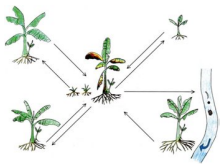
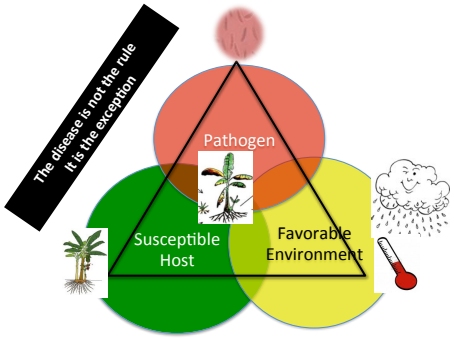
Epidemiology of Fusarium wilt of banana: Critical aspects for Sustainable Management



Miguel Angel Dita Rodriguez- PhD

miguel.dita@embrapa.br

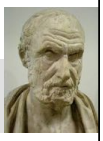
EPIDEMIOLOGY: BASIC CONCEPTS



Epidemiology of Fusarium wilt of banana: Critical aspects for Sustainable Management

Epidemiology?
What it means ?

he Greek philosop *used*
the term epidemi
epi = about, dem



So... Epidemiology the population and in plant pathology w populations of plants? **Easy no**?

Epidemiology of Fusarium wilt of banana: Critical aspects for Sustainable Management

For the purposes of this course we will uses the definition of Zadoks & Schein (1979)

Epidemiology is "the study of the progress and spread of disease and the factors that affect these processes."

In short: Progress = dynamic of epidemics in the dimension "Time"
Spread = Dynamic of the epidemics in the dimension "Space"

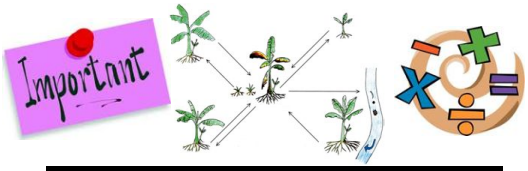
Fundamental equation: $Y = Y_0 + r.t$

Y = disease // Yo = Initial inoculum// r = disease progress rate// t= time

Epidemiological principles of control

Berger, R. D. Application of epidemiological principles to achieve plant disease control Annual Review of Phytopathology 15: 165-183. 1977

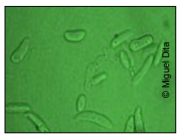
Epidemiology of Fusarium wilt of banana: Critical aspects for Sustainable Management



It is fundamental to understand:
1. The Pathogen, the host & its interaction
2. Disease cycle
3. Spatio-temporal dynamic
4. Related factor – biotics & abiotics

The causal agent of Fusarium wilt of banana

Structures of *F. o* f. sp. *cubense*



Microconidia are 5 - 16 x 2.4 - 3.5 µm, one- or two-celled, oval- to kidney-shaped, and are borne in false heads

Macroconidia: are 27 - 55 x 3.3 - 5.5 µm, four- to eight-celled and sickle-shaped with foot-shaped basal cell

Chlamydospores: Terminal and intercalary are 7 - 11 µm in diameter, usually globose and are formed singly or in pairs in hyphae or conidia

- Fox: ~ 100 *formae speciales* cause wilting in plants
  It contains pathogenic and saprophytic strains that cannot be distinguished morphologically

Source: Ploetz (2000)

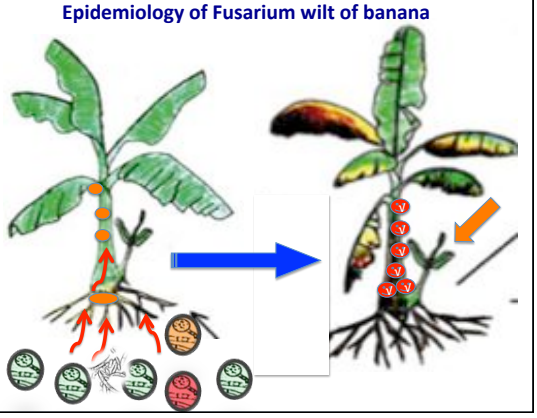
Micro – & Macroconidias: Epidemiological roles

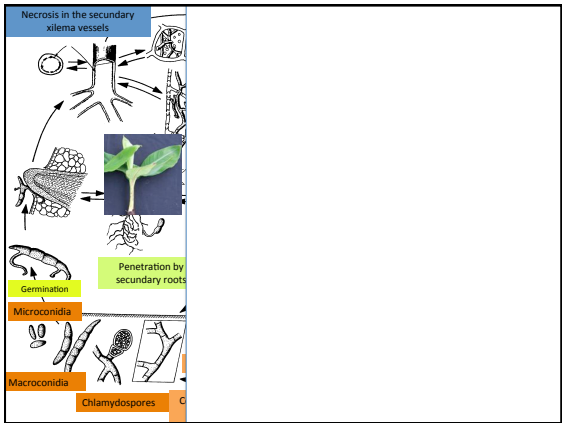
- Both structures are infective, but evidence (greenhouse) suggest that Macroconidia that would be more efficient to cause infection compared to Microconidia. In the Field?
- It has been given an important role to microconidia in systemic invasion of host tissues - are easily transported in the flow of water/sap and nutrients
- Contrarily to what some thinks macro and microconidia play very important role in the field, either in the dispersion of the pathogen, generating chlamydospores and infecting plant directly. **Not always what infect plants in the field are chlamydospores…**

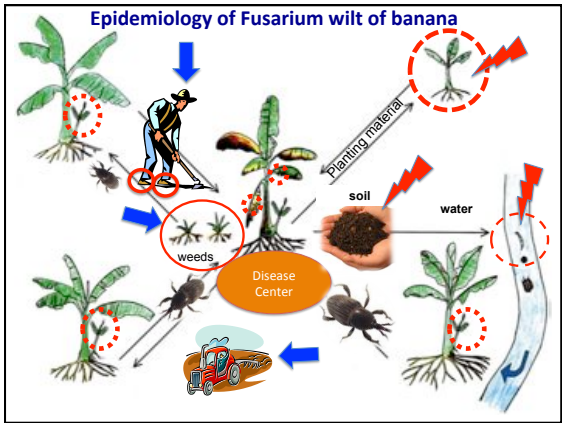
Chlamydospores: key structures for Fusairum wilt epidemiology

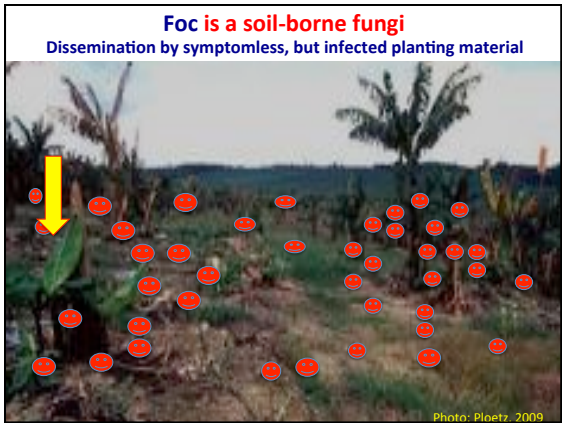
- Are developed from hypha or conidia, have 1 -2 cells
- Thickened cell wall, with verrucose appearance and a darker colour.
- Could appear be single or forming chains
- Can survive long periods in the soil in the absence of susceptible hosts – For Foc it has been stated > **30 years, but nobody knows exactly how long!**

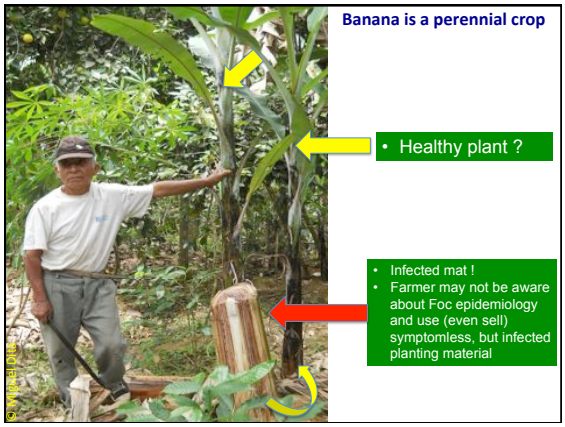
Epidemiology of Fusarium wilt of banana



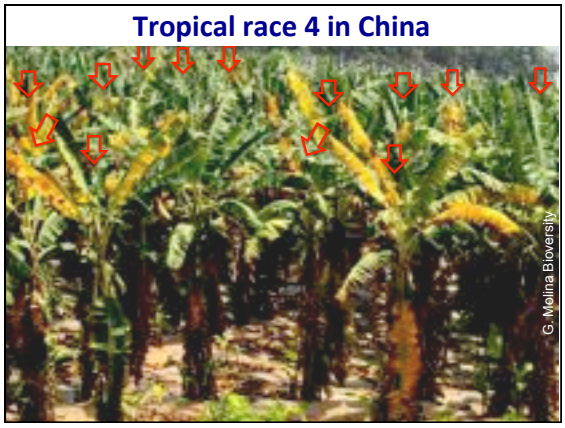

Necrosis in the secundary xilema vessels
Penetration by secundary roots
Germination
Microconidia
Macroconidia
Chlamydospores


Epidemiology of Fusarium wilt of banana
Planting material
soil
water
weeds
Disease Center

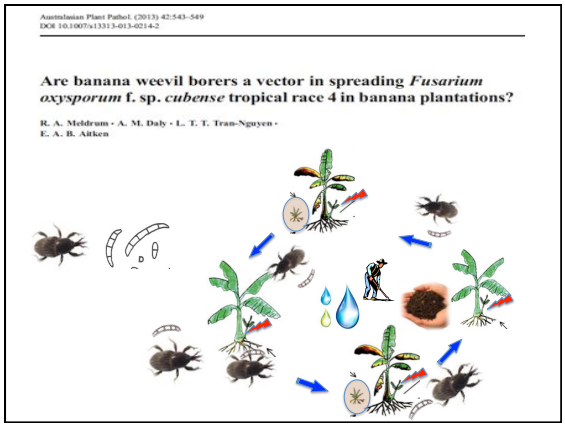

Foc is a soil-borne fungi
Dissemination by symptomless, but infected planting material
Photo: Ploetz, 2009


Banana is a perennial crop
• Healthy plant ?
• Infected mat !
• Farmer may not be aware about Foc epidemiology and use (even sell) symptomless, but infected planting material


Dissemination by contaminated soil and plant debris
Banana field in China, © Miguel Dita. 2009


Tropical race 4 in China
G. Molina Bioversity

Dissemination by contaminated soil and plant debris



Australasian Plant Pathol. (2013) 42:543–549
DOI 10.1007/s13313-013-0214-2

Are banana weevil borers a vector in spreading *Fusarium oxysporum* f. sp. *cubense* tropical race 4 in banana plantations?

R. A. Meldrum · A. M. Daly · L. T. T. Tran-Nguyen · E. A. B. Aitken

CSIRO PUBLISHING
www.publish.csiro.au/journals/app
Australasian Plant Pathology, 2005, 34, 115–117

SHORT RESEARCH NOTES

Weed hosts of *Fusarium oxysporum* f. sp. *cubense* tropical race 4 in northern Australia

Chelsea Hennessy[A], *Geoff Waldsuck*[B], *Andrew Daly*[B] *and Anna Padovan*[C,D]

[A]Charles Darwin University, Faculty of Education, Health & Science, Darwin, NT 0909, Australia.
[B]Northern Territory Department of Business, Industry & Resource Development (DBIRD), GPO Box 3000, Darwin, NT 0801, Australia.
[C]CSIRO Plant Industry, PMB 44, Winnellie, NT 0822, Australia.
[D]Corresponding author. Email: anna.padovan@csiro.au

Cyanthillium cinereum
Little ironweed

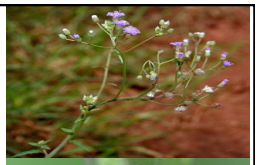
Chloris inflata
Purpletop Rhodes grass

Tridax procumbens
[Tridax daisy]

Milkweed
Euphorbia heterophylla

Cyanthillium cinereum (L.) H. Rob.

Little ironweed



Synonyms

Conyza cinerea L.

Vernonia cinerea (L.) Less. var. *parviflora* (Reinw.) DC.

Senecioides cinerea (L.) Kuntze ex Britton & P. Wilson

Vernonia cinerea (L.) Less.

http://uforest.org/Species/C/Cyanthillium_cinereum.html

Tridax procumbens
[Tridax daisy]

Scientific Name: Tridax procumbens L.
Common Names : coat buttons, coatbuttons, Mexican daisy, tridax, tridax daisy, wild daisy
Family
Asteraceae (New South Wales, Queensland, Victoria, Tasmania, Western Australia and the Northern Territory)
Compositae (South Australia)
Origin
Native to Mexico, Central America (i.e. Belize, Costa Rica, El Salvador, Guatemala, Honduras and Nicaragua) and tropical South America (i.e. Venezuela, Bolivia, Colombia and Peru).
Naturalised Distribution

Widely naturalised in northern and eastern Australia (i.e. throughout large parts of Queensland, in far north-eastern New South Wales, in the northern and central parts of the Northern Territory, and in Western Australia). Also naturalised on Christmas Island, the Cocos Islands and the Coral Sea Islands.

Naturalised elsewhere in the tropical regions of the world, including in south-eastern USA (i.e. Florida), Africa (e.g. Zimbabwe), south-eastern Asia (i.e. Papua New Guinea, the Philippines, Cambodia, Indonesia, Malaysia, Singapore, Thailand and Vietnam), and on numerous Pacific islands (e.g. the Gal pagos Islands, Fiji, French Polynesia, Guam, Kiribati, the Marshall Islands, Nauru, New Caledonia, Palau, Western Samoa, the Solomon Islands and Hawaii).
Impacts
Notes
Tridax daisy (Tridax procumbens) is regarded as an environmental weed in Western Australia, the Northern Territory and Queensland.

http://uforest.org/Species/C/Cyanthillium_cinereum.html

Chloris inflata
Purpletop Rhodes grass

Synonyms
Andropogon barbatus L.
Chloris barbata Sw.
Common Names
airport grass, Mexican blue grass, purple top chloris, purple top Rhodes grass, purple-top chloris, purpletop chloris, purple-top Rhodes grass, purpletop Rhodes grass, swollen finger grass, swollen fingergrass, swollen windmill grass
Family
Gramineae (South Australia)
Poaceae (Queensland, New South Wales, the ACT, Victoria, Tasmania, Western Australia and the Northern Territory)
Origin
This species is widespread in the tropics and sub-tropics, and its exact origin is uncertain. It is most likely native to Central and South America or perhaps south-eastern Asia.
Naturalised Distribution
Widely naturalised in northern Australia (i.e. in northern, central and south-eastern Queensland, northern and north-western Western Australia, north-eastern South Australia and many parts of the Northern Territory). Also naturalised on Christmas Island and on the Cocos Islands.
Naturalised overseas in southern USA (i.e. Florida and Texas) and on numerous Pacific islands.

Notes
Purpletop Rhodes grass (Chloris inflata) is an environmental weed in central and northern Queensland, the Northern Territory and northern Western Australia. In the northern regions of Australia it is an aggressive invader of degraded land and coastal sites. It and is actively managed by community groups in the Northern Territory. This species is primarily found along roadsides and footpaths, in disturbed sites and waste areas, and in pastures. It spreads from these initial locations into natural habitats, where it out-competes native species.

http://keyserver.lucidcentral.org/weeds/data/03030800-0b07-490a-8d04-0605030c0f01/media/Html/Chloris_inflata.htm

Milkweed
Euphorbia heterophylla

Scientific Name: Euphorbia heterophylla L.
Synonyms
Euphorbia cyathophora Murr. (misapplied)
Euphorbia geniculata Ortega
Euphorbia prunifolia Jacq.
Poinsettia geniculata (Ortega) Klotzsch & Garcke
Poinsettia heterophylla (L.) Klotzsch & Garcke
Common Names
desert spurge, fire plant, Japanese poinsettia, Mexican fire plant, Mexican fireplant, milk weed, milkweed, painted euphorbia, painted leaf, painted spurge, paintedleaf, summer poinsettia, various leaved euphorbia, wild poinsettia, wild spurge, yellow spurge
Family
Euphorbiaceae
Origin
Native to tropical America (i.e. from southern USA, through Central America and the Caribbean, south to Argentina).
Naturalised Distribution
Widely naturalised in the northern regions of Australia. This species is most common in the coastal districts of Queensland, in the coastal and sub-coastal districts of the Northern Territory, and in the northernmost parts of Western Australia. It is occasionally also naturalised in other parts of these states, present in south-eastern South Australia, and naturalised on Christmas Island.
Habitat
A weed of crops, orchards, roadsides, gardens, waste areas and disturbed sites in tropical, sub-tropical, semi-arid and occasionally also temperate regions. Also commonly growing in urban bushland and along creekbanks (i.e. in riparian vegetation).

http://keyserver.lucidcentral.org/weeds/data/03030800-0b07-490a-8d04-0605030c0f01/media/Html/Euphorbia_heterophylla.htm

Foc dissemination in the field

Distribution of Fusarium wilt over the time

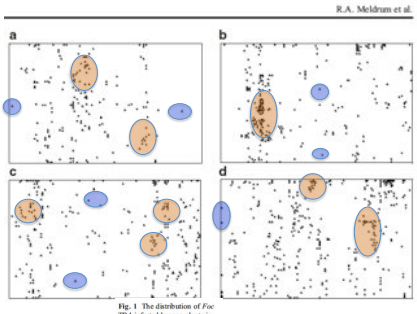


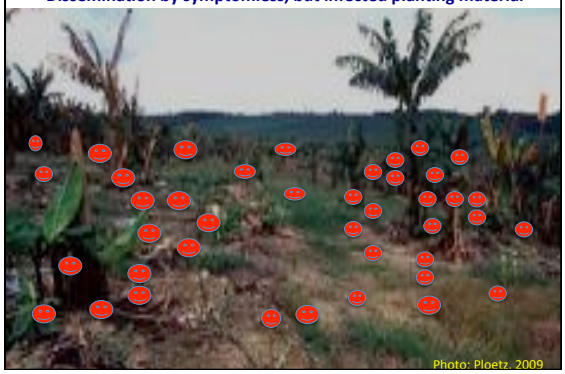
Fig. 1 The distribution of *Foc* TR4-infected banana plants in four fields at Lambells Lagoon in the NT, **a** field 1, **b** field 2, **c** field 3 and **d** field 4, recorded after 20 weeks of assessment, from January to May 2008. Infected plants are represented by (X)

Fusarium oxysporum* f. sp. *cubense *vs. Typhoon*

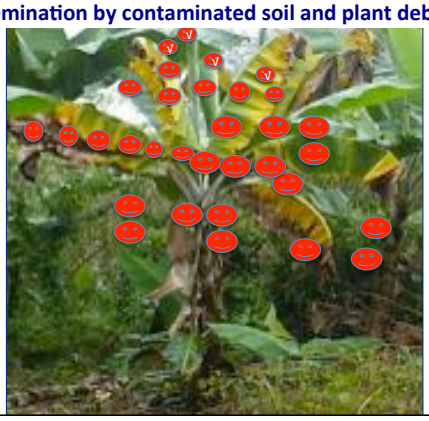
What is the main difference with Fusarium wilt in terms of management ?

Foc a Soilborne fungi

Dissemination by symptomless, but infected planting material

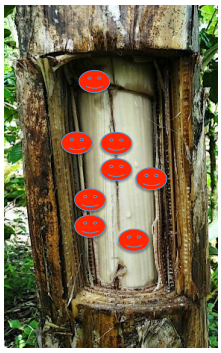


Dissemination by contaminated soil and plant debris



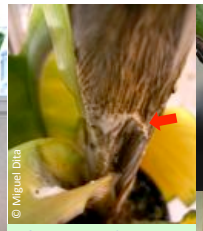
Dissemination by contaminated soil and plant debris

The pathogen is lively present on infected tissues



Dissemination by contaminated soil and plant debris

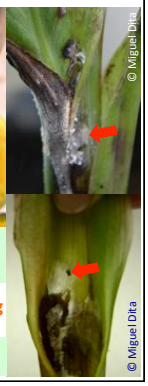
Aerial dissemination of Foc ?



Sporodochia formation and external mycelia growth

Validation under- going

Foc RT4 en Cavendish
Foc R1 Gros Michel



Sporulation of *Fusarium oxysporum* f. sp. *lycopersici* on Stem Surfaces of Tomato Plants and Aerial Dissemination of Inoculum

Talma Katan, E. Shlevin, and J. Katan

irst author: Department of Plant Pathology, ARO, The Volcani Center, P.O. Box 6, Bet Dagan 50250, Israel; and second and third authors: Department of Plant Pathology and Microbiology, The Hebrew University of Jerusalem, Faculty of Agricultural, Food, and Environmental Quality Sciences, Rehovot 76100, Israel.
ccepted for publication 27 March 1997.

Soilborne pathogens are considered monocyclic in nature, namely, they have one life or disease cycle per growing season, although exceptional cases of soilborne pathogens that exhibit polycyclic behavior have been reported.

The airborne conidia of *F. oxysporum* f. sp. *lycopersici* have the capacity to incite a disease, but it is not known whether they can function in the same season to induce disease in different plants under natural conditions.

We assume that deposition on the soil of large numbers of airborne conidia disseminated throughout the season could create new foci of contamination. In the long run, this may be manifested as a polycyclic disease pattern or be considered polyetic .

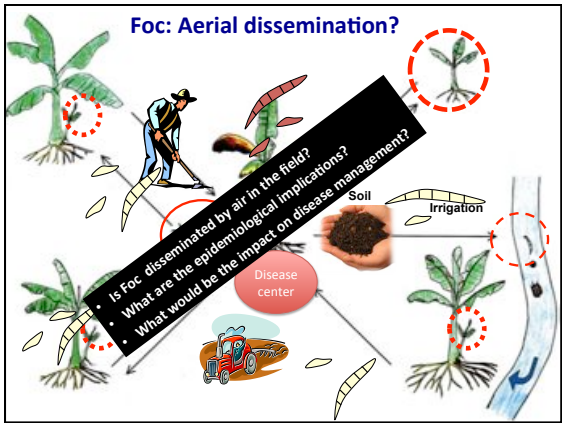
Fig. 1. Sporulation of *Fusarium oxysporum* f. sp. *lycopersici* on the lower stem surface of a diseased cherry tomato plant (natural infection).

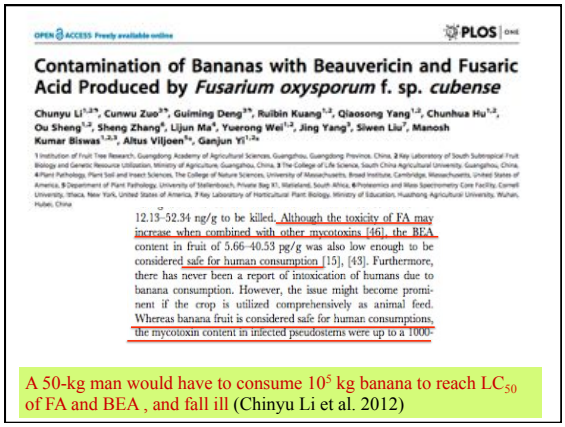
Aerial dissemination of other Fusarium species, as well as sporodochia formation is well-known in other pathosystems Banana-Foc couldn't be an exception

Fusarium lateritium - hazelnut

http://www.apsnet.org/publications/imageresources/Pages/PD_April_2010_Cover.aspx

Foc: Aerial dissemination?





OPEN ACCESS Freely available online

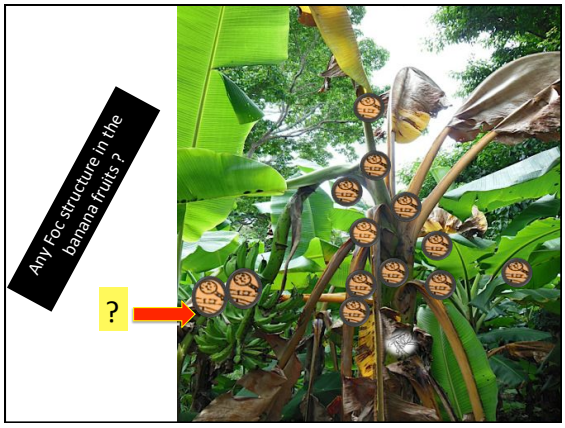
PLOS | ONE

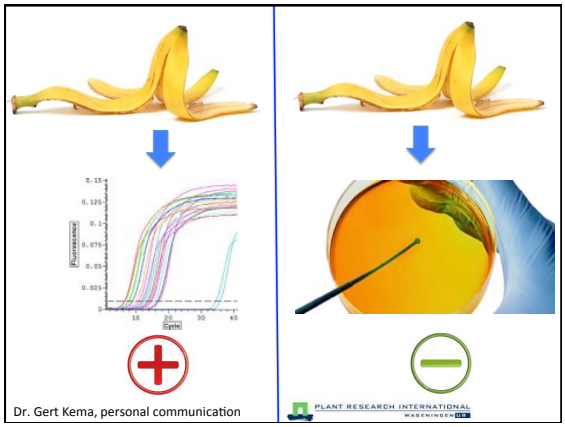
Contamination of Bananas with Beauvericin and Fusaric Acid Produced by *Fusarium oxysporum* f. sp. *cubense*

Chunyu Li[1,2*], Cunwu Zuo[3*], Guiming Deng[3*], Ruibin Kuang[1,2], Qiaosong Yang[1,2], Chunhua Hu[1,2], Ou Sheng[1,2], Sheng Zhang[4], Lijun Ma[5], Yuerong Wei[1,2], Jing Yang[6], Siwen Liu[7], Manosh Kumar Biswas[1,2,3], Altus Viljoen[8*], Ganjun Yi[1,2*]

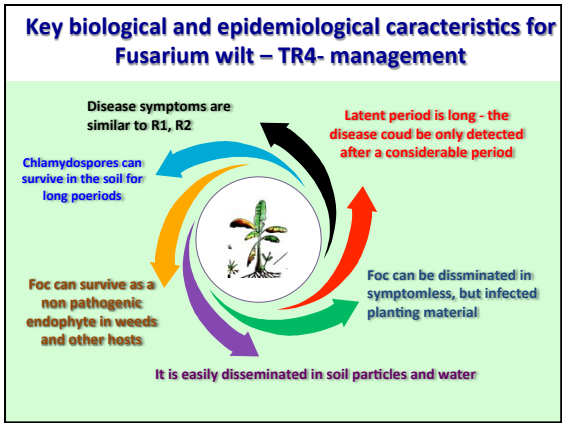
12.13–52.34 ng/g to be killed. Although the toxicity of FA may increase when combined with other mycotoxins [46], the BEA content in fruit of 5.66–40.53 pg/g was also low enough to be considered safe for human consumption [15], [43]. Furthermore, there has never been a report of intoxication of humans due to banana consumption. However, the issue might become prominent if the crop is utilized comprehensively as animal feed. Whereas banana fruit is considered safe for human consumptions, the mycotoxin content in infected pseudostems were up to a 1000-

A 50-kg man would have to consume 10^5 kg banana to reach LC_{50} of FA and BEA , and fall ill (Chinyu Li et al. 2012)




Dr. Gert Kema, personal communication
PLANT RESEARCH INTERNATIONAL
WAGENINGEN UR


If Foc structures are viable in the banana peels, but are not detected in culture medium, large volumes of residues (for example supermarkets) may be a potential source of inoculum!
A-peel for compassion: Go vegan!
PETA


Key biological and epidemiological caracteristics for Fusarium wilt – TR4- management
Disease symptoms are similar to R1, R2
Latent period is long - the disease coud be only detected after a considerable period
Chlamydospores can survive in the soil for long poeriods
Foc can survive as a non pathogenic endophyte in weeds and other hosts
Foc can be dissminated in symptomless, but infected planting material
It is easily disseminated in soil particles and water

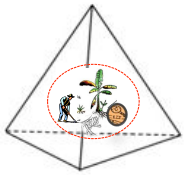
Epidemiology for Integrated Management

Farmer

- Farms with open access with intern walking routes No fences
- Introduction of planting material and soil fom infected sites
- Lack of erradication measures
- Low levels of infomation on disease epidemology
- No application (or lower) of organic ammendements

Pathogen

- High virulent
- Wide host range



Host

- Susceptible variedades
- Monocrop systems Low genetic diversity

Environment

Acid soils
Desqilibrium (Chemical, Phisical, Biological)
Inadequated topography, enabling flooding
Poor drainage; Adequate temperatures

Some key questions

Knowing the epidemiology of this pathogen:

- What would be the management measures to implement in a banana field?
- Why the big banana companies just abandoned 'Gros Michel' and planted Cavendish?
- What would be the measure(s) more important(s) to implement in LAC towards Foc TR4?

GRACIAS

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