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

Agustin B. Molina

Topics

- Brief History of occurrence of *Fusarium oxysforum 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

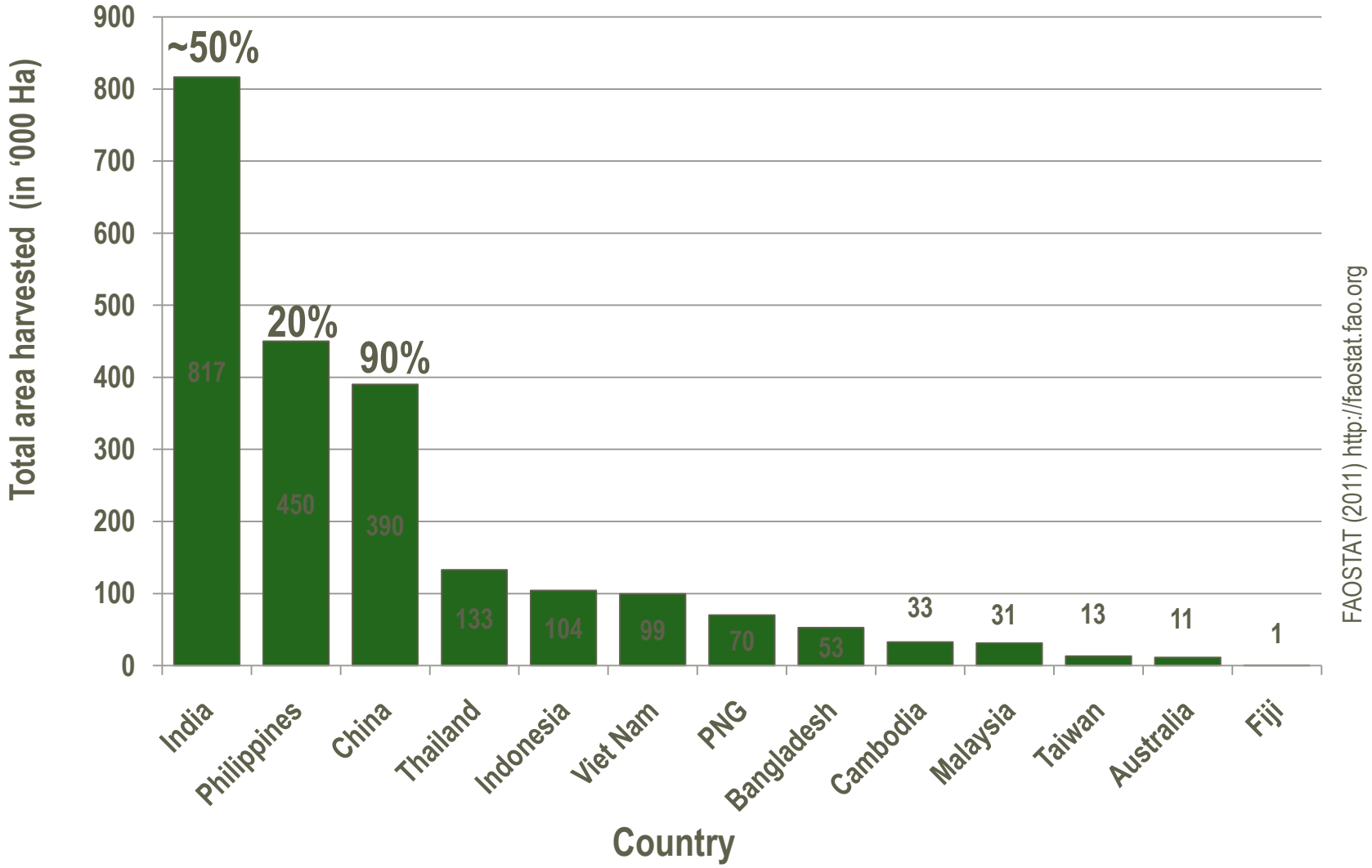
- Some thoughts

In Asia
Foc TR4 is primarily a Cavendish monoculture problem

Photo: Gus Molina

Bioversity International

TR4-vulnerable banana production systems



Total Area Grown for Banana in different BAPNET member countries

TR4 in Malaysia and Indonesia:

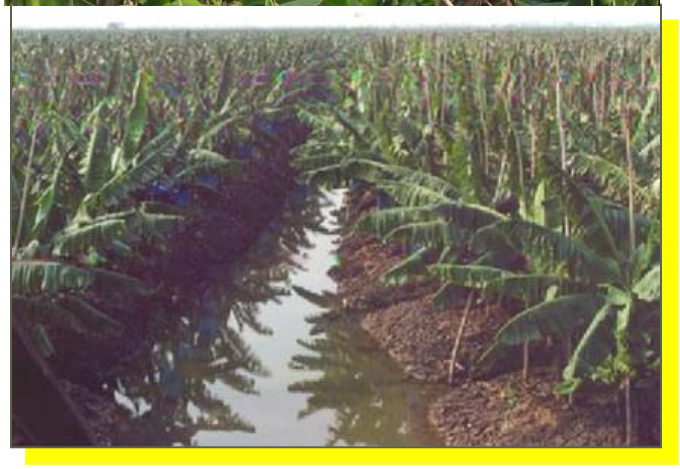
- Late 80s multinational companies established Cavendish plantations in Indonesia and Malaysia for the expanding markets of the middle east

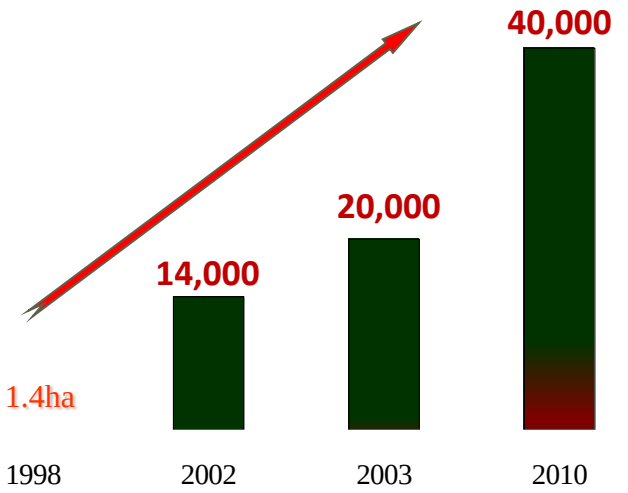
- 1990-92 epidemics of Foc TR4 destroyed plantations

- Companies abandoned their palantations 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


Photo Gus Molina

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*

Bioversity International

Agustin Molina[1], Emily Fabregar[2], Vida Grace Sinohin[3], Lorna Herradura[4], Gerda Fourie[5], and Altus Viljoen[6]

[1] *Regional Coordinator for Asia-Pacific, Bioversity International, Commodities for Livelihoods – Musa Programme, 3/F Khush Hall, IRRI, Los Baños, Laguna, Philippines (A.MOLINA@cgiar.org)*

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

Table 1. Monthly incidence of Fusarium wilt disease on two Cavendish plantations in Davao City, Philippines

	Buhangin, Davao City*			Calinan Davao City**		
	2005	2006	2007	2005	2006	2007
January	146	200	835	342	340	1110
February	167	164	777	453	480	1301
March	104	153	795	280	236	958
April	113	227	604	298	365	601
May	97	419	480	428	219	634
June	250	795	576	272	313	648
July	235	2301	1650	121	354	670
August	216	2480	1698	150	400	773
September	179	1422	1345	216	356	654
October	121	1064	1038	443	145	967
November	120	1061	940	430	412	1670
December	124	816	1358	277	723	2835
January	168	662	1450	778	1557	2280
Total:	2,040	11,764	13,546	4,488	5,900	15,101
Average	170	980	1129	345	454	1678

*400 hectares, 25 meters above sea level
** 28 hectares, 465 meters above sea level

Verifying the VCG of the recent infections of *Foc* Infected plant samples were

Molina et al. 2008, American Phytopathology

Mapping of *Foc* Strains in Asia

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

(Molina et al, 2010, American Phytopahological Society)

*Funded by ACIAR, BAPNET countries, with collaboration of DPI, Australia, FABI/Stellenbosch University

"an ounce of prevention is equivalent to tons of cure"

- 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

China

Australia

Capacity building to enhance abilities to prevent spread, and implement IPM measures

Prevention of Spread: raising awareness through symposia

Mitigation measures

- Disinfestation, Quarantine- prevention of in-farm spread
- Scouting, early detection, eradication

Varietal Resistance

Bioversity International

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)

FHIA 25, highly resistant to Black Sigatoka and Foc TR4

Somaclonal selection,TBRI, Taiwan

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

Highly resistant clones	Moderately resistant clones
GCTCV-40	GCTCV-46
GCTCV-44	GCTCV-53
GCTCV-104	GCTCV-62
GCTCV-105 (1995)	GCTCV-201
GCTCV-119 (1997)	GCTCV-215 (1991)
GCTCV-217 (1998)	GCTCV-216
GCTCV-218 (2002)	

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

Bioversity International

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

2011

ZJ6 Highly Resistant To TR4, Bunch 24.7 Kg

(Yi, 2014)

2014

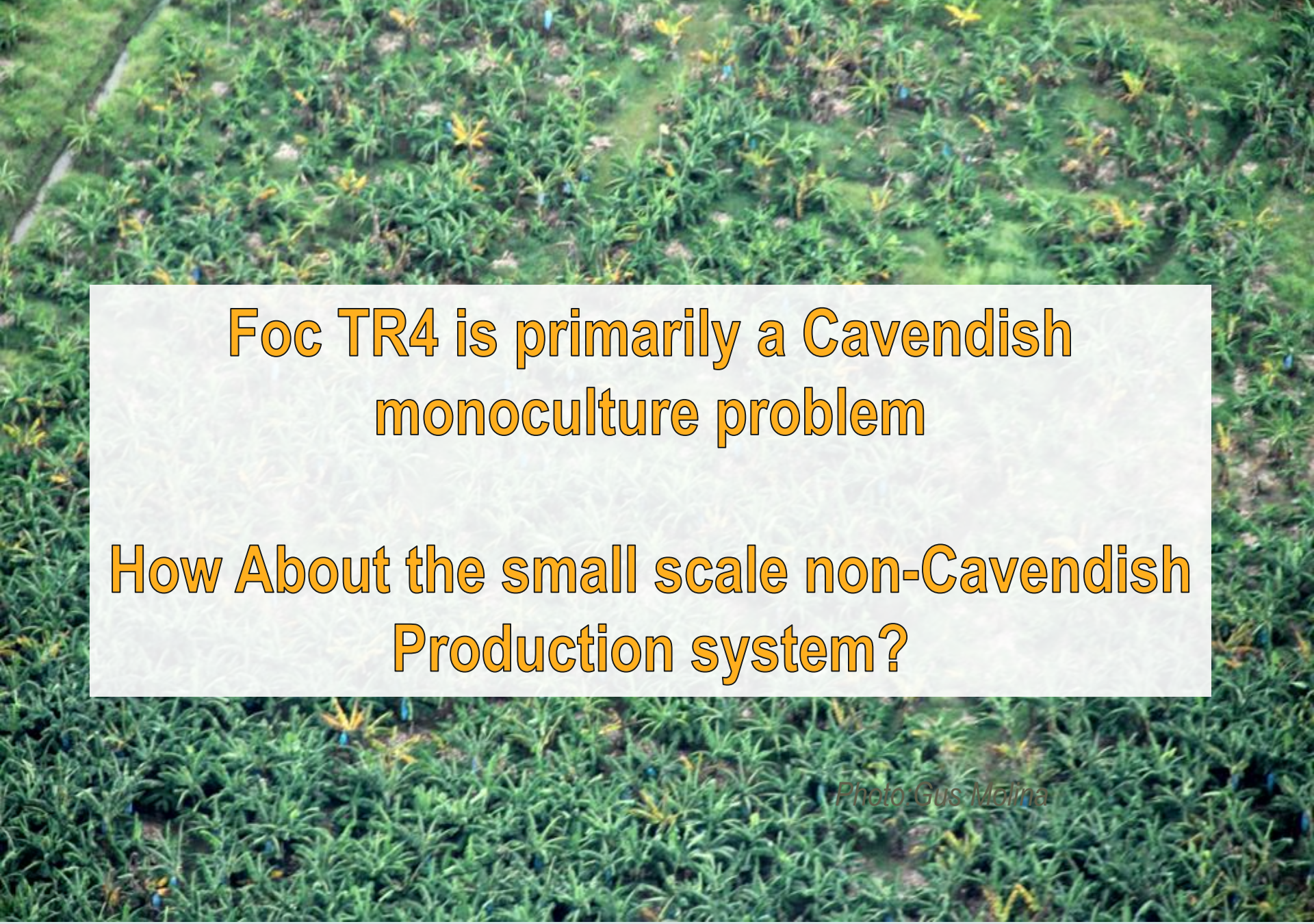
New GCTCVs from Taiwan Banana Research Institute

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?

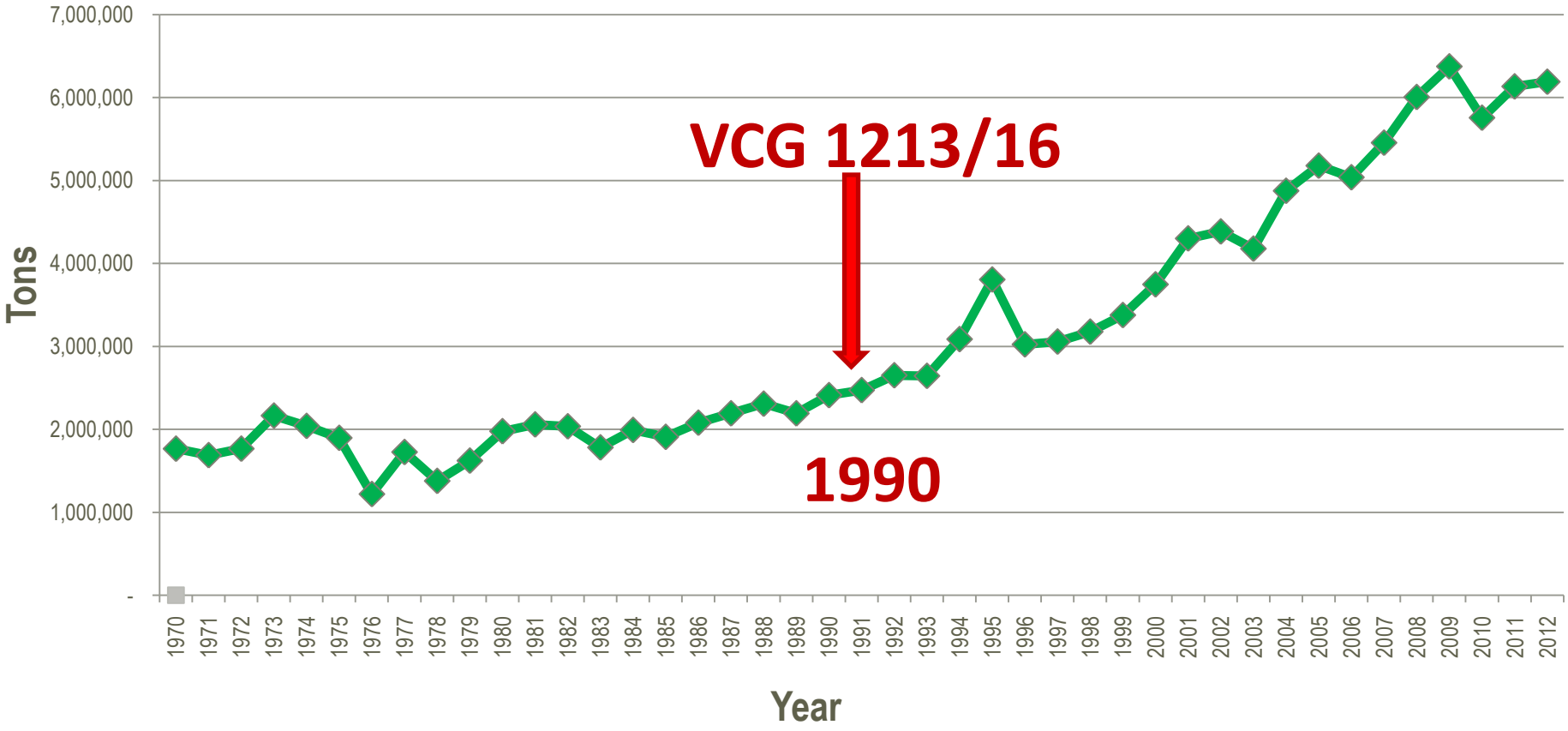
Photo: Gus Molina

Bioversity International

Local cultivars against TR4

Variety	Genome	Fusarium Wilt Incidence 52weeks (%)	Fusarium Wilt Incidence 77weeks (%)
Lakatan	AAA	76	92
Latundan	AAB	40	60
Gran naine	AAA	57	78
Cardava (Saba)	BBB	0	0
Kluai Namwa	ABB	0	1
GCTCV 119	AAA	0	0

Banana Production in Indonesia (1970-2012)



Since 1990 when TR4 was identified affecting Cavendish in Indonesia, banana production has continued to increase.

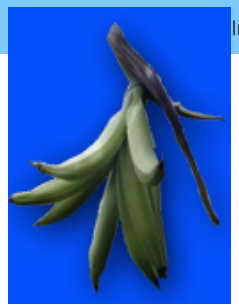
Bioversity International

Local cultivars grown by farmers in Indonesia

Resilience due to cultivar and cropping system diversity!

Kepok

Barangan



Tanduk

Ambon Kuning

Ketan

Ambon Hijau

Awak

Rajasere

Berlin

Tongkat langit

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

Photo: Tony Pattison

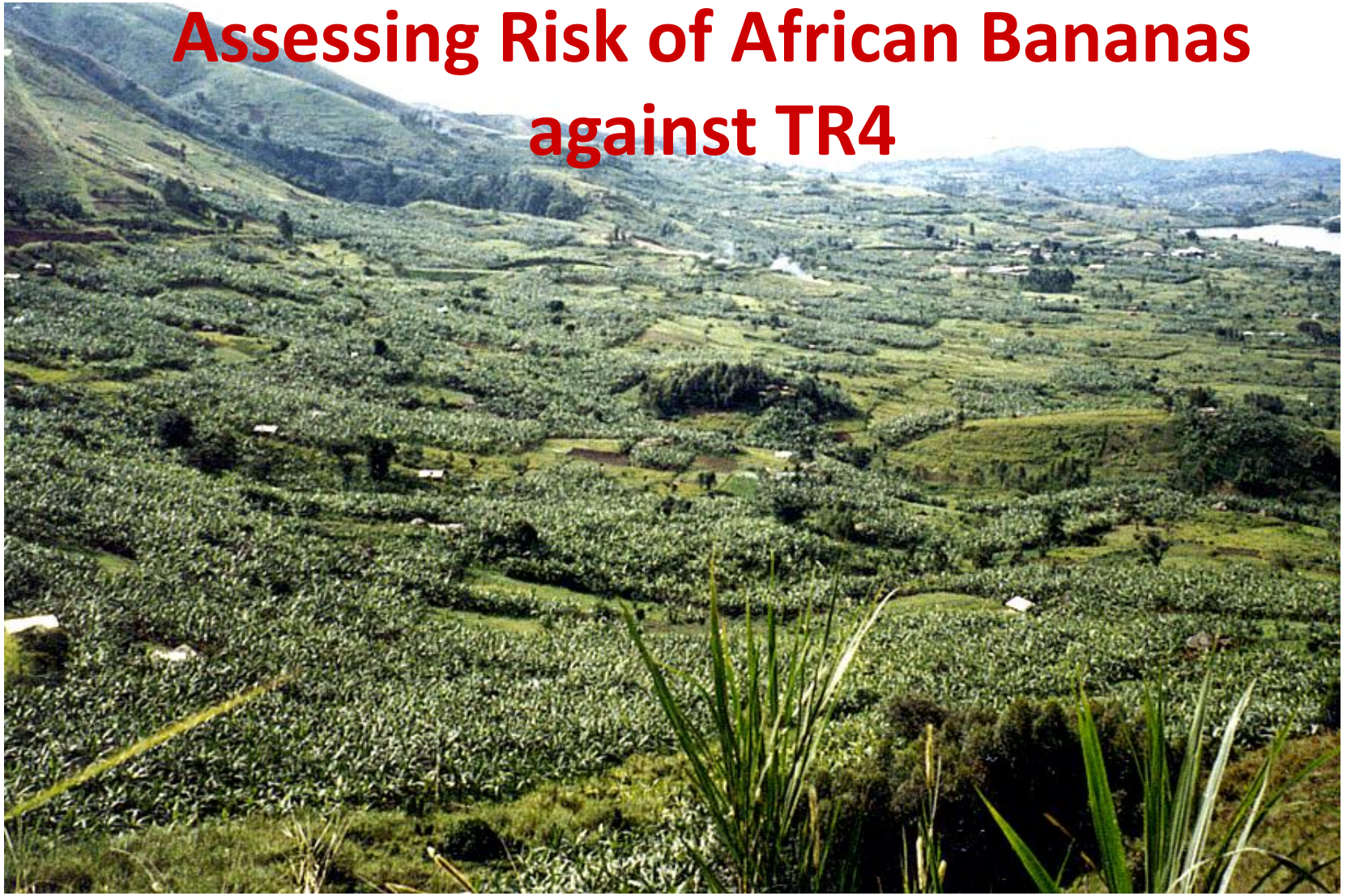
Bioversity project with DAFF, funded by ACIAR; to be validated in the Philippines

Bioversity International

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)

Variety Name	Genome	Sub-Group	% PD Incidence	
			52 weeks	72 weeks
Igitsiri (Intuntu)	AAA	Lujugira-Mutika	3	3
Mbwazirumi	AAA	Lujugira-Mutika	2	2
Ingagara	AAA	Lujugira-Mutika	5	5
Inkira	AAA	Lujugira-Mutika	4	4
Akpakpak	AAB	Plantain	1	1
Obubit Ntanga	AAB	Plantain	0	0
Enzirabahima	AAA	Lujugira-Mutika	1	3
Kazirakwe	AAA	Lujugira-Mutika	1	1
Ibwi	AAA	Lujugira-Mutika	23	32
Grand Naine	AAA	Cavendish	58	77
Lakatan	AAA	Barangan	76	92

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

Some Thoughts:

- Monocuture 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

- Bananagedon 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

Bioversity International

Thank you

www.bioversityinternational.org

Bioversity International

CGIAR
Science for a food secure future