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Banana Fusarium wilt

Return of a catastrophic plant disease

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The Gros Michel era: 1866-1962





Panama disease in Central America



Bowden

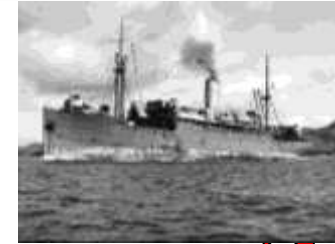


Central American railway



Keith

1st plantings in Panama



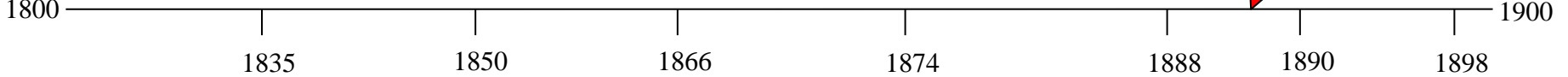
1st banana boat to US

PD

Establishment of UFC

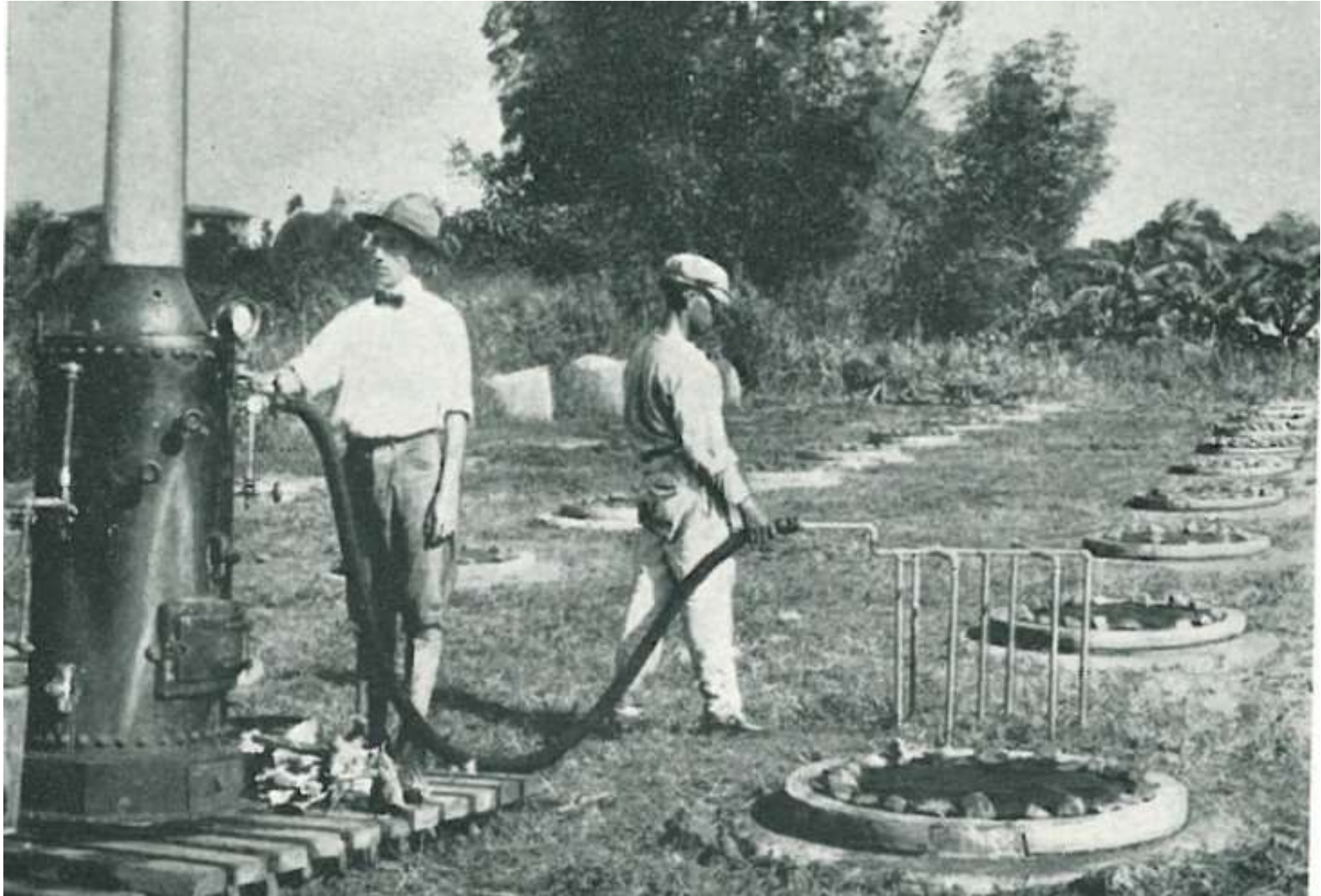
Gros Michel to New World

1st plantings in Jamaica





What is killing our bananas?





Infection biology and symptomatology



The central botanical drawing shows a banana plant with three green arrows pointing to the inflorescence, the stem, and the base. The top-left inset shows a banana leaf with necrotic damage. The top-right inset shows a cross-section of a banana stem with vascular damage. The bottom-left inset shows a microscopic view of banana seeds. The bottom-right inset shows a cross-section of a banana stem with a large necrotic lesion.

Abb. 12. Fusarium oxysporum f. cubense, Erbg. von 4 Makrokonidien der Fusarium-Gruppe. Entomol. Zeitschrift 1910, 4. Heft, S. 10. Die Abbildung zeigt die charakteristische Form der Makrokonidien und die charakteristische Struktur der Makrokonidien.



Sustainable Gros Michel production?



Plantation management:

- Plant nutrition
- Irrigation
- pH adjustment of soil
- New tillage practices





The battle continues ...



1947: Costa Rica ran out of new land

1950: UFC intensifies research:

- Chemical control revisited
- Cover crops
- Deep cultivation
- Flood following





Gros Michel converts to Cavendish





Fusarium wilt of Cavendish bananas





Fusarium wilt: Races in Foc

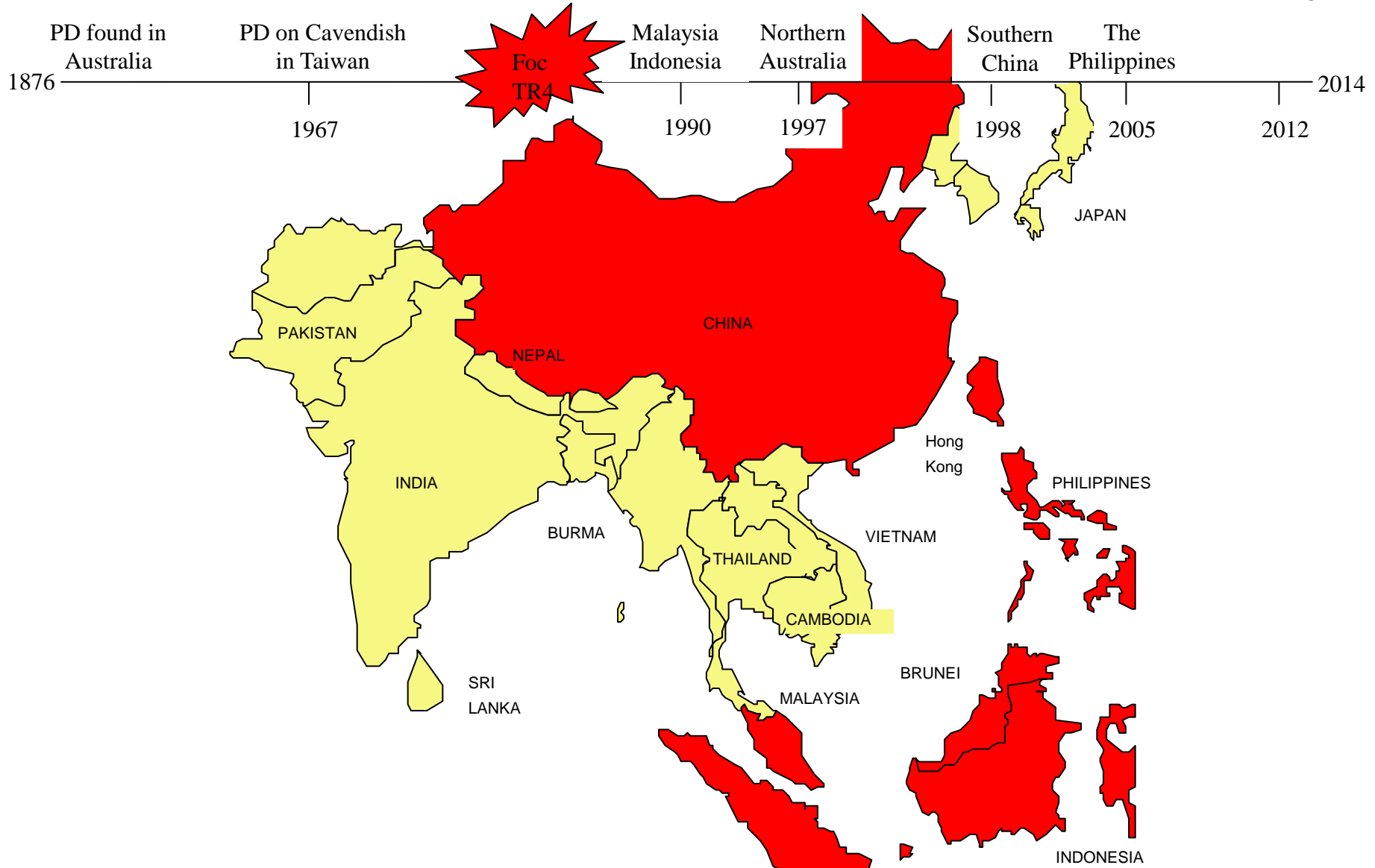


- Race 1 → 'Gros Michel' (AAA), 'Silk' (AAB),
'Pome' (AAB), 'Pisang Awak' (ABB)
 - Race 2 → 'Bluggoe' (ABB)
 - Race 3 → *Heliconia* species
 - Race 4 → Cavendish (AAA), 'Pisang Mas' (AA),
cvs susceptible to Foc races 1 and 2
- "tropical"
 - "sub-tropical"





Foc TR4 (VCG 01213/16) in Asia



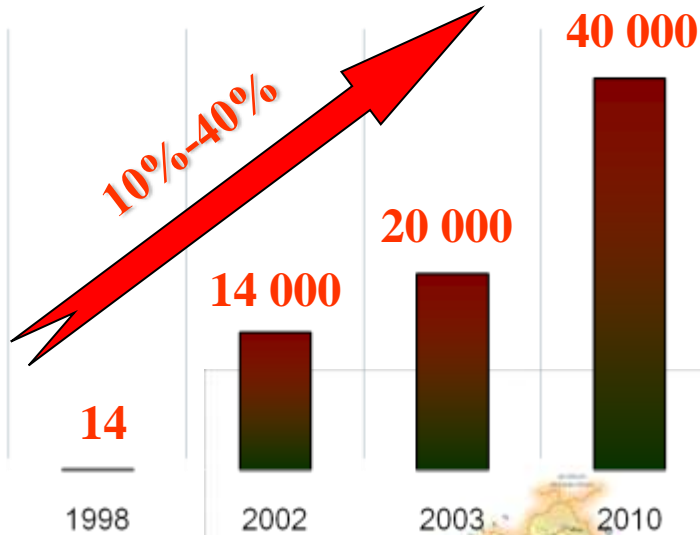
Banana Fusarium wilt in The Philippines

- The Philippines is the second largest exporter of bananas
- Cavendish cultivars accounting for about 51% of national banana production, Saba 29%, Lakatan 10% and Latundan about 11%.
- More than 80% of the bananas (and 99% of the Cavendish cultivars) are produced in Mindanao.
- 2001: Cavendish bananas in the highlands severely affected by Fusarium wilt
- 2003: Sporadic cases observed in lowlands
- 2005: Significant increase in lowlands
- 2013: Small-scale growers severely affected

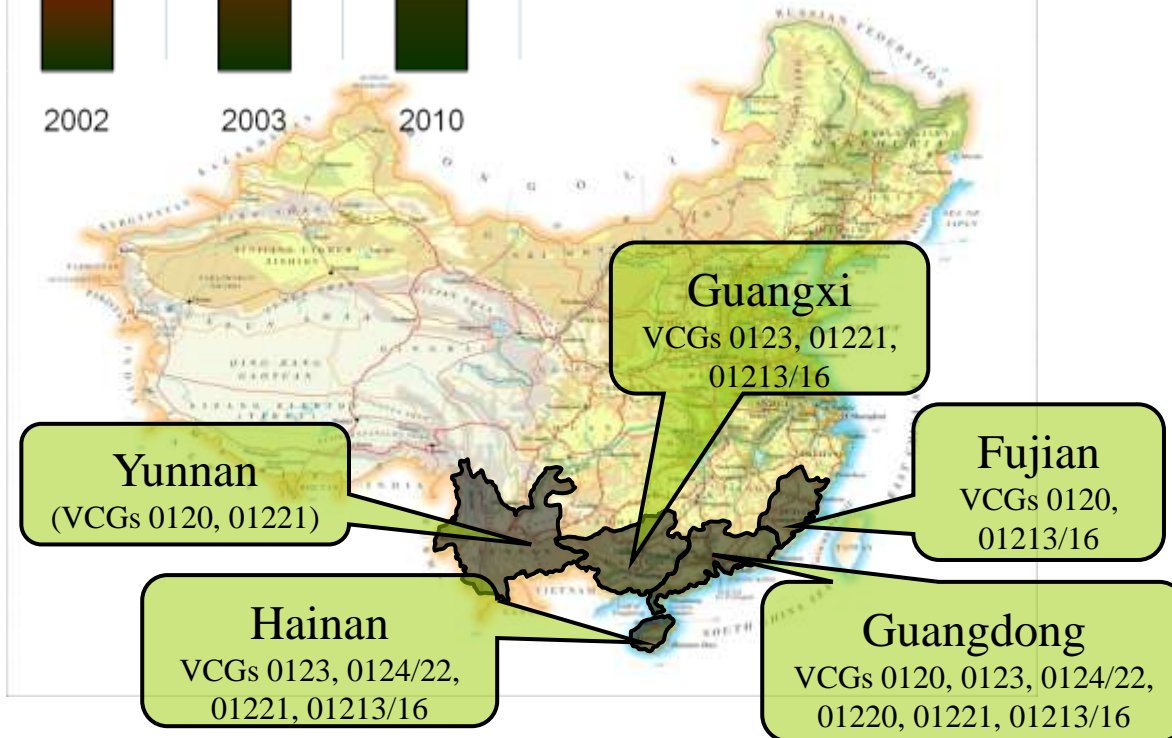




Occurrence of Fusarium wilt in China

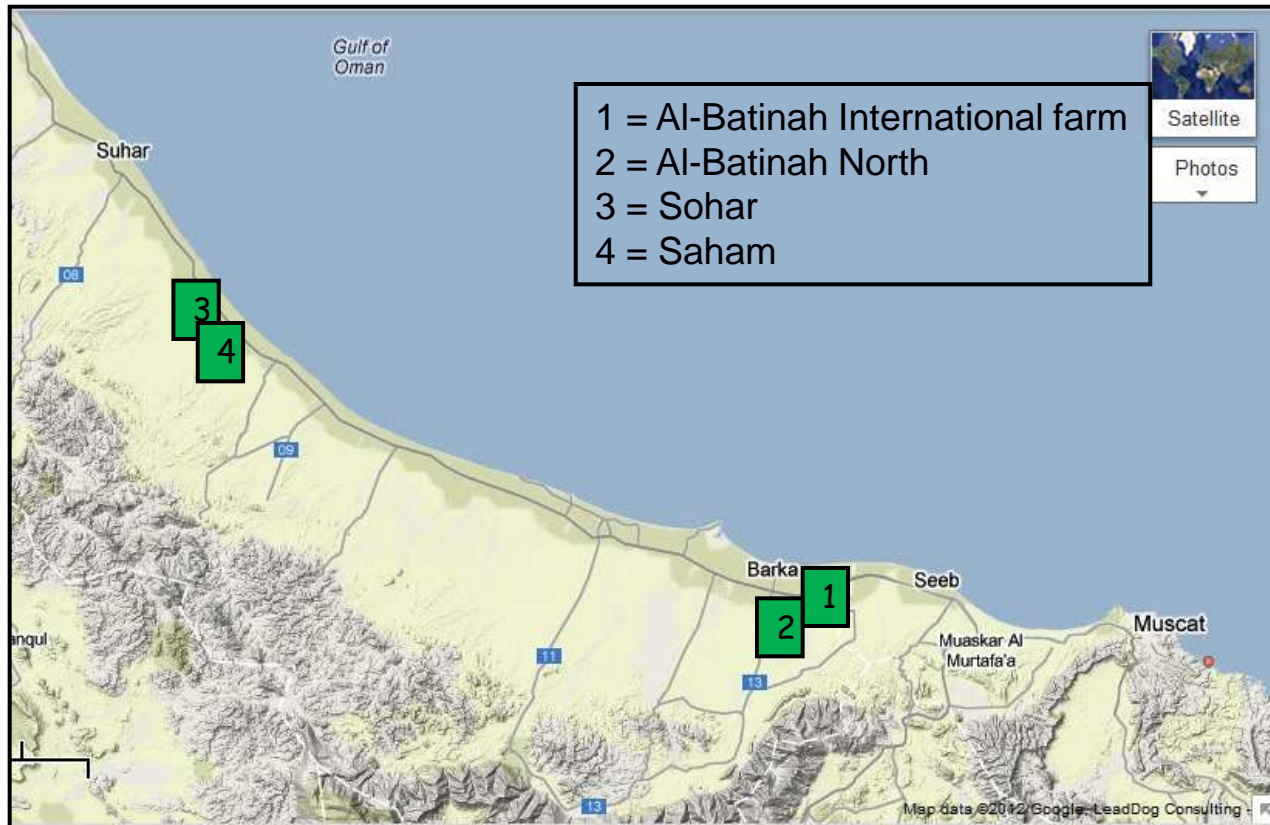


- Fusarium wilt was first discovered in Fanyu of Guangzhou in 1998
- The disease now occurs in all of the main production areas
- Cost of Fusarium wilt estimated to be more than 500 million Yuan/year





Banana Fusarium wilt in Oman



- 2009: Fusarium isolated from banana in Saham; Foc not confirmed
- May 2011: Foc confirmed from banana in Sohar
- July 2011: Foc confirmed from Cavendish bananas in Al-Batinah



Reasons for Fusarium wilt epidemics



1. Large scale monoculture of bananas
2. Expansion of the international trade
3. Domination of trade with Cavendish bananas
4. Disregard of quarantine regulations
5. Movement of plants, people and equipment





Next stop - Africa



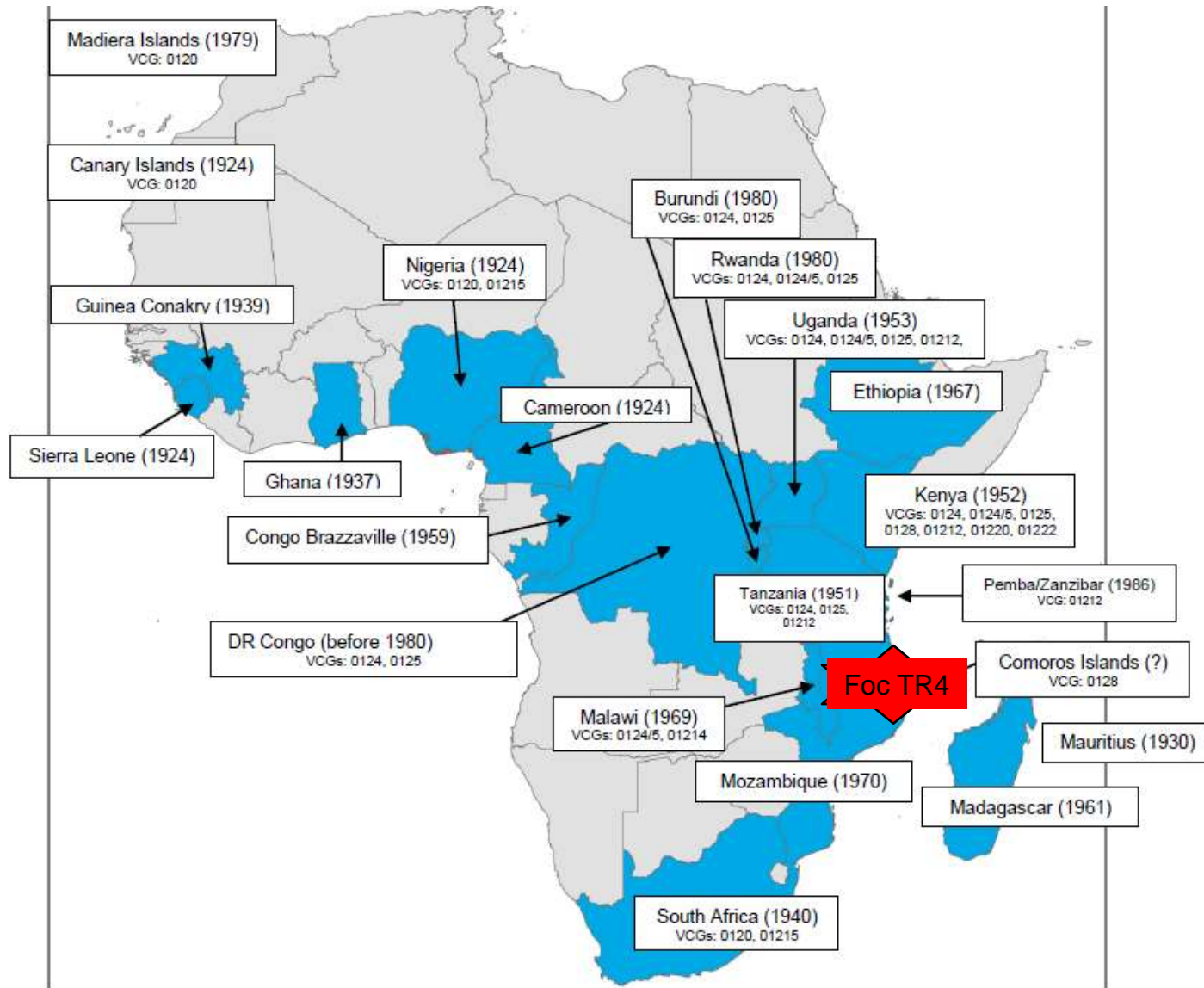
“But it is Africa where the cause is most urgent. While Europe attempts to promote the interest of small growers, big banana companies are moving operations to countries that Europeans can buy bananas from. Cavendish plantations are now expanding across the African continent.”

Dan Koeppel – Banana: The fate of the fruit



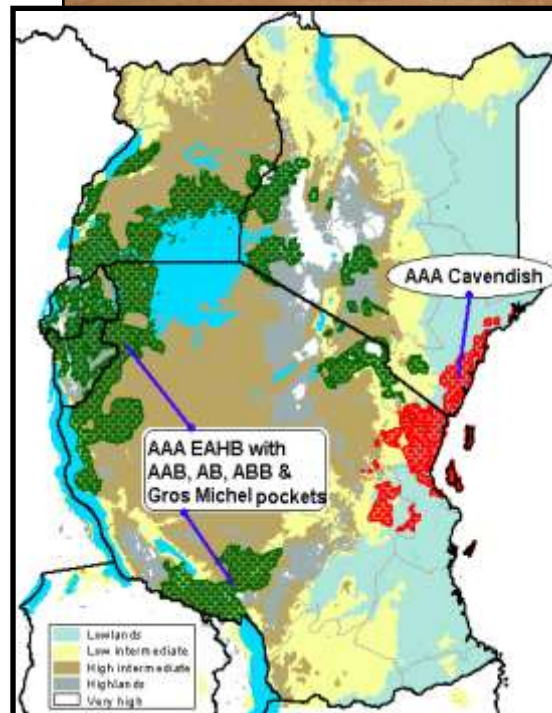


Fusarium wilt in Africa



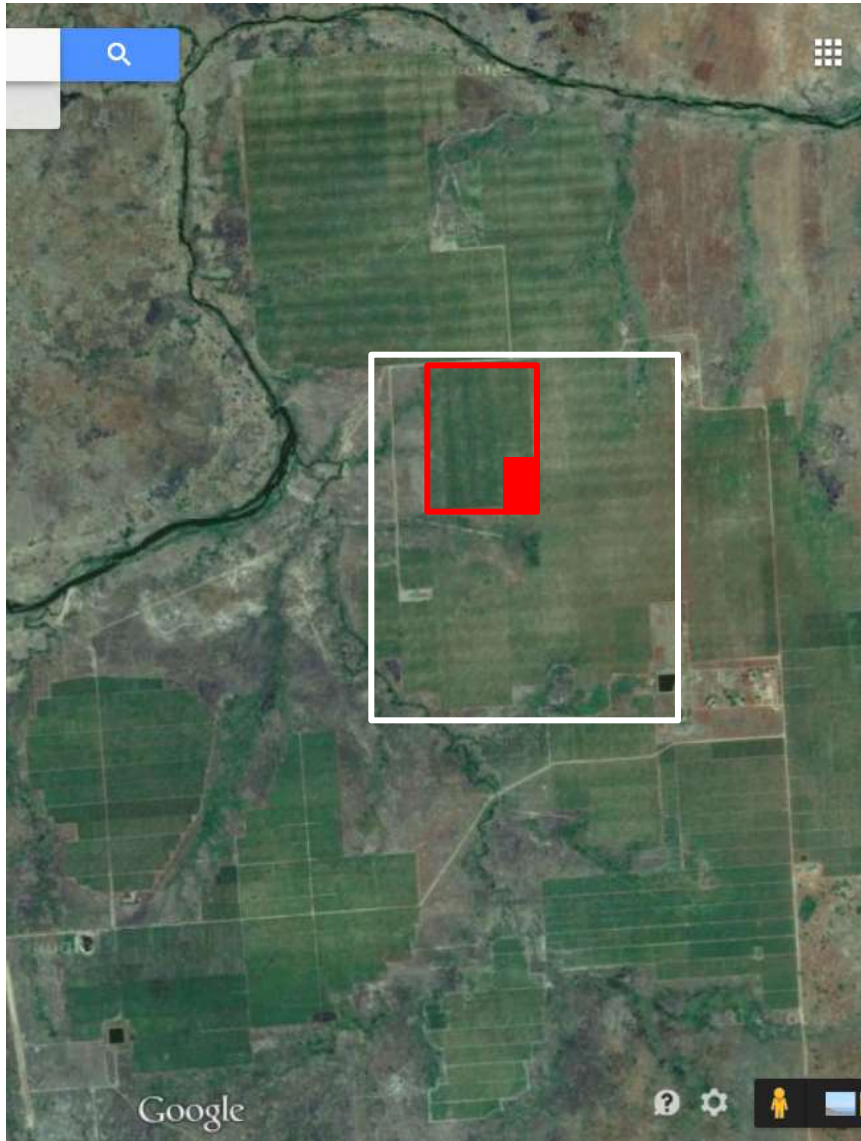


Introduction of Foc TR4 into Africa





Introduction of Foc TR4 into Africa



- Farm developed in 2009 near Namialo, a dry region in northern Mozambique
- No other banana farm in a radius of 100 km, with only pockets of volunteer bananas (cooking type)
- Water deficit was experienced in 2012, with Farm 2 being particularly affected
- Symptoms first observed in Feb 2013
- Water from Monapo River feeds into two ponds for sprinkler irrigation
- Considerable pedestrian movement of people from local communities through
- Farm personnel were rotated between fields
- International staff is replaced fairly regularly



Metocheria farm, Mozambique





On-farm movement of Foc TR4



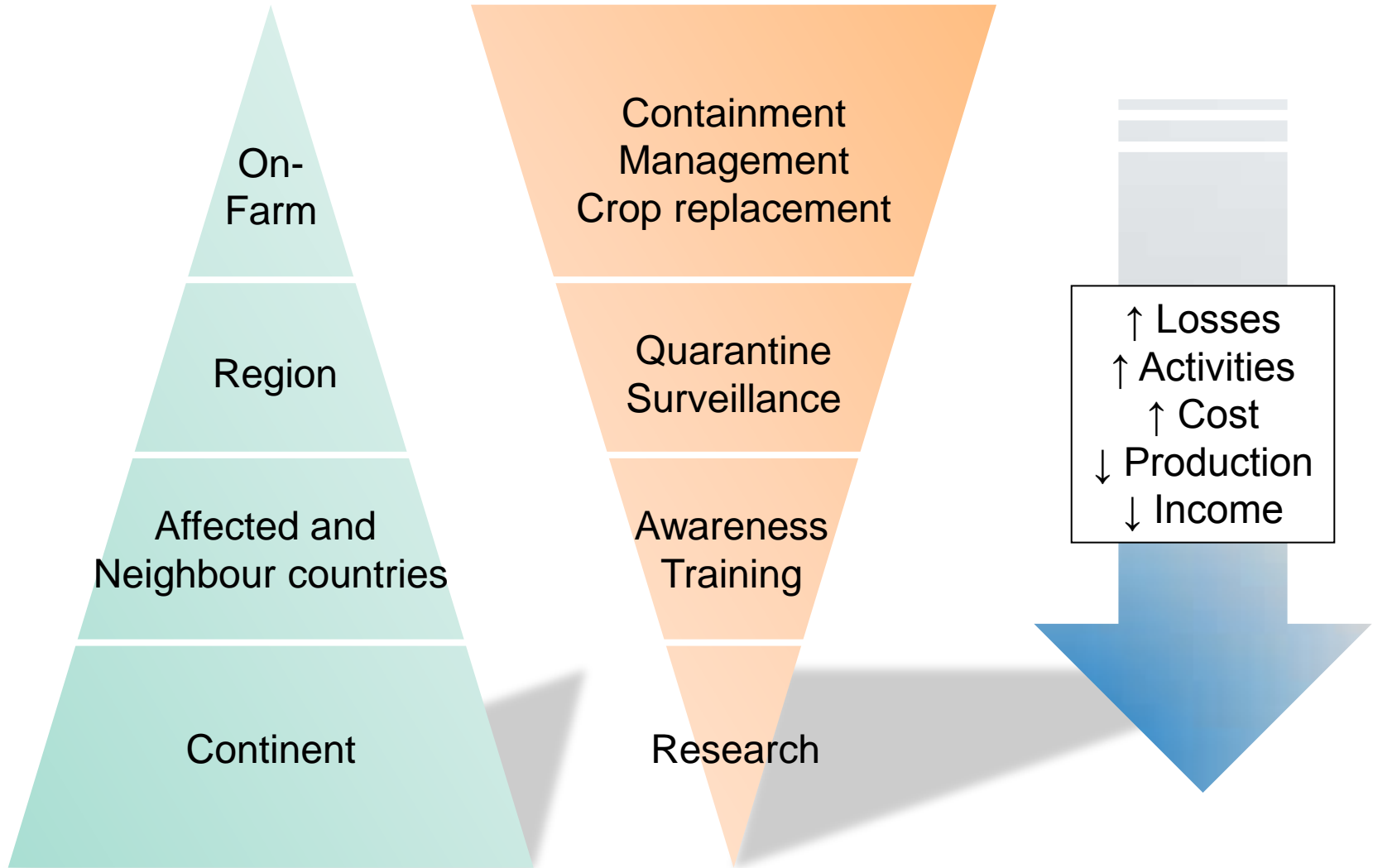


Foc TR4 in Mozambique: Feb 2015





Impact of Foc TR4 in Africa





Regional strategy meetings on Foc TR4



RESEARCH PROGRAM ON
Roots, Tubers
and Bananas





Action plan for Foc TR4 in Africa



Goal:

To control the current disease outbreak of banana Fusarium wilt (Foc TR4) in Mozambique and to prepare other African countries that rely on banana for food security and income generation, against similar incursions.

Objectives:

1. Arrest and contain the spread of Foc TR4 in Mozambique and surrounding countries
2. Strengthen the capacity of NARS to sustainably manage the disease in Africa
3. Institute mechanisms to coordinate and communicate AC4TR4 activities in Africa.
4. Carry out research to generate new information and technologies for sustainable management of Foc TR4



Managing Fusarium wilt: Metocheria





Somaclone resistance to Foc TR4



Farm name	Planting date	Variety	# seedlings	PD incidence (%)	
				Aug 2013	Feb 2014
Phil Fresh Fruits	Oct 2012	GCTCV 219	3800	0.1	1.39
		G Naine	200	79.5	100
Bancud Farm	Oct 2012	GCTCV 219	500	0	2
		G Naine	100	46	97
Lapiz Farm	Oct 2012	GCTCV 219	1800	0	0
		G Naine	200	2.5	76





Awareness raising



Tropical race 4 in Africa

In November 2013, it was announced that tropical race 4 (TR4) had been confirmed in northern Mozambique, in a plantation of Cavendish bananas for export. It was the first, and so far only, report of the fungal strain on the African continent. Until then, the distribution of the pathogen had been limited to parts of Asia and a region of Australia.

Distribution of tropical race 4 (TR4)



What is TR4?

Tropical race 4 (TR4) is the name given to the strains of the soil-borne fungus *Fusarium oxysporum* f. sp. *cubense* that causes *Fusarium* wilt (popularly known as Panama disease) in Cavendish cultivars in the tropics. The term TR4 was coined to distinguish these strains from the ones that only affect Cavendish cultivars in the presence of predisposing factors, such as low temperatures, and have since become known as subtropical race 4 (STR4).

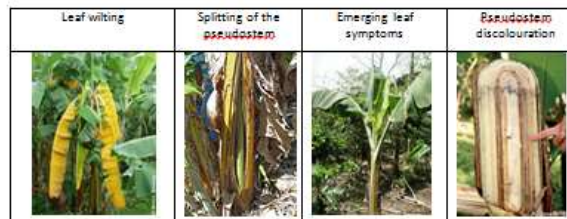
What does TR4 mean for African bananas?

Many African countries* already have fungal strains – collectively known as race 1 and race 2 – that cause *Fusarium* wilt in cultivars such as Gros Michel (*Bogoya*) and Pisang Awak (*Kaviraja*). Since TR4 also causes disease in cultivars susceptible to these two races, it has the potential of affecting cultivars beyond the Cavendish ones. The main unknown is the reaction of Plantains and East African highland bananas. Since they are normally resistant to races 1 and 2, symptoms of *Fusarium* wilt in these cooking bananas should be investigated, even if preliminary field trials conducted in Asia suggest that they might also be resistant to TR4.

How to recognize TR4

TR4 produces characteristic *Fusarium* wilt symptoms. The first visible symptom is usually the yellowing of the older leaves. As the disease progresses, the leaves collapse, forming a skirt of dead leaves around the lower part of the plant. Alternately, leaves may remain green, but collapse as a result of buckling of the petiole. Splitting of the base of the pseudostem is another common symptom, as is wrinkling and distortion of the emerging leaf. The main internal symptom is vascular discoloration of the rhizome and pseudostem, which varies from pale yellow in the early stages to

dark red or almost black in later stages. The fruits do not show any specific disease symptoms. The above- and below-ground parts of affected plants eventually rot and die.



What can it be confused with?

The early wilt symptoms can be confused with nutritional deficiency or water stress. The leaf symptoms can also be confused with those of *Xanthomonas* wilt, better known as BXW. In plants affected by *Fusarium*, yellowing and wilting of the leaves typically progresses from the older to the younger leaves. The wilted leaves may also snap at the petiole and hang down the pseudostem. In plants affected by *Xanthomonas* wilt, the wilting can begin with any leaf and the infected leaves tend to snap along the leaf blade.



Leaf snapping in a BXW-infected plant

How to confirm TR4

The quickest way to confirm a suspected TR4 infection is by analysing tissue samples using the TR4-specific PCR molecular test, whose results can be obtained in less than a day. Fungal isolates can also be analysed to determine their vegetative compatibility group (VCG), a process that can take four months or more. TR4 isolates belong to the VCG 01213/16 complex, although other VCGs are also known to cause *Fusarium* wilt in Cavendish cultivars.

How to avoid spreading TR4

The disease can be spread through infected planting material, infested soil adhering to farm equipment and footwear and surface water. The fungus can persist in the soil for decades and cannot be managed using chemical pesticides. Using clean planting material, such as tissue-culture plantlets, avoiding sharing farm equipment with other growers, promptly destroying suspected cases, fencing the affected area, digging a trench to prevent water from flowing out of the area and planting a cover crop are among the actions that can be taken to avoid spreading the disease.

For more information and access to resources go to www.promusa.org/Tropical+race+4+--+TR4.

BioMusa is a knowledge-sharing network managed by Bioversity International as part of the CGIAR Research Program on Roots, Tubers and Bananas.

* In Africa, *Fusarium* wilt has been reported in Ethiopia, Kenya, Uganda, Rwanda, Burundi, Tanzania, including Zanzibar, Malawi, Mozambique, South Africa, Madagascar, as well as the islands of Mauritius, Comoros and Pemba, DR Congo, Congo Brazzaville, Cameroon, Nigeria, Ghana, Sierra Leone and Guinea Conakry.



BARNESA meeting



BARNESA STEERING COMMITTEE MEETING ON Foc TR4
Golf View Hotel, Entebbe, Uganda
26th to 28rd October 2014





Awareness and training




inibap

Advancing banana and plantain R&D in Asia and the Pacific - Vol. 13

Proceedings of the 3rd BAPNET Steering Committee meeting held in Guangzhou, China 23-26 November 2004

A.S. Mehra, L.S. Ju, Y.K. Hsu, J. Varisco Singh and K.A. Simonsen, editors



Workshop recommendations

After the presentations, a workshop was held to review and discuss the status of the various projects in the region, the direction and the future plans of BAPNET. These were the recommendations agreed by the committee members:

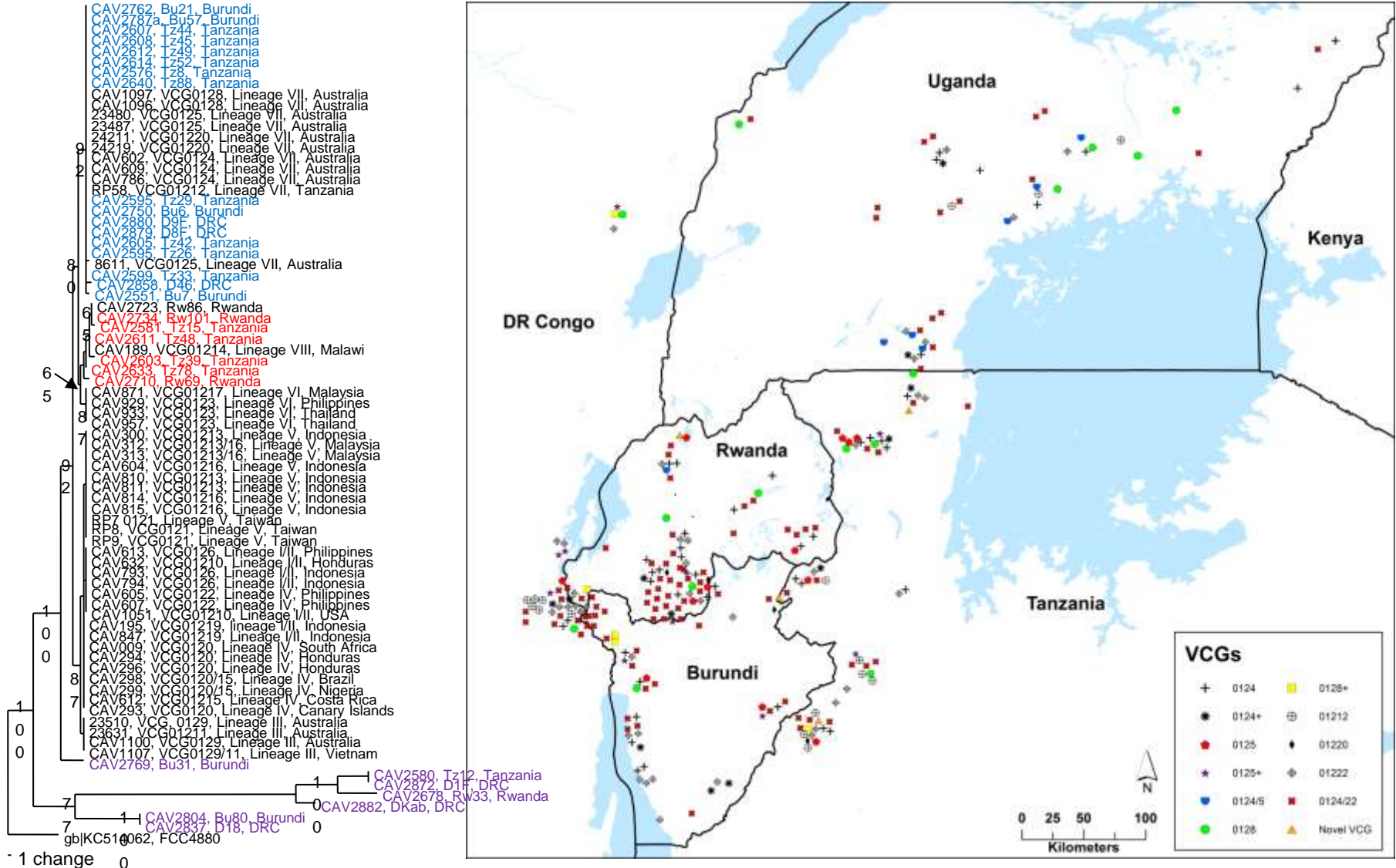
1. R&D in the area of IPM with emphasis on banana bunchy top wilt, banana viruses and bacterial wilt
The observed selection of banana wilt on Cavendish in China, Taiwan, Indonesia, Malaysia, Philippines and Australia, and the absence or limited information about Foc from other countries such as Cambodia, Myanmar, Sri Lanka and other BAPNET member countries, necessitate a new survey-characterization of the Foc pathogens in the region. A map distribution of the various races and VCGs of Foc has to be developed. The Regional Coordinator (RC) together with the VCGs of Australia will explore some possibilities of funding support for the activity from the Australian government.
2. Review the status and need of a banana breeding program in Asia

- Two funded projects by ACIAR were developed.
- Small grants from Bioversity
- National R&D efforts and resource sharing (BAPNET)





Distribution of Foc VCGs in Africa





Evaluation of African bananas in Asia



- Natural infection by *Fusarium oxysporum* f. sp. *cubense* TR4



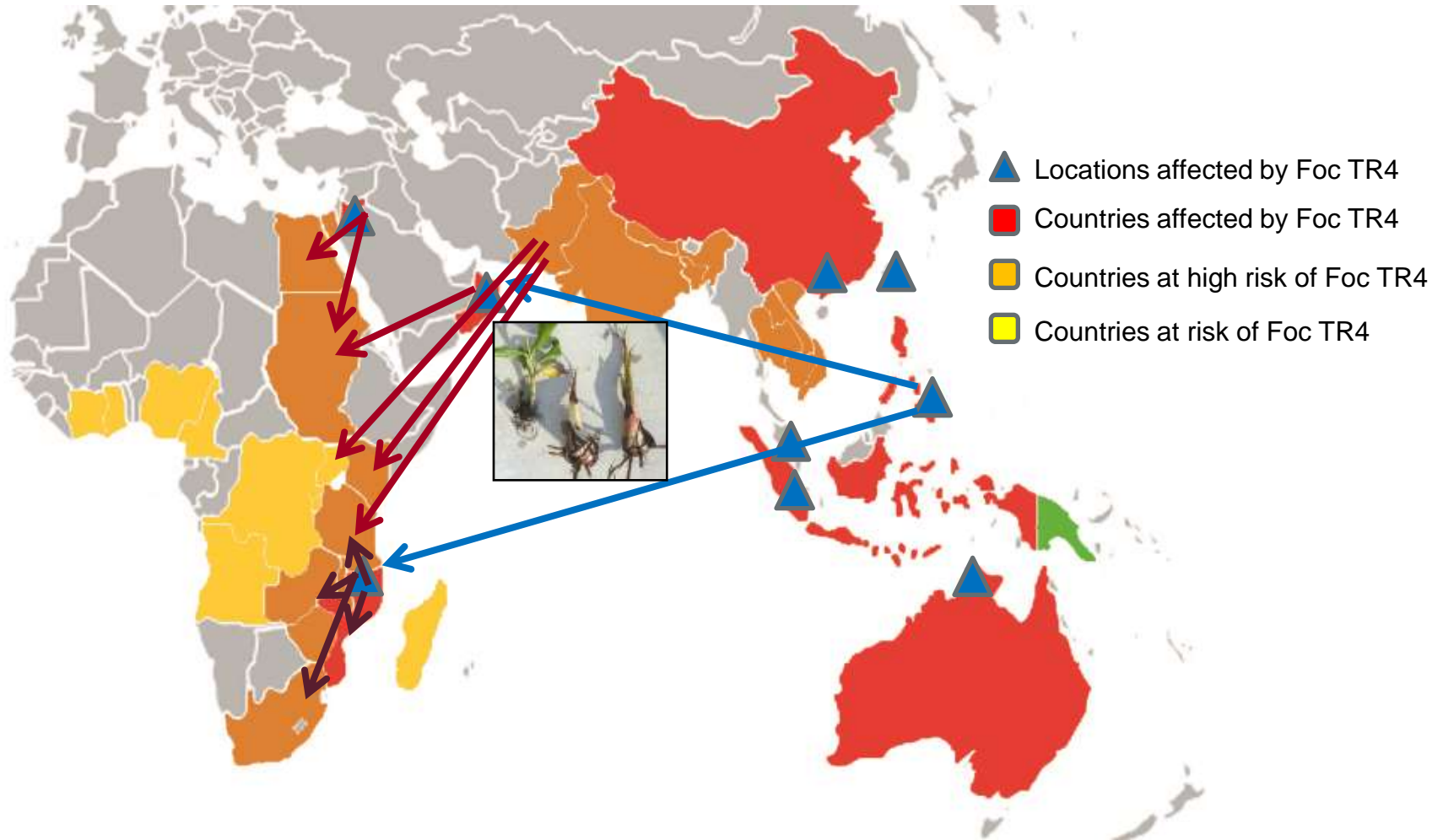
Results: Mindanao, Philippines



BANANA CULTIVARS	ITC CODE		NAME	VARIETY	# PLANTS	As of week 2, 2013			Mortality
						% PD	% Moko	% BBT	
African Varieties	1	ITC0081	Igitsiri (Intuntu)	EAHB - AAA	100	3			12
	2	ITC0084	Mbwazirumi	EAHB- AAA	100	3	2	7	18
	4	ITC0166	Ingagara	EAHB- AAA	100	5		2	11
	5	ITC0179	Inkira	EAHB- AAA	100	4			18
	8	ITC0217	Akpakpak	Plantain – AAB	100	1			4
	9	ITC0519	Obubit Ntanga	Plantain – AAB	100	0	2		13
	13	ITC1354	Enzirabahima	EAHB- AAA	100	3	1	1	12
	14	ITC1355	Kazirakwe	EAHB- AAA	100	1		6	7
	15	ITC1465	Ibwi	EAHB- AAA	100	32		11	3
	10	ITC0570	Williams	EAHB- AAA	100	46		3	1



Movement of Foc TR4 – **illegal** plants!





Cavendish banana production in Sudan



Source of map: [Perry-Castañeda Library Map Collection](#)



Photo by Gerardo Gutiérrez



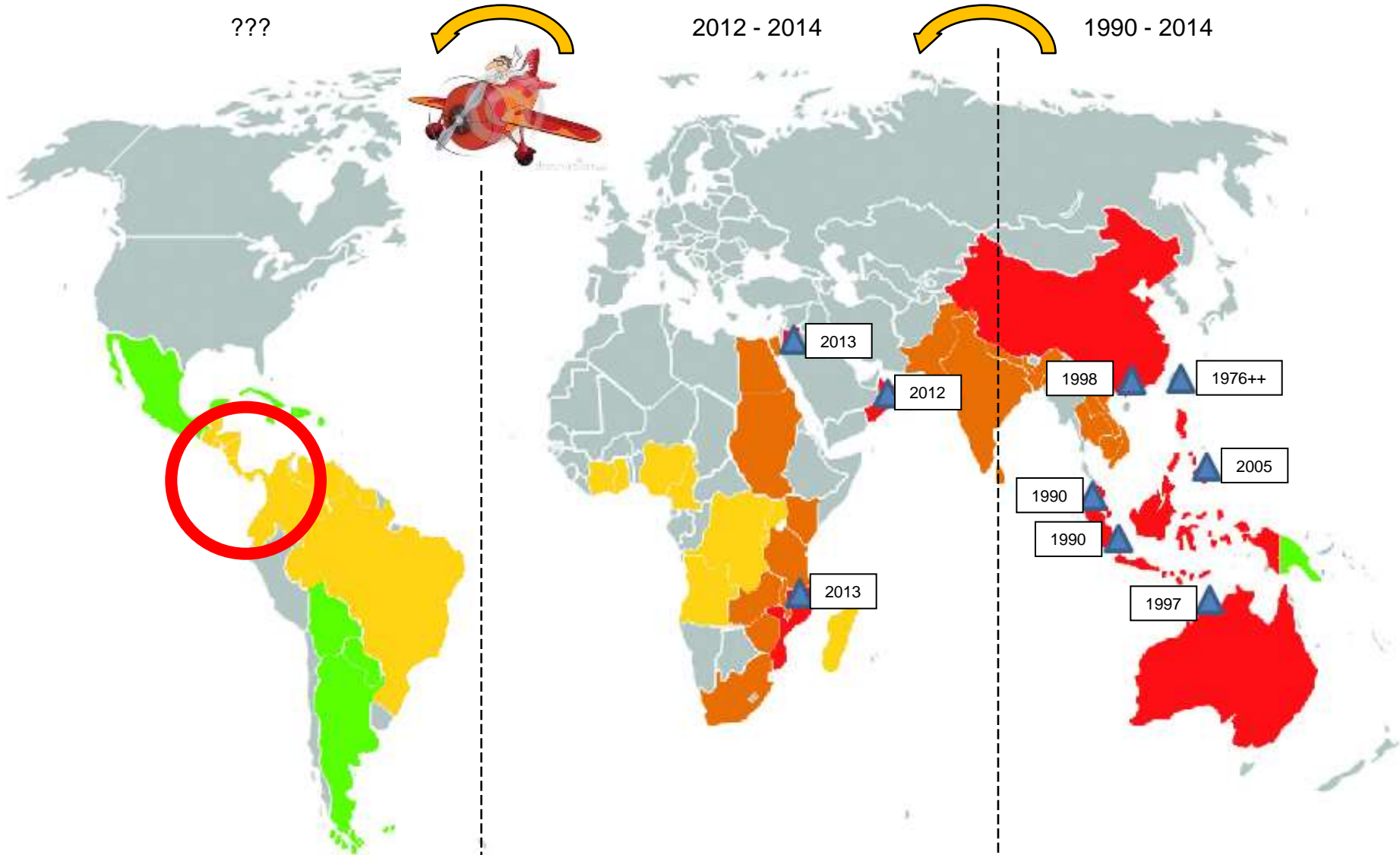
Prevention of banana Fusarium wilt



- Can be achieved by means of enhanced awareness, legislation, regulation, quarantine and avoidance
- These actions take place before Foc enters countries and farms, or once it has been introduced into countries
- The activity chosen to deal with Fusarium wilt depends on the availability, affordability, geographical area and production systems under threat
- Successful prevention depends on a proper knowledge of the disease and its management
- Protecting bananas against Foc TR4 is the responsibility of a number of stakeholders, including national and regional authorities, research scientists, extension officers and producers



Global distribution of Foc TR4





FAO Global Foc TR4 programme





FAO Global Foc TR4 programme



Draft

I



Global Programme on Prevention of Fusarium wilt (Foc) Disease of Banana 2015-2018

(Draft working paper)

Rome, 2014



Policy and Technical Guide for

Prevention and Management of Fusarium Wilt Disease of Banana (*Fusarium oxysporum* f. sp. *cubense*)

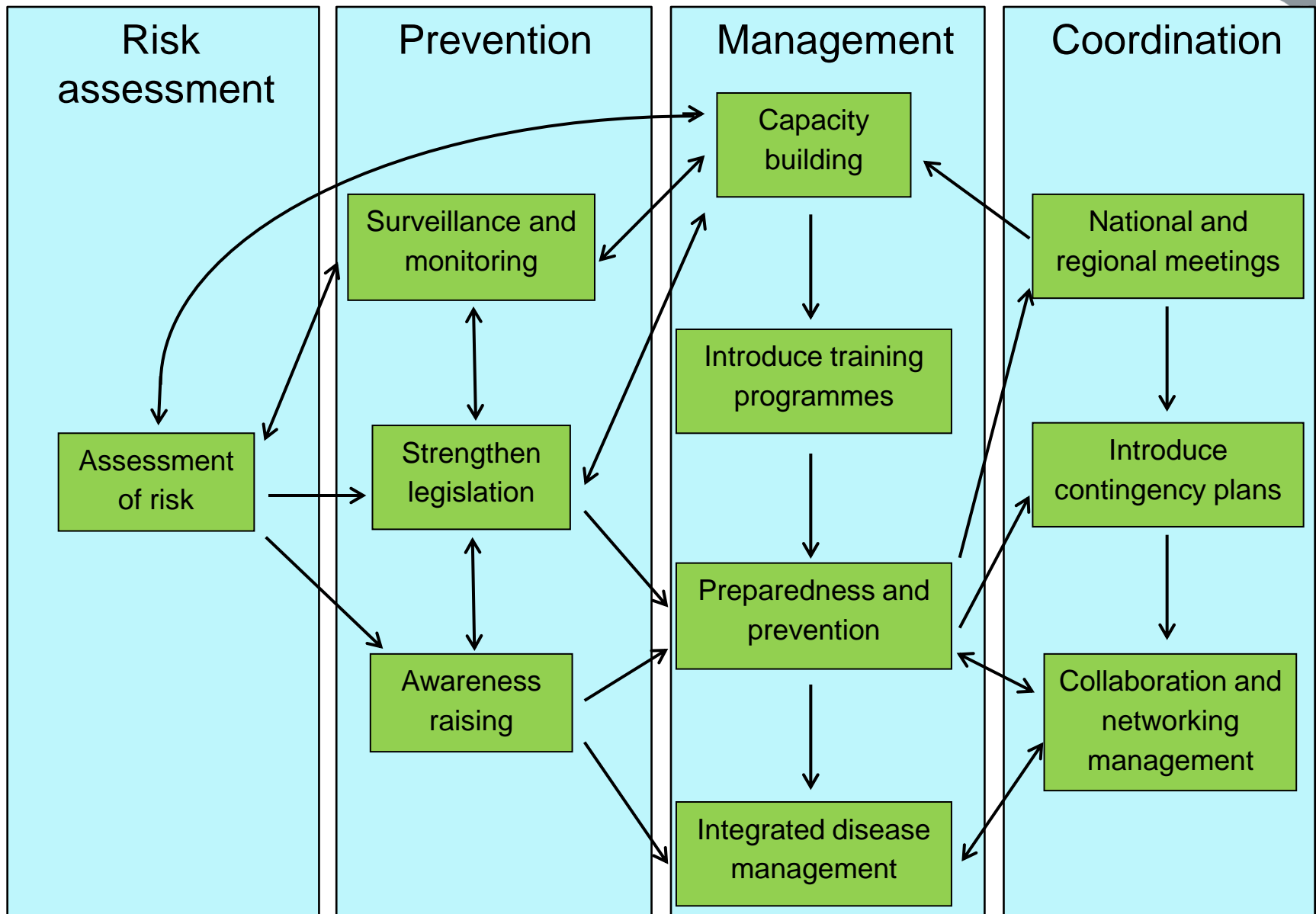
in Particular Tropical Race 4 (Foc TR4)

(Draft working paper)

Rome 2014



FAO global programme on Foc TR4






sun.ac.za/banana-fusarium-wilt-africa




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wilt in Africa**

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**New 13.8 million \$
project to help
banana farmers in
Africa!**
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Events Notices

- 10 Nov 2014 V Cumbre Mundial de Banano
- 19 Nov 2014 International Banana Symposium





Pre-border activities



- Assess national biosecurity legislation and regulations
- Assess a country's ability to prevent and respond to incursions of Foc
- Obtain sufficient knowledge on Foc and means to deal with it
- Raise awareness about Foc TR4 among policy makers, government and quarantine officials, the public, researchers, producers and other stakeholders
- Develop standardised training manuals, identification and surveillance protocols, and methods to deal with Foc incursions nationally and regionally
- Develop national capacity and infrastructure to deal with incursions
- Train plant health officials, scientists, extension officers, border control and quarantine people, and producers on Foc identification and management
- Distribute posters, brochures and information materials on Foc TR4 and other races
- Prepare technical materials on the prevention, detection, contention and eradication of Foc-affected plants.
- Introduce an emergency fund to rapidly respond to incursions
- Develop an entrance risk analysis and identify high-risk entry points



On-border activities



- Evaluate quarantine measures and strengthen border control
- Include Foc TR4 as quarantine pest on national lists
- Develop legislation and phytosanitary regulation for bananas and/or parts of bananas introduced from Foc TR4-affected countries or countries at risk
- Strictly control the importation of banana and plantain plants and plant parts from countries affected or at risk of Foc TR4 through national quarantine stations
- Request *in vitro* plants to be accompanied by certificates for disease indexing
- Identify and strengthen high risk entry points for banana plants infected with Foc
- Train scientists in the use of reliable diagnostics for Foc TR4 identification

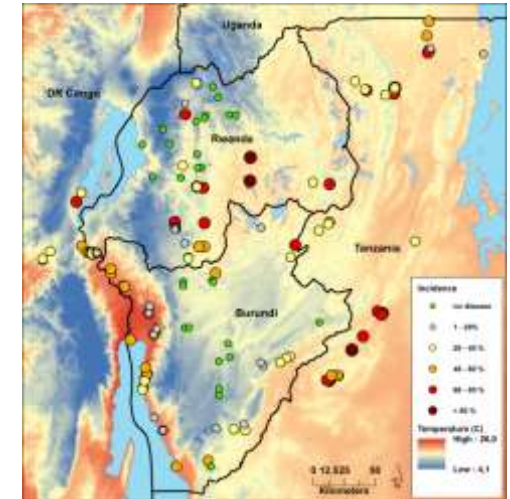




Post-border, off-farm activities



- Map the distribution of Foc TR4 and other Foc races in banana-growing countries
- Gather epidemiological data to establish means of introduction and spread
- Assess, train and introduce surveillance systems and teams in-country
- Introduce legislation to regulate the movement of banana planting materials and other risky materials within country borders
- Set up quarantine zones to prevent the movement of infected planting materials and other possible risky materials in-country
- Collaborate nationally and regionally to prevent the introduction of Foc TR4 in the region
- Organise training workshops and expert consultations with *Fusarium* specialists





Farm-border activities



- Obtain clean planting and propagation material from reputable sources, preferentially tissue culture bananas
- Put up highly visible and clearly understandable signs at farm entrances to notify visitors about farm biosecurity
- Clean all vehicles by hosing-off clay and plant parts and disinfection before entering or leaving farm gates
- Manage visitors and vehicles entering farm borders:
 - Allow visitors only by appointment and upon signing in
 - Disinfect shoes and vehicles of visitors
 - Use only on-farm vehicles and provide boots to visitors
- Enquire about the employment history, nationality and movement of all farm workers
- Avoid sharing farm machinery, equipment and field tools
- Strictly control access of contractors and service providers

