EPIDEMIOLOGY: BASIC CONCEPTS

The disease is not the rule; it is the exception.

Epidemiology?
What it means?

So... Epidemiology is about knowing the population and in plant pathology is not easy yes or no?

The Greek philosopher Hippocrates (around 400 BC) used the term epidemic:

epi = about, demo = population.
Epidemiology of Fusarium wilt of banana: Critical aspects for Sustainable Management

For the purposes of this course we will use 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: \[ Y_{0} + rt \]

\( Y \) = disease // \( Y_{0} \) = 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

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, oval- or bean-shaped, borne in false heads
Macroconidia are 27 - 55 x 3.1 - 5.3 µm, four- to eight-celled and sickle-shaped with foot-shaped basal cell
Chlamydospores: Terminal and intercalary are 7 - 11 µm in diameter and are formed singly or in pairs in hyphae or conidia

• Fox: "100 formers specialties cause wilting in plants
It contains pathogenic and saprophytic strains that cannot be distinguished morphologically

Source: Ploetz (2000)
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 Fusarium wilt epidemiology

- Are developed from hypha or conidia, have 1-2 cells
- Thicken 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
Epidemiology of Fusarium wilt of banana

Foc is a soil-borne fungi
Dissemination by symptomless, but infected planting material
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

Banana field in China, © G. Molina Bioversity
Dissemination by contaminated soil and plant debris

![Image of contaminated soil and plant debris](http://cdn5.wn.com/pd/9a/9a91faa594e04388b8d8c8650f65_grande.jpg)

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

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![Diagram of banana weevil borers as vectors](image_url)
Chloris inflata
Purpletop Rhodes grass

Synonyms:
Andropogon inflatus L.
Chloris inflata Steud.

Common Names:
airport grass, Mexican blue grass, purple top chloris, purple top Rhodes grass, purple top choris, purple top Rhodes grass, purpletop Rhodes grass, swollen finger grass, swollen finger grass, swollen varnelli 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 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 invasive species of degraded land and coastal dunes. It is actively managed by community groups in the Northern Territory. The 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 competes with other species.

Chloris inflata
Purpletop Rhodes grass

Milkweed
Euphorbia heterophylla

Scientific Name: Euphorbia heterophylla L.
Synonyms:
Euphorbia heterophylla Maurit. (misapplied)

Common Names:
desert spurge, fire plant, Japanese poinsettia, Mexican fire plant, Mexican fireplant, milk weed, milkweed, painted euphorbia, painted leaf, painted spurge, paintedweed, summer poinsettia, summer painted euphorbia, wild poinsettia, wild spurge, yellow spurge

Family:
Euphorbiaceae

Origin:
Na-ve 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 mainly seen in the coastal districts of Queensland, in the coastal and sub-coastal districts of the Northern Territory, and in the north-western parts of Western Australia. It is occasionally also naturalised in other parts of those states, present in south-eastern South Australia, and naturalised on Christmas Island.

Notes:
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 creeksides (i.e. in riparian vegetation).
According to Horticulture Plant Protection Department (2007), reported that epidemic rates of Foc race 4 in Sumatra and other provinces reach 100 km/year.

Distribution of Fusarium wilt over the time

Foc dissemination in the field

Next victim

RIP - Killed by TR4

Future victim?
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

[Image of a field affected by Fusarium wilt]

[Image of symptomless but infected planting material]

[Image of dissemination by contaminated soil and plant debris]
The pathogen is likely 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 Gros Michel ©"Miguel" Dita"
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 polycyclic.

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

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

Fusarium lateritum - hazelnut

Foc: Aerial dissemination?

+ Is Foc disseminated by air in the field? Yes.
+ Is the aerial dissemination biologically meaningful? Yes.
+ What are the effects of aerial dissemination? Disease center.
A 50-kg man would have to consume 10 kg of bananas to reach LC50 of FA and BEA, and fall ill (Chinyu Li et al. 2012).
If Foc structures are stable 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.

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

**Farmer**
- Farms with open access with intern walking routes
- No fences
- Introduction of planting material and soil from infected sites
- Low levels of information on disease epidemiology
- Lack of eradication measures
- No application (or lower) of organic amendments

**Pathogen**
- High virulent
- Wide host range
- Acid soils
- Disequilibrium (Chemical, Physical, Biological)
- Inadequate topography, enabling flooding
- Poor drainage; Adequate temperatures
- Monocrop systems
- Low genetic diversity

**Host**
- Incompatible varieties

**Environment**
- Acid soils

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**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?

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**GRACIAS**

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