Fusarium Wilt: Occurrence, impact, R&D and mitigation measures in Asia Pacific

Agustin B. Molina
Topics

• Brief History of occurrence of *Fusarium oxysporum f.sp. cubense* (*Foc*) TR4 in Asia

• Mitigation R&D in Asia (beyond)

• Some positive outcomes

• *Foc* TR4 on non-Cavendish small scale production systems

• Some thoughts
In Asia
Foc TR4 is primarily a Cavendish monoculture problem
TR4-vulnerable banana production systems

Total Area Grown for Banana in different BAPNET member countries

Country
India 817
Philippines 450
China 390
Thailand 133
Indonesia 104
Viet Nam 99
PNG 70
Bangladesh 53
Cambodia 33
Malaysia 31
Taiwan 13
Australia 11
Fiji 1

Total area harvested (in '000 Ha)

TR4 in Malaysia and Indonesia:

• Late 80s multinational companies established Cavendish plantations in Indonesia and Malaysia for the expanding markets of the middle east

• 1990-92 epidemics of Foc TR4 destroyed plantations

• Companies abandoned their plantations for export market
**TR4 in China**

- 1996 – First infection in Guandong, along the Pearl River.
- Spread through planting materials and river water (irrigation)
- 2001 – positive for VCG 01213-16 (TR4)
- 2005 – more than 20,000 ha
- 2010 – Spread to Hainan, Guangxi, Yunnan and Fujian provinces
- 2013 – 40,000 hectares affected in varying levels
**TR4 in Philippines**

- 2001 - first appeared in Cavendish plantation grown for “sweet bananas” in the highlands of Mindanao

- 2003 - sporadic cases observed in the traditional lowland plantations

- 2005 – increased *Foc* infections in the lowland; further spread

- 2013 – Thousands of hectares affected. Small-independent growers farms are most affected.
The Philippine Cavendish industry

- Total hectares: 80,000 has.
- 60% big plantation
- 40% small independent growers (1 to 200 hectares)
- Small growers are most affected by severe epidemics.
- 3,000 has. abandoned
- 6,000 affected in varying levels
- Big growers farms also affected but no accurate data
Why is it so difficult to control?
General epidemic in many small growers farms

Urgent need for a solution!
Research and Development in Asia (BAPNET)

• The *Foc* epidemics in China and the Philippines brought concerns in the region; new R&D initiatives to address the serious threat

• Bioversity International and its partners the Banana Asia Pacific Network put R&D to mitigate *Foc TR4* a top priority agenda.
BAPNET: Platform for Banana R&D collaboration in Asia and the Pacific

**Countries:**

- Australia
- Bangladesh
- Cambodia
- China
- India
- Indonesia
- Myanmar
- Malaysia
- Papua New Guinea
- Philippines
- Sri Lanka
- Thailand
- Vietnam

**Institutions:**

- Taiwan Banana Research Institute
- South Pacific Community
- Bioversity International
  Asia Pacific Office: Secretariat
Bioversity/BAPNET: mitigating initiatives

Goal: Manage where Foc TR4 occurs; Prevent spread to where it is not yet found

- Mapping the distribution of Foc TR4 and other strains
- Prevent spread by raising awareness
- Readiness on the threat: training, workshops, symposia, public media.
- Develop disease management measures: varietal resistance; IPM approaches; biological control.
- Research to understand basic knowledge to enhance abilities to mitigate the disease: epidemiology, mechanism of soil suppression; disease resistance
TR4 was confirmed in the Philippines, 2005

CONFIRMATION OF TROPICAL RACE 4 OF Fusarium oxysporum f. sp. cubense INFECTING CAVENDISH BANANAS IN THE PHILIPPINES

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Fusarium wilt disease of banana (also known as Panama Disease), caused by Fusarium oxysporum f. sp. cubense (Foc), is a major concern of the banana industry, having wiped out Gros Michel plantations in Central America in the 1950s and consequently caused a costly shift to the Cavendish variety. To date, Cavendish remains resistant to the Fusarium strain that prevails in Central America. However, a virulent strain that can attack the Cavendish was found causing epidemics in Asia. Known as Tropical Race 4 (TR4), this pathogen destroyed commercial plantations of Cavendish in Taiwan, Northern Territory of Australia, Indonesia, Malaysia, and China making their banana exports less competitive. For many years TR4 has not been found in the Philippines, contributing to its dominance in the export banana trade in Asia.

This paper reports the first study to confirm the occurrence of Fusarium Tropical Race 4 in the Philippines.

The new Fusarium wilt outbreaks. In 2002, an outbreak of Fusarium wilt disease was observed in a Highland Cavendish farm in Southern Philippines. Subsequently, from 2004 to 2005, new incidences of Foc infections were observed in some traditional lowland commercial Cavendish farms. Although occurrences of Fusarium wilt disease have been

Molina et al. 2008, American Phytopathology
# Mapping of Foc Strains in Asia

<table>
<thead>
<tr>
<th>Country</th>
<th>Identified VCGs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Indonesia</td>
<td>01213/16 0123 0124/5 01218 0120 0126 01219 0121</td>
</tr>
<tr>
<td>Malaysia</td>
<td>01213/16 0121 0124/5</td>
</tr>
<tr>
<td>Taiwan</td>
<td>01213/16 0121</td>
</tr>
<tr>
<td>Philippines</td>
<td>01213/16 0126 0122</td>
</tr>
<tr>
<td>China</td>
<td>01213/16</td>
</tr>
<tr>
<td>Bangladesh</td>
<td>0124/5 0128 01217 01220</td>
</tr>
<tr>
<td>Cambodia</td>
<td>0124/5 0123 01221 01217</td>
</tr>
<tr>
<td>India</td>
<td>0124/5 0128 01220</td>
</tr>
<tr>
<td>Vietnam</td>
<td>0124/5 0123 0128 01221</td>
</tr>
<tr>
<td>Sri lanka</td>
<td>0124/5 01217</td>
</tr>
<tr>
<td>PNG</td>
<td>No Foc Isolated</td>
</tr>
</tbody>
</table>

*Molina et al, 2010, American Phytopathological Society*

*Funded by ACIAR, BAPNET countries, with collaboration of DPI, Australia, FABI/Stellenbosch University*
Mapping the distribution of the various “strains” of *Foc* was a tool in the campaign of prevention of spread.

Raising public awareness and training programs.

Organization of symposia, conferences, to raise regional as well as global interest and support to R&D.
Capacity building to enhance abilities to prevent spread, and implement IPM measures
Prevention of Spread: raising awareness through symposia

Guyaquil, Ecuador, 2008
V FORO INTERNACIONAL DE BANANO Y FRUTAS FRESCAS
GUAYAQUIL 14-15-16/2008 HILTON COLON

San Salvador, El Salvador, 2010

Guangzhou, China, 2010

Australia, 2013
Mitigation measures

• Disinfestation, Quarantine- prevention of in-farm spread
• Scouting, early detection, eradication
Grand Naine Varietal Resistance
Resistant Variety Against Diseases

• The promise of breeding for disease resistant Cavendish still an elusive dream

• Conventional breeding produced disease resistance but failed consumers acceptance

• The promise of molecular biology (transgenic/sysgenic) to produce a commercial variety is still wanting. Since 1990, the potential of molecular biology is yet to bear fruit.

• Non-conventional method of crop improvement through somaclonal selections have produced Cavendish resistant to Foc TR4 (since 1990s)
Somaclonal variant selection in Taiwan Banana Research Institute

• Annual cropping of TC Cavendish, in Foc infested fields provided an opportunity for farmer-participatory selection of resistant & agronomically accepted Cavendish as a result of somaclonal variantion caused by Tissue Culture

<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 BAPNET - IMTP/NRMDC
Adapting GCTCVs in areas of TR4 epidemics

- Cultivar evaluation against Foc TR4, in Lapanday Foods Corporation.
- GCTCV 119, Grand Naine, and other varieties, Sept. 28, 2009
GCTCV 119 vs Grand Naine field trial in a heavily infested Foc TR4 farm, Philippines, March 2010
Grand naine

GCTCV 219
GCTCV 219 at GEA Farm, Davao Del Norte
Participatory data collection and protocol optimization

Participatory collection of data carried out with growers

- Disease incidence
- Agronomic traits
- Yield and fruit characteristics
- Post-harvest traits optimization
- Recurrent selection for desirable traits

Peel splitting, GCTCV 219

Age-grade harmonization
GCTCV 219 fruits shipped to Japan
Somaclonal Selections of Cavendish in China

ZJ6 Highly Resistant To TR4, Bunch 24.7 Kg

(Yi, 2014)
New GCTCVs from Taiwan Banana Research Institute

Tai-Chiao No.5

Tai-Chiao No.7

Pei-Chiao

Source: Dr. CP Chao
Foc TR4 is primarily a Cavendish monoculture problem

How About the small scale non-Cavendish Production system?
Local cultivars against TR4

<table>
<thead>
<tr>
<th>Variety</th>
<th>Genome</th>
<th>Fusarium Wilt Incidence 52weeks (%)</th>
<th>Fusarium Wilt Incidence 77weeks (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lakatan</td>
<td>AAA</td>
<td>76</td>
<td>92</td>
</tr>
<tr>
<td>Latundan</td>
<td>AAB</td>
<td>40</td>
<td>60</td>
</tr>
<tr>
<td>Gran naine</td>
<td>AAA</td>
<td>57</td>
<td>78</td>
</tr>
<tr>
<td>Cardava (Saba)</td>
<td>BBB</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Kluai Namwa</td>
<td>ABB</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>GCTCV 119</td>
<td>AAA</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>
Since 1990 when TR4 was identified affecting Cavendish in Indonesia, banana production has continued to increase.
Local cultivars grown by farmers in Indonesia

Resilience due to cultivar and cropping system diversity!

Source: Catur Hermanto, 2012
Integrated Crop Production System in managing banana wilt diseases in small scale farms in Indonesia

• Project funded by ACIAR implemented by Bioversity and national partners

Resilience due to diversified cropping system
Managing soil for suppression of Race 1 on Lady Finger Australia

Ground Cover to promote soil suppression to Foc

Bioversity project with DAFF, funded by ACIAR; to be validated in the Philippines.
Foc TR4 in Mozambique, Africa! Brought Heightened Threat of Foc!

• Commercial Cavendish plantation established in 2009

• Symptoms observed early 2013

• Confirmed by Viljoen/Molina to be TR4, 2013

• "BANANAGEDON" in popular media
Assessing Risk of African Bananas against TR4

Small scale highland banana production system, Uganda

*Slide: E. Karamura*
### Reaction of East African Highland Banana and Plantain cultivars to *Fusarium oxysporum* f.sp. *cubense* (Foc) Tropical Race 4 (Philippines)

<table>
<thead>
<tr>
<th>Variety Name</th>
<th>Genome</th>
<th>Sub-Group</th>
<th>% PD Incidence</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>52 weeks</td>
</tr>
<tr>
<td>Igitsiri (Intuntu)</td>
<td>AAA</td>
<td>Lujugira-Mutika</td>
<td>3</td>
</tr>
<tr>
<td>Mbwazirumi</td>
<td>AAA</td>
<td>Lujugira-Mutika</td>
<td>2</td>
</tr>
<tr>
<td>Ingagara</td>
<td>AAA</td>
<td>Lujugira-Mutika</td>
<td>5</td>
</tr>
<tr>
<td>Inkira</td>
<td>AAA</td>
<td>Lujugira-Mutika</td>
<td>4</td>
</tr>
<tr>
<td>Akpakpak</td>
<td>AAB</td>
<td>Plantain</td>
<td>1</td>
</tr>
<tr>
<td>Obubit Ntanga</td>
<td>AAB</td>
<td>Plantain</td>
<td>0</td>
</tr>
<tr>
<td>Enzirabahima</td>
<td>AAA</td>
<td>Lujugira-Mutika</td>
<td>1</td>
</tr>
<tr>
<td>Kazirakwe</td>
<td>AAA</td>
<td>Lujugira-Mutika</td>
<td>1</td>
</tr>
<tr>
<td>Ibwi</td>
<td>AAA</td>
<td>Lujugira-Mutika</td>
<td>23</td>
</tr>
<tr>
<td>Grand Naine</td>
<td>AAA</td>
<td>Cavendish</td>
<td>58</td>
</tr>
<tr>
<td>Lakatan</td>
<td>AAA</td>
<td>Barangan</td>
<td>76</td>
</tr>
</tbody>
</table>

* Experimental plots were planted in July 2011, each variety was planted in 10 replicates with 10 plants per replicate
Some Thoughts:

• Monoculture Cavendish is highly vulnerable to TR4

• Once infestation occurred in an area “business as usual” no longer work. Cost of production will go up

• Prevention of spread is key to disease management. Policies, public awareness, capacity building put in

• Disease management tools are available but must be optimized, upscaled and effectively integrated to systems

• Bananageddon will not happen, but R&D must be pursued to mitigate the severe impact of the disease to productivity

• Small scale non-cavendish production systems are relatively resilient. Appropriate attention to this system however as these are The more socio-economic vulnerable section
Thank you

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