not significantly different at 5% DMRT level*
Disease Resistance Evaluation

Introduced versus local cultivar’s reaction to BBTV in the Philippines.
Improved versus local cultivar’s reaction to Sigatoka disease
Foc TR4-IMTP trial – Guangdong, China, 2004
Reaction of some banana varieties to Fusarium wilt in Southern China.

<table>
<thead>
<tr>
<th>Variety</th>
<th>% infected plants</th>
</tr>
</thead>
<tbody>
<tr>
<td>FHIA 01 (AAAB)</td>
<td>0</td>
</tr>
<tr>
<td>FHIA 02 (AAAB)</td>
<td>0</td>
</tr>
<tr>
<td>FHIA 03 (AABB)</td>
<td>0</td>
</tr>
<tr>
<td>FHIA 25 (AAAA)</td>
<td>0</td>
</tr>
<tr>
<td>Pisang Jari Buaya (AA)</td>
<td>0</td>
</tr>
<tr>
<td>GCTCV 119 (AAA)</td>
<td>5</td>
</tr>
<tr>
<td>FHIA 21 (AAAB)</td>
<td>20</td>
</tr>
<tr>
<td>FHIA 17 (AAAA)</td>
<td>60</td>
</tr>
<tr>
<td>FHIA 23 (AAAA)</td>
<td>80</td>
</tr>
<tr>
<td>Williams (AAA)</td>
<td>100</td>
</tr>
<tr>
<td>Senorita (AA)</td>
<td>100</td>
</tr>
<tr>
<td>Baxi Jiao (AAA)</td>
<td>100</td>
</tr>
<tr>
<td>Robusta (AAA)</td>
<td>100</td>
</tr>
</tbody>
</table>
New Cultivars, More Options for the Banana Farmer

Catalogue of introduced and local banana cultivars in the Philippines

The Diversity of Local Banana Varieties

Cardaba

Farmers' Handbook on Introduced and Local Banana Cultivars in the Philippines
Outcomes of FHIA Variety Studies

- FHIA varieties are high yielding and disease resistant

- Commercial acceptance of FHIA varieties for the local market were limited.

- Promotion of FHIA is more for home or backyard growing for home consumption

- Processing and other uses of FHIA varieties
FHIA 17 processed as Banana Chips in Los Banos
The New Threat of Fusarium Wilt in Asia

- 2002 - commercial Cavendish plantation grown for “sweet bananas” in Calinan, Davao, Philippines (350-400 m above sea level) were severely affected by Panama wilt, and later was abandoned (this area was previously planted with Lakatan which was reportedly destroyed by Panama wilt, presumed to be Race 1)

- 2003 - more farms in this area were affected; some cases observed in the traditional lowland plantations

- 2005 – increased Foc infections in the traditional lowland
Spread by irrigation water
Spread of Foc TR4 in new areas through ground equipment
EVOLUTION OF AN EPIDEMIC

sporadic infection

Spreading to an epidemic proportion

Abandonment
IS THIS THE TROPICAL RACE 4?
A survey and characterization study conducted in 2005 confirmed that VCG 01213/16 -- the VCG associated with Tropical Race 4.

The new epidemics appeared to be more aggressive than the earlier epidemics.
Activities towards mitigation and prevention of Foc TR4 epidemics in Asia

- Mapping the distribution of Races

- Prevention of spread, early detection and spread eradication

- Public awareness, training program activities for prevention of spread

- Research on mitigating measures – varietal resistance
Regional survey = ACIAR-BAPNET-Australia-South Africa
Map of the distribution of Foc strains in Asia:
with emphasis on TR4-VCG 1213/16

Diversity profile based on VCGs in the surveyed Asian countries

<table>
<thead>
<tr>
<th>Country</th>
<th>Identified VCGs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Indonesia</td>
<td>01213/16</td>
</tr>
<tr>
<td>Malaysia</td>
<td>01213/16</td>
</tr>
<tr>
<td>Taiwan</td>
<td>01213/16</td>
</tr>
<tr>
<td>Philippines</td>
<td>01213/16</td>
</tr>
<tr>
<td>China</td>
<td>01213/16</td>
</tr>
<tr>
<td>Bangladesh</td>
<td>0124/5</td>
</tr>
<tr>
<td>Cambodia</td>
<td>0124/5</td>
</tr>
<tr>
<td>India</td>
<td>0124/5</td>
</tr>
<tr>
<td>Vietnam</td>
<td>0124/5</td>
</tr>
<tr>
<td>Sri Lanka</td>
<td>0124/5</td>
</tr>
<tr>
<td>Papua New Guinea</td>
<td>No Foc isolated</td>
</tr>
</tbody>
</table>

*(Molina et al, 2012)*

ACIAR-BAPNET-Bioversity funding
Study on: VCG x Variety Interaction, Concept of Race?
(Indonesia-funded by ACIAR)

Reaction of Ambon hijau (AAA green-ripe Cavendish) inoculated by various Foc VCGs.
(Hermanto and Molina, 2012)
VCG X Variety Interaction?

Reaction of *pisang* Rejang (AA) inoculated by several *Foc* VCGs; 30 days after inoculation.

(Hermanto and Molina, 2012)
Fusarium wilt in Cavendish in Tamil Nadu India
Total destruction of banana garden due to Fusarium wilt in Cavendish in Thenidt of TN
• Prevention of incursion in countries where TR4 is not yet found (Biosecurity)
• Management measures where it is found
Raising awareness of the threat of Foc Tropical Race 4: prevention of spread
Philippines: Finally - the threat sunked in!!

**Fungal disease threatens banana industry**

By MARVYN BENAR

September 19, 2011, 5:40 PM

MANILA, Philippines - Biologists have estimated a 1,200

The fungus, which is in the soil, has killed banana trees

Earlier, the infected only affected a very small area of

Steven Arlig, vice chairman of the Philippine Banana Growers

The dreaded Panama disease

By Henryito D. Tacio

Sunday, October 23, 2011

ON NOVEMBER 28, 2008, Dr. Agustin Molina warned that “a more virulent type of

Panama disease” that attacks banana “has already made its appearance in the country.”

Dr. Molina, senior scientist and regional coordinator for Asia-Pacific of the Biodiversity

International, sounded the alarm during a seminar convened at the Bureau of Agricultural

Research (BAR).

Today, the warning has become a reality that now threatens the country’s P35 billion banana

industry. The disease has the potential of wiping out 1,200 hectares of banana plantations in

Mindanao, particularly in Bukidnon.

Panama disease, also known as Fusarium wilt, is caused by a fungal pathogen, Fusarium

oxysporum f. sp. cubense (Foc). A soil-borne disease, it remains in an affected area for

decades.
WHY IS IT SO DIFFICULT TO CONTROL?

MOSTLY ON SMALL CAVENDISH FARMS

Sept 2012
AND THE MENACE IS SPREADING!
Big plantation

Philippines: big vs small growers

• Big plantations (70%), are less affected by Foc TR4
• Technical and infrastructure capabilities

• Small scale independent growers (about 30%), more Foc incidence
• Lack of technical, infrastructure, logistic capacities
Big growers

• Disinfestation, Quarantine-prevention of spread

• Scouting, early detection, eradication
Early and Correct Diagnosis: Key To successful Eradication and Prevention of spread

Panama wilt:

Moko:
Small Growers

Wrong eradication technique:

Dead infected plants left in the field promote production of spores

Increase spore production for subsequent infection
Disease Resistant Cavendish: the Elusive Search

• Some success in conventional breeding, but commercial acceptability is lacking

• Since 1990, the potential of molecular biology (GMO) is yet to bear fruit. New tools will bring success?

• Non-conventional method of crop improvement through somaclonal selections have produced Cavendish resistant to Foc TR4, since 1990s
Somaclonal selection: a practical and successful variety improvement approach

Requirements:
- extensive planting of tissue culture
- severely infested areas for selection pressure
- systematized selection protocol
Somaclonal variant selection in Taiwan

<table>
<thead>
<tr>
<th>Highly resistant clones</th>
<th>Moderately resistant clones</th>
</tr>
</thead>
<tbody>
<tr>
<td>GCTCV-40</td>
<td>GCTCV-46</td>
</tr>
<tr>
<td>GCTCV-44</td>
<td>GCTCV-53</td>
</tr>
<tr>
<td>GCTCV-104</td>
<td>GCTCV-62</td>
</tr>
<tr>
<td>GCTCV-105 (1995)</td>
<td>GCTCV-201</td>
</tr>
<tr>
<td>GCTCV-217 (1998)</td>
<td>GCTCV-216</td>
</tr>
<tr>
<td>GCTCV-218 (2002)</td>
<td></td>
</tr>
</tbody>
</table>

Shared in Asia through IMTP/NRMDC Program of Bioversity
Evaluation of GCTCVs in the Philippines

- First trial of GCTCV 119 vs Grand Naine in 2005

- Second field trial conducted in Sept 2009, Lapanday Food Corp., Philippines

- Field previously high incidence of Foc (TR4-VCG 1213/16)

- 8 varieties were evaluated – 10 TC-derived seedlings/plot, replicated 10x (100plants/ variety)
## Fusarium incidence on test banana cultivars, 2009-2011

<table>
<thead>
<tr>
<th>Cultivar</th>
<th>Primary Crop</th>
<th>Ratoon Crop</th>
<th>Cultivar</th>
<th>Primary Crop</th>
<th>Ratoon Crop</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gran Naine</td>
<td>97</td>
<td>N/A</td>
<td>Lakatan</td>
<td>100</td>
<td>N/A</td>
</tr>
<tr>
<td>Williams</td>
<td>94</td>
<td>N/A</td>
<td>Latundan</td>
<td>41</td>
<td>100</td>
</tr>
<tr>
<td>GCTCV 119</td>
<td>1</td>
<td>15</td>
<td>Cardava</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>GCTCV 219</td>
<td>1</td>
<td>14</td>
<td>FHIA 21</td>
<td>81</td>
<td>N/A</td>
</tr>
</tbody>
</table>

* N/A – Not applicable to ratoon crop due to high Fusarium wilt incidence
GCTCV 119 vs Grand Naine field trial in a heavily infested Foc TR4 farm, Philippines, March 2010.
## Third Field Trial

**Fusarium incidence (%) at 52 and 77 weeks after planting**  
July 2011 – Jan 2013 Callawa, Davao, Philippines

<table>
<thead>
<tr>
<th>Variety</th>
<th>Fusarium wilt (%) (52 weeks)</th>
<th>Fusarium wilt (%) (77 weeks)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lakatan</td>
<td>76</td>
<td>92</td>
</tr>
<tr>
<td>Latundan</td>
<td>60</td>
<td>70</td>
</tr>
<tr>
<td>Gran Naine</td>
<td>57</td>
<td>78</td>
</tr>
<tr>
<td>GCTCV 218</td>
<td>6</td>
<td>6</td>
</tr>
<tr>
<td>GCTCV 105</td>
<td>2</td>
<td>8</td>
</tr>
<tr>
<td>GCTCV 219</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Dwarf Pisang Awak</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Saba</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>GCTCV 119</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>
Dwarf Pisang Awak
Comparative fruit characteristics of Grand Naine vs *Foc* TR4 resistant GCTCV varieties

<table>
<thead>
<tr>
<th>Cultivar</th>
<th>Fruit Characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Hand Class</td>
</tr>
<tr>
<td></td>
<td>Primary Crop</td>
</tr>
<tr>
<td>Grand Naine</td>
<td>9</td>
</tr>
<tr>
<td>GCTCV 119</td>
<td>7</td>
</tr>
<tr>
<td>GCTCV 219</td>
<td>7</td>
</tr>
</tbody>
</table>

**GCTCVs**
- sweeter than Grand Naine
- test marketed as sweet banana in Japan
- now planted in commercial scale in severely affected farms
China

- Somaclonal selection of Cavendish

- Commercial plantation somaclonal selection of Pisang Awak in Foc TR4 areas
Farmer planting Formosana in Taiwan (GCTCV 218)
DPM 25 1st Ratoon, Williams sustained 90% infection in the first crop.

Northern Territory, Australia
Formosana (GCTCV 218)
New plantings; crops in the
Background are same variety
After 2 ratoons. Highly
resistant to TR4
Helping the small independent growers in the Philippines

Mitigating banana Fusarium wilt Tropical Race 4 through a farmer-participatory approach of developing disease management strategies

21-independent growers - at least a hectare of GCTCV 219
Project to adopt resistant cultivars:

- does not aim to replace existing varieties where these are still economically produced
- to be recommended as options to areas where existing varieties can no longer be economically grown
- opportunity for small scale growers who do not have flexibility of land areas
- opportunity for capacity building for small growers
- opportunity to further improve through recurrent selection
Standing plants of Gran Naine and GCTCV 219 at Bancud Farm (June 2013)
Light at the End of the Tunnel!!
Some Thoughts About Fusarium Wilt

- Fusarium wilt is a real threat to the banana industry especially to the monoculture plantations.

- Small scale growers (non-cavendish) are also at risk, but species and cultivar diversity make them more resilient.

- TR4 may not have same impact as the TR1 on Gros Michel, but can cause significant increase in cost of production.

- Fusarium wilt is not as explosive as Sigatoka, but once established it has longer and lasting effect, and extremely difficult to eradicate.

- Need for a more concerted and intensive/extensive R&D.

- Prevention of spread (Biosecurity) is the most fundamental approach in dealing with this threat.
BOLD PREDICTION
IN 2003

2013 – Doomsday for the Bananas?

NOT Quite

But no longer
Bananas are safe.
FHIA varieties may become relevant to small scale
Thank you!