Citrus Leprosis, a Major Threat to Production of Oranges

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July 7, 2010

Overview

- Economic importance
- Distribution
- Geographic Distribution of Citrus leprosis
- Citrus Leprosis pathosystem
- Spread
- Emergency response and management

Economic importance

- Emergence of mite vectored viruses
  - Increase in importance
  - Localized symptoms characteristic of diseases associated with these vectors
  - Becomes important where attacks by the vector mite are significant

Economic importance

- Mite groups implicated
  - Eriophyidae
    - Vectors of several Rymo, Clostero and possibly Nepo-viruses (*Kitajima et. al., 2003*)
  - Tenuipalpidae
    - Brevipalpus mites emerging threat as virus vectors
    - Associated with an economically important disease ***CITRUS LEPROSIS***

Economic importance

- The *Brevipalpus* spp. are widely distributed
  - *B. obovatus,B. phoenicis and B. californicus* most economically important
  - Vectors involved in the Citrus Leprosis pathosystem

- Only in the presence of Citrus Leprosis virus are these species considered key pests
- Severe losses in yield may occur (Rodrigues et al., 2003):
  - If mite control is not effective
  - If citrus cultivar is susceptible

Economic importance

- *Losses due to:*
  - Increase in cost of production
    - Brazil spends US $80 million each year to control vector
  - Reduced yield both in quantity and quality of fruit
    - Lower commercial value of spotted fruit especially for fresh market
  - Decline/death of the trees shortening the life of the orchard

Economic importance

- Citrus Leprosis prior to its disappearance from Florida after 1960 almost decimated the citrus industry (Childers, 2001)

- Fawcett (1907) estimated loss of 35-75% to the Florida citrus industry; figures are similar to that recorded in Brazil (Rodrigues et. al., 2003)

Economic importance

- Citrus Leprosis disease is one of the most economically important disease of Brazil (Bastianel et. al., 2010)
  - Environmental conditions favour vector development
  - Vector colonizes citrus throughout the year
  - Large contiguous areas planted
  - 80% of plantings highly susceptible sweet orange varieties

Economic importance

- Endemic presence of virus in traditional citrus growing regions
- Epidemics occur during drought, favours mite reproduction and CiLV-C spread
- In years where citrus prices are low this discourages growers from applying acaricides this may lead to epidemics

Geographic Distribution of Citrus Leprosis

- *South America*
  - Endemic to
    - Argentina (1930s)
    - Paraguay & Uruguay (1950s)
    - Brazil (1940's)
  - Recently detected in
    - Bolivia (2003)
    - Colombia (2006)
    - Venezuela (1999)

- *Spread northward to*
  - Central America
    - Panama (2000)
    - Costa Rica (2000)
    - Nicaragua (2003)
    - Guatemala (2003)
    - Honduras (2003)
    - El Salvador (2003)
  - Recently detected in Southern Mexico

Geographic Distribution of Citrus Leprosis

- Proximity of disease to leprosis free areas
  - The United States
  - Caribbean Islands
- Potential introduction/reintroduction, spread and damage a cause for concern
- Potential vectors are already present in the PRA
  - Eg *Brevipalpus phoenicis* is present in Jamaica

Geographic Distribution of Citrus Leprosis

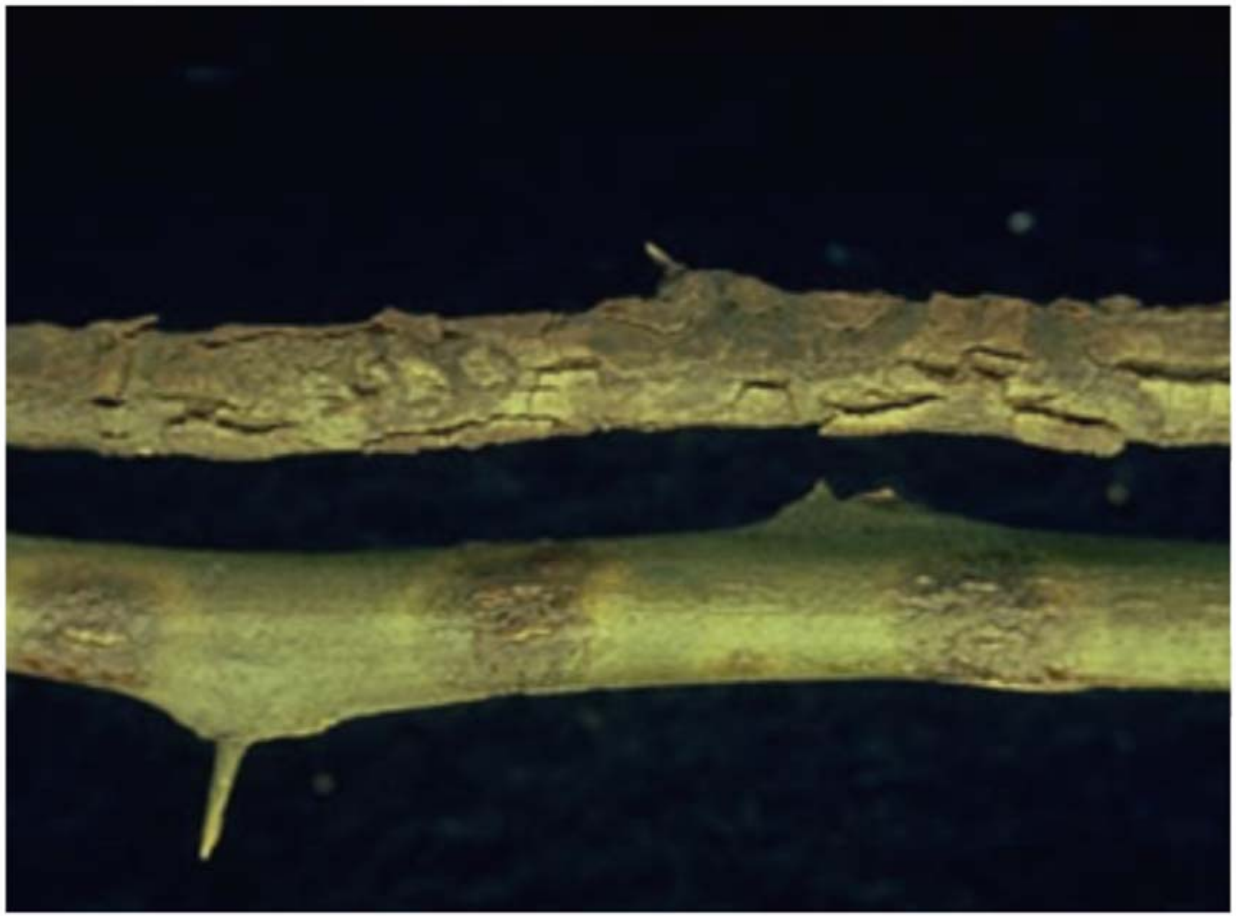
- Citrus industries of Florida and Jamaica being impacted by presence of citrus greening
- Jamaican citrus industry already rebounding from Citrus tristeza however faces competition from cheaper imported concentrates and economic challenges

Citrus Leprosis Pathosystem

- *Symptoms*
  - Can take several weeks to months to appear
  - Present on citrus leaves, stems and fruits
  - Varies with host species
  - Varies with stage of development
  - Varies with the pathogen isolates
  - Typical lesions can be described as follows:
    - » Chlorotic or necrotic
    - » Circular with diameter ranging from 5-12 mm
    - » Localized where mites have fed
    - » Darker central point in older lesions may also be observed
    - » Ring spots may also occur

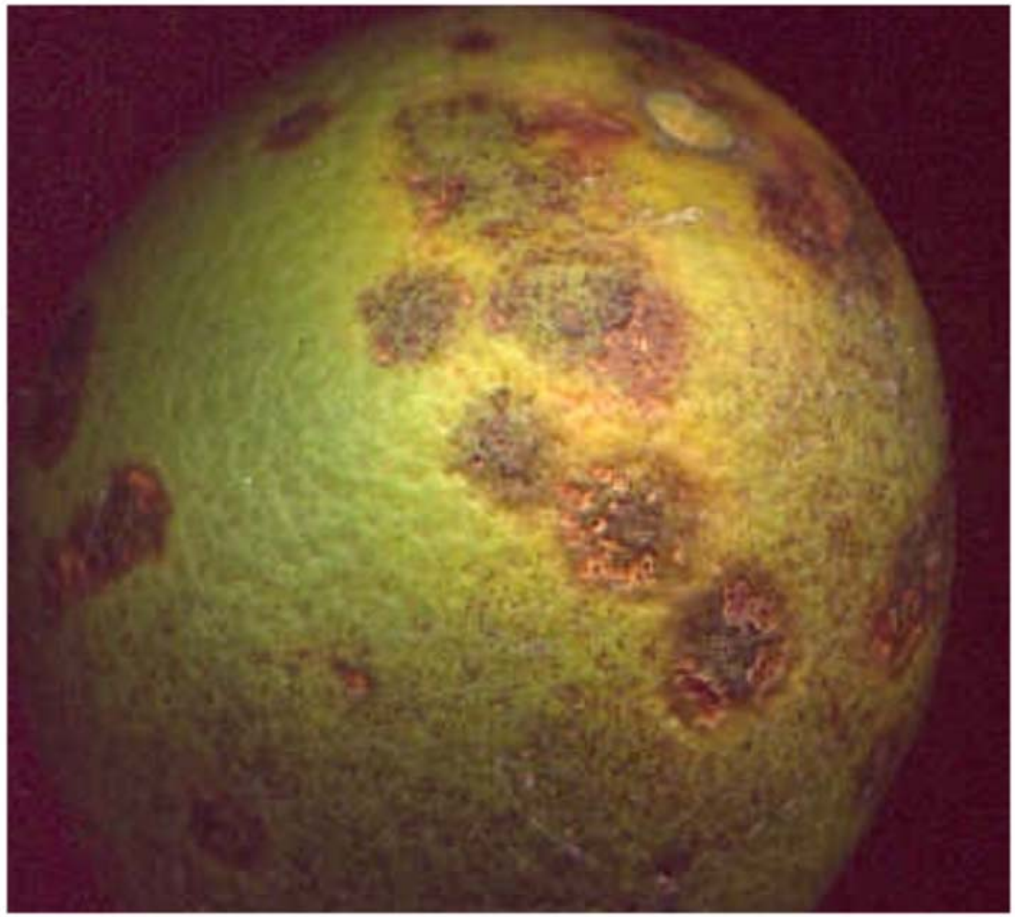
Foliar symptoms on Citrus Leaves

Photo: Carlos Amadeu Leite de Oliveira, Universidade Estadual Paulista, Bugwood.org



Lesions on stem

Photo: Carlos Amadeu Leite de Oliveira, Universidade Estadual Paulista, Bugwood.org



Lesions on Fruits

Photo: Carlos Amadeu Leite de Oliveira, Universidade Estadual Paulista, Bugwood.org

Citrus Leprosis Pathosystem

- *Symptoms*
  - Trees
    - Decrease in production due to reduction in tree canopy development
    - Premature fruit and leaf drop
    - Dieback
    - Even death of young susceptible plants

Photo: Carlos Amadeu Leite de Oliveira, Universidade Estadual Paulista, Bugwood.org

Citrus Leprosis Pathosystem

- *Etiology*
  - In Florida initially thought to be caused by fungi due to the association of certain fungi with scaly bark symptoms (Fawcett and Burger, 1911)
  - After its appearance in Brazil it was thought be caused by a virus due to presence of ringspot symptoms usually associated with viral pathogens

Citrus Leprosis Pathosystem

- *Etiology*
  - In Argentina it was demonstrated that citrus leprosis was transmitted by a mite – identified later as *Brevipalpus obovatus Donnadieu* (Vergani, 1945)
  - Later confirmed in the US, Knorr (1950);
    - Transmitted by *B. californicus* Banks in Florida and Guatemala
  - In Brazil, Musumecci and Rosetti (1963) associated *B. phoenicis* Giejskes with symptomatic plants

Eric Erbe USDA ARS, Budwood.org

304µm

Brevipalpus phoenicis Adult

Citrus Leprosis Pathosystem

Association with Citrus Leprosis symptoms

Symptoms attributed to
- Saliva Toxins from mite?
- Pathogen such as virus?

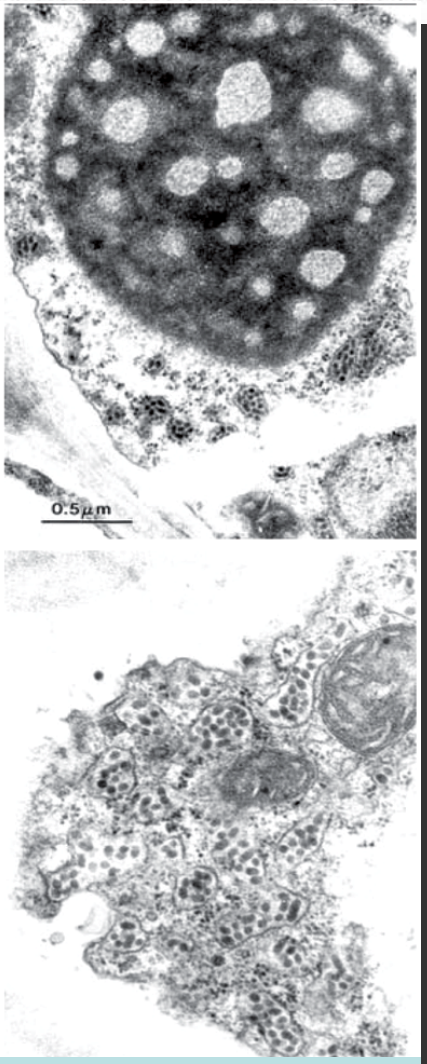
Brevipalpus mites

Etiology

Experiments proved viral cause:
- Leprosis transmissible via tip grafting to receptor tissue on healthy plants
- Bacilliform virus-like particles observed only in symptomatic tissues
- Typical symptoms of leprosis reproduced following mechanical sap inoculation
- Only mites with access to lesions caused leprosis

Citrus Leprosis Pathosystem

- *Etiology*
  - The disease can be caused by two completely distinct viruses (do not share genomic sequences)
    - Citrus Leprosis virus – Cytoplasmic type (CiLV-C) (prevalent form)
    - Citrus Leprosis virus – Nuclear type (CiLV-N) (little known)
      - » Both share similar morphology and vector
      - » CILV-C under consideration as full species



Transmission Electron Microscopy of CiLV-C infected cells exhibiting A) cytoplasmic viroplasm and B) virions in the lumen of the endoplasmic reticulum; (Bastianel et al. 2006)

Citrus Leprosis Pathosystem

- *Etiology*
  - Virus found localized only in conspicuous lesions (Bastianel et al., 2010)
  - Hence infection not systemic but localized

Citrus Leprosis Pathosystem

- *Host Range*
  - Natural
    - Citrus spp. Grapefruits (*C. paradisi*) and oranges (*C. sinensis*) found naturally infected
    - Lemons (*C. limon*) and mandarins (*C. reticulata*) considered less susceptible
    - First Non-citrus host *Swinglea glutinosa* (Rutaceae) reported in Columbia

- *Host Range*
  - Experimental
    - Transmission to viruliferous mites to *Solanum violaefolium*, *Phaseolus vulgaris*, and other species of plants that occur near citrus orchards. (Rodrigues et al., 2005; Bastianel, 2010)
    - List of alternative hosts for CiLV-C growing
    - Role played by alternative hosts in the epidemiology of the disease unknown

Citrus Leprosis Pathosystem

- *Transmission*
  - All active stages of *Brevipalpus* spp can acquire and transmit virus
  - CiLV-C not transovarially transmitted
  - CiLV-C circulative in vector but not propagative (Bastianel et al., 2010)

Spread

- Symptomless tissue considered CiLV-free and use for grafting should not permit propagation of the disease
- Main means of spread through feeding and movement of viruliferous mites.
- *Brevipalpus* mites have been found infesting more than 200 different plant species
  - » (Rodrigues et.al., 2003)

Spread

- However, known plant hosts of *B. californicus*, *B. obovatus* and *B. phoenicis* include nearly 100 species
- Rate of increase of citrus leprosis is proportional to the amount of disease and the amount of available healthy tissue.
  - » (Rodrigues et.al., 2003)

Spread

- *International spread*
  - Pathogen more likely to be spread on rooted symptomless plants harbouring viruliferous mites
  - Happens when plants are moved illegally from region to region
  - Little known re role of alternative natural hosts for virus may be slight risk of introduction via other plant species
  - Other plants could carry viruliferous mites because they are polyphagous and could move from citrus to other hosts

» (Rodrigues et.al., 2003)

Spread

- Childers and Rodrigues (2005) found that plant shipments arriving via air cargo from Central America contained:
  - Mites from 11 families recovered from a variety of ornamental plant genera
  - The mite species included B. Phoenicis
  - Paper suggested:
    - a special sampling program for mites on live plant material received at ports of entry
    - New legislation for imported plant propagules to be free of pest mites
    - Mandatory risk mitigation in nurseries abroad where shipments originate

Spread

- *Current spread in Central America*
  - Most likely disease went unnoticed for some time
  - If the vector is not managed the disease will spread though slowly at first and damage will be evident in 2 to 3 years
  - Leprosis is considered a polyetic disease in that the amount of infected tissue as well as initial inoculum increases yearly
    - » (Bastianel et al., 2010)

Emergency Response and Management

- *Eradication*
  - Attempts made by countries after first report
  - Began too late, when symptoms identified the disease had already spread for some time
  - Success in Costa Rica limited area affected but country still threatened by detection of disease in Nicaragua
  - Success in the US
    - Attributed to use of sulfur acaricides and unfavourable climatic weather
    - Possibility that virus present in US was the CiLV-N
      - Low fitness of virus?
        - » (Bastianel et al., 2010)

Emergency Response and Management

Recommended approaches (Childers et. al. 2001)

- Establish quarantine re movement of citrus plant parts from affected countries
- Develop a programme for rapid detection and identification of disease symptoms and pathogen Linkages with the Universities
- Public Awareness campaigns with images of symptoms of the disease and of the vector
  - Sensitize growers/stakeholders
- Develop a monitoring programme
- Establish area-wide management zones to facilitate treatments

Emergency Response and Management

- Those countries who are currently living with the disease such as Brazil are faced with
- Increased production costs due to:
  - Continued scouting of fields
    - One to two % inspection
  - Application of acaricides which must be timed using empirical threshold
    - When incidence of mites on assessed fruits and branches reaches 10%
      - » (Bastianel et al., 2010)

Emergency Response and Management

- Sampling challenges because of low mite population densities and their uneven distribution in orchards
- Economic and environmental impacts of pesticide use are high
- Investigations now showing low correlation between mites and disease foci in the field since only a percentage of population vectors the virus
  - » (Bastianel et al., 2010)

Emergency Response and Management

- Medium term investigations needed
  - Role of alternative hosts in the epidemiology of the disease
  - Identification of environmentally yet efficacious field mite treatments

- Long term solutions include
  - Development of resistant varieties which must also have acceptable horticulture traits

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Thank You