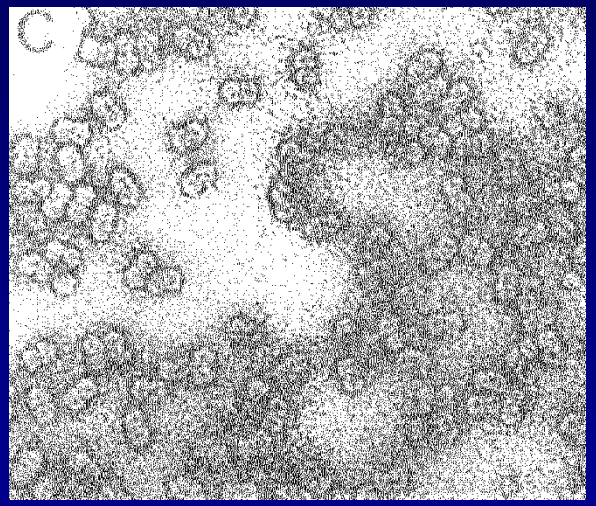
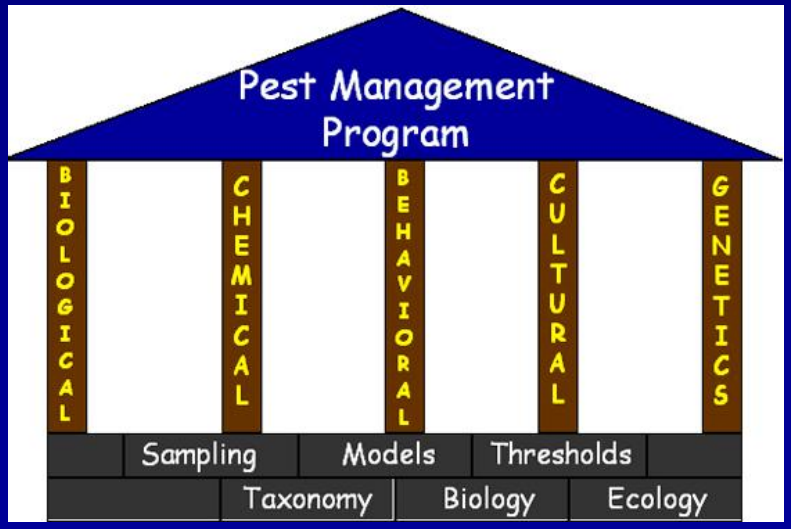
Host-free period for *Tomato yellow leaf curl virus* control



Robert L. Gilbertson
Department of Plant Pathology
University of California-Davis

Integrated Pest Management (IPM) of Insect-Transmitted Plant Viruses

- An approach that combines multiple management strategies (e.g., biological, chemical, cultural, genetic and physical) selected based on knowledge of the biology of the virus(es)
- Goal is efficient management with minimal inputs of pesticide; economically and environmentally friendly
- Three basic steps:
    1. Correct pathogen ID
    2. Understanding pathogen biology/ disease epidemiology
    3. Development and evaluation of an integrated management strategy

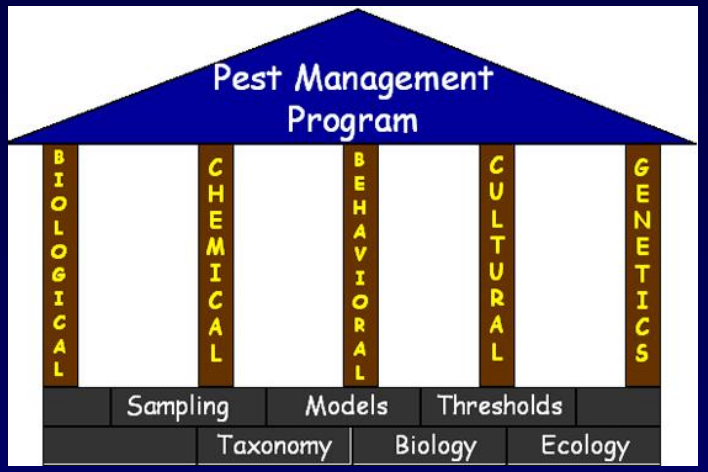


Once the problem is identified: Understanding the biology of the virus is necessary for effective disease management

- **Biology of the virus**
  (host range, mode of transmission, etc.)
- **Biology of the insect vector**
  (host range, population dynamics etc.)
- **Insect-virus interaction**
  (mode of transmission)
- **Sources of inoculum**
  - **-seed**
  - **-weeds/other reservoir hosts**
  - **-old crops**
  - **-insects**
- **Means of survival in the absence of the economic hosts**

Disease management

- Select appropriate management strategies based on knowledge of the biology of the virus
  - -regulatory (do not introduce exotic pathogens on/in seeds and transplants)
  - -avoidance (field location, planting dates)
  - -disease resistance (conventional and transgenic)
  - -pathogen-free propagative materials (seeds and transplants)
  - -protection (screenhouses, greenhouses, row covers)
  - -disease monitoring and forecasting
  - -vector management (insecticides)
  - -removal of diseased plants (roguing)
  - -sanitation (harvested crops, weeds, volunteers)
  - -crop rotation
  - -host-free periods



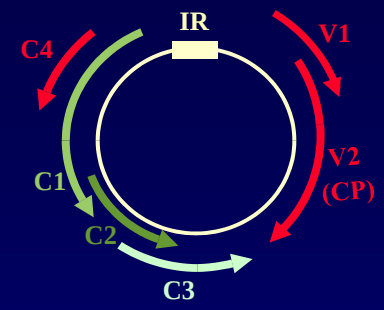
What is a host-free period?

- A means of breaking continuous cropping patterns through a **defined period of time where a susceptible crop(s) is not grown**, resulting in the 'cleansing' of virus inoculum from the agroecosystem
- In temperate regions the winter can provide a natural host-free period
- Best suited to **annual crops harvested over a short period** (e. g., vegetables and cotton)
- **Nature of the host-free period** (e.g., time of year, length, crops involved, area) will depend on crop, cropping system, and virus-host and -vector interaction
- Must be done along with **extensive sanitation**
- Can be **legally enforced or voluntary**

Tomato yellow leaf curl virus (TYLCV)

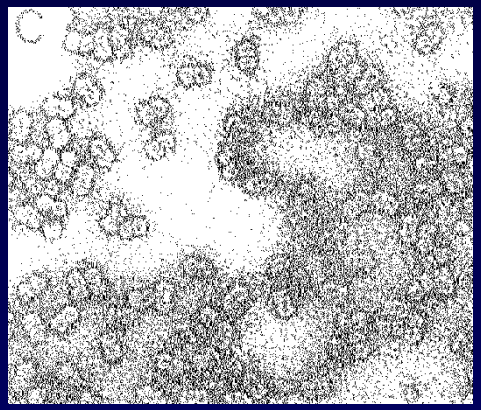
'The mother of all tomato viruses'

- TYLCV was **first described in Israel** around 1940
- Transmitted by the **sweet potato whitefly** (*Bemisia tabaci*)
- Causes the devastating **tomato yellow leaf curl disease (TYLCD)**
- **First begomovirus shown to have a monopartite genome**
- **Introduced into the Western Hemisphere** in the early 1990s
- Now present throughout the Caribbean Basin, Southern USA, Mexico, Guatemala and Venezuela



TYLCV has a monopartite genome

Biological properties that make a host-free period effective for management of TYLCV



TYLCV is a geminivirus

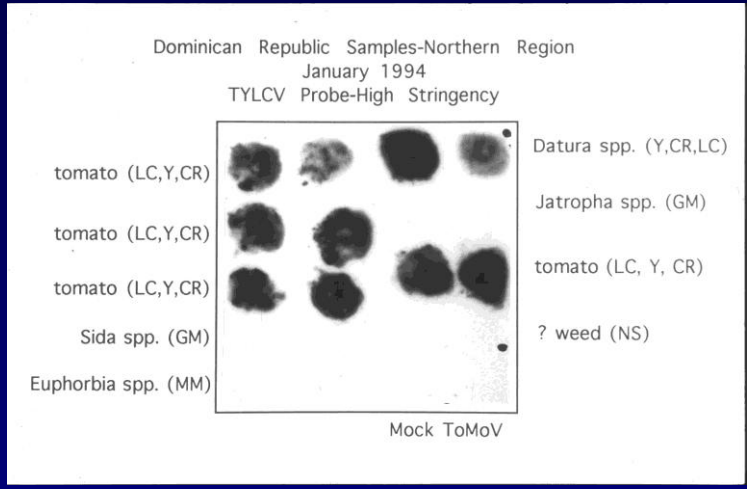
- Not seed-transmitted
- Has a narrow host range (i.e., most important inoculum source is the crop plant itself)
- Host plant (tomato) is an annual crop
- Whitefly vector has a relatively short (~30 day) life cycle and the virus is not transovarially transmitted
- Thus, a 2-3 month host-free period can be a very effective and sustainable management strategy for TYLCV and can also reduce whitefly populations

Implementation of a government-enforced host-free period has been a critical component of a successful IPM program for *Tomato yellow leaf curl virus* in the Dominican Republic

- In the early 1990's TYLCV was inadvertently introduced into the Dominican Republic (DO)
- Molecular tools (PCR and sequencing) confirmed it was TYLCV
- The virus was spread quickly by high populations of indigenous *Bemisia tabaci* and caused heavy losses on the highly susceptible varieties grown in the DO
- TYLCV threatened to destroy the DO processing tomato industry

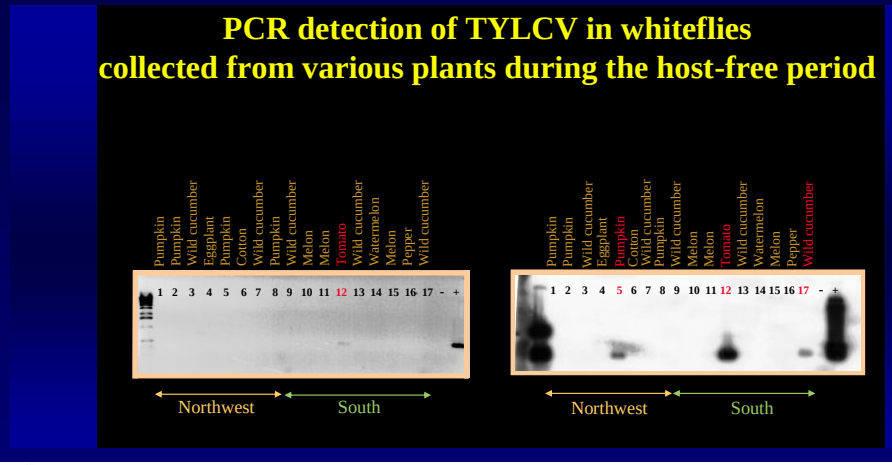
Investigation into the biology of TYLCV in the DO led to establishment of a host-free period for TYLCV

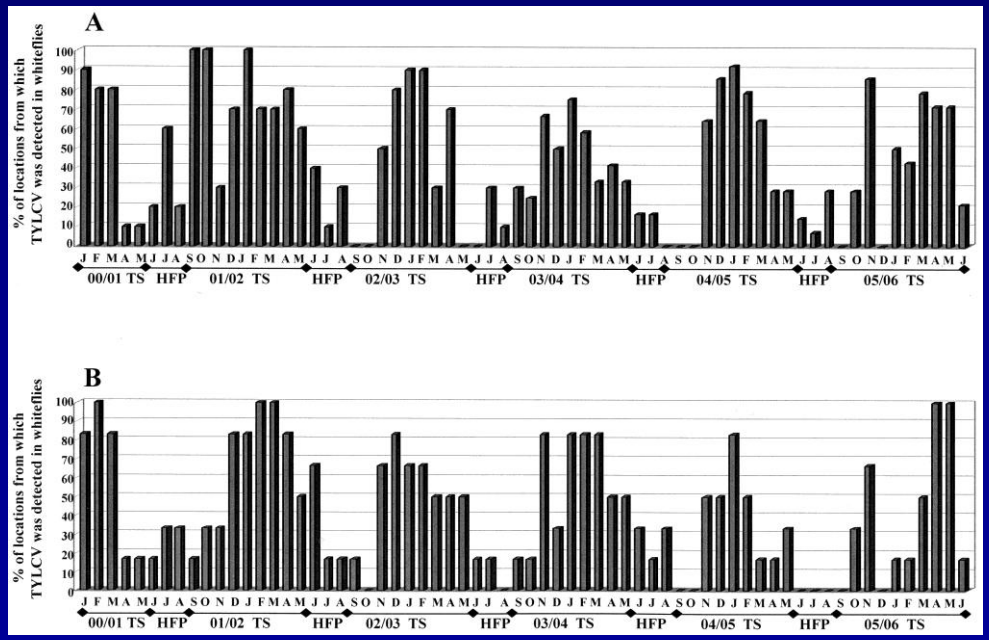
- **Squash blot hybridization** with a TYLCV-specific probe indicated that the virus **was primarily infecting tomato** and not other crops and weeds
- Recommendation was made to **implement a tomato-free period in the main growing areas of the North and South**
- The government decided to **implement a mandatory 3 month whitefly host-free period** to because of the importance of the tomato industry and the damage to other crops by whiteflies



Investigation into the biology of TYLCV in the DO led to establishment of a host free period for TYLCV

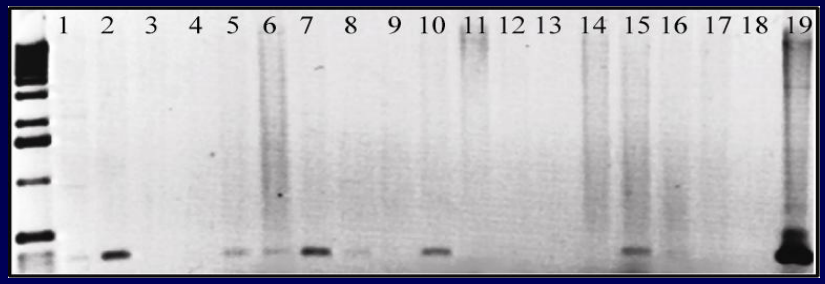
- The host-free period was implemented along with a number of other practices (vector control [esp. in transplants], planting early maturing/resistant varieties), and sanitation
- This IPM approach has been used for ~20 years and has allowed for the recovery of the industry
- Evidence that the host-free period is a key component of this program comes from:
  - -4-8 week delay in the appearance of TYLCV symptoms following the host-free period
  - -Dramatic drop in detection of TYLCV whiteflies during host-free period





Detection of TYLCV in whiteflies

The host-free period stimulated research that revealed other aspects of the biology of TYLCV in the DO



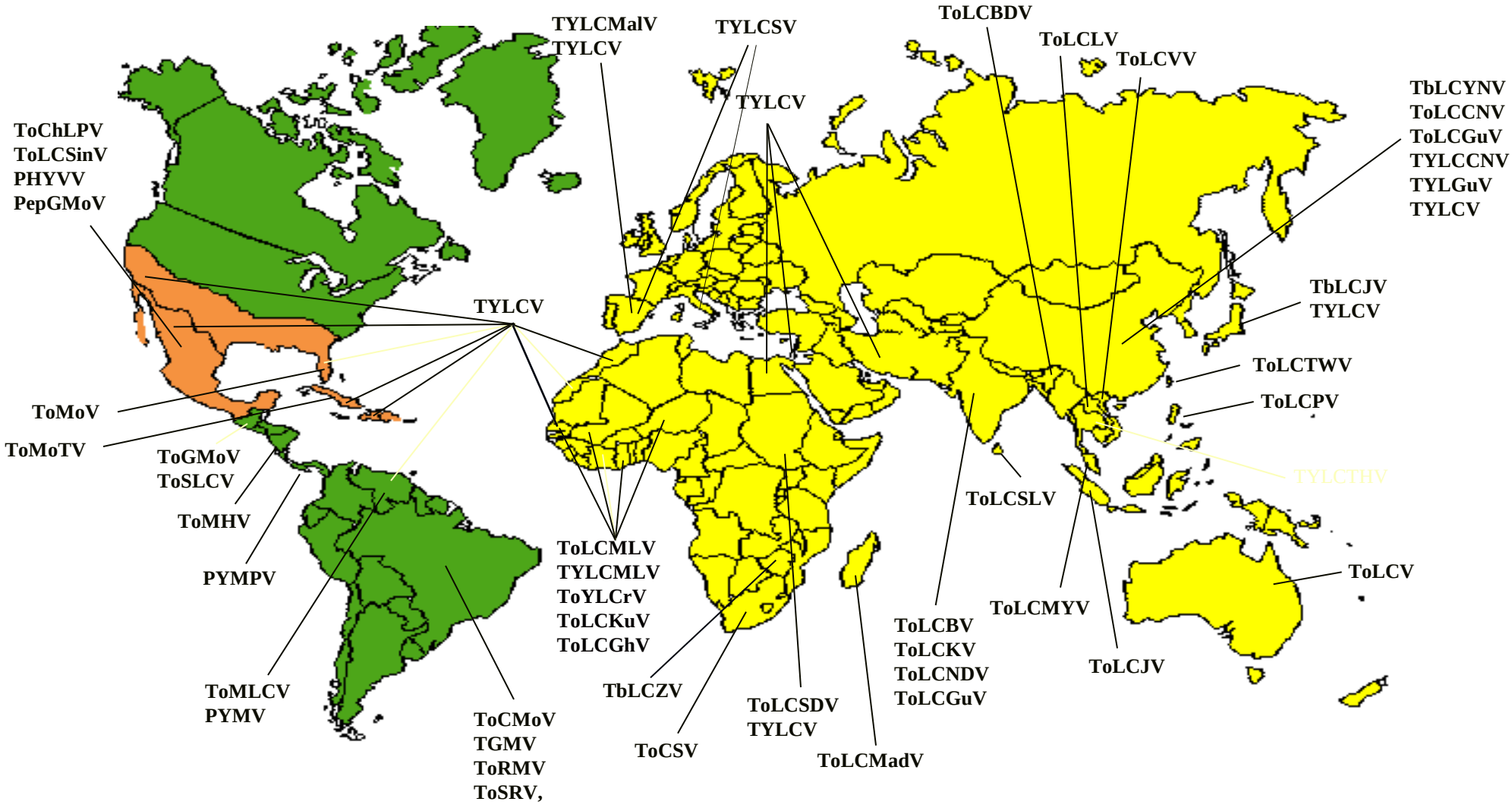
PCR detection of TYLCV in symptomless weeds

- TYLCV persists during the host-free period in symptomless weeds
- This is consistent with an 'edge-effect' for the initial appearance of TYLCV in the field
- Pepper is a poor host of TYLCV, but will develop symptoms under high virus pressure
- Common bean is also a TYLCV host, especially large-seeded Andean types
- Certain TYLCV-resistant tomato varieties sustain high virus titers despite not showing symptoms
- These finding have helped fine-tune or maintain aspects of the host free period

The host-free period in the DO has been a critical component of the IPM program that has allowed for the recovery of the tomato industry

- Three-month period (June/Sept)
- Government-enforced
- Results in a reduction of TYLCV inoculum and whitefly populations
- Provides a 4-8 wk window after planting before TYLCV appears
- Includes peppers, beans, and cucurbits
- Grower acceptance facilitated by education, and it has now become institutionalized
- Violators are a continual challenge

Worldwide Emergence of Tomato-infecting Begomoviruses

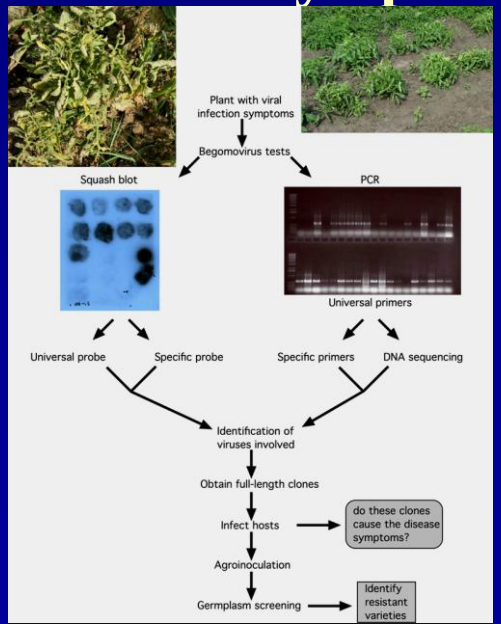


New World
Bipartite
Begomoviruses

Old World
Monopartite
Begomoviruses ± betasatellite

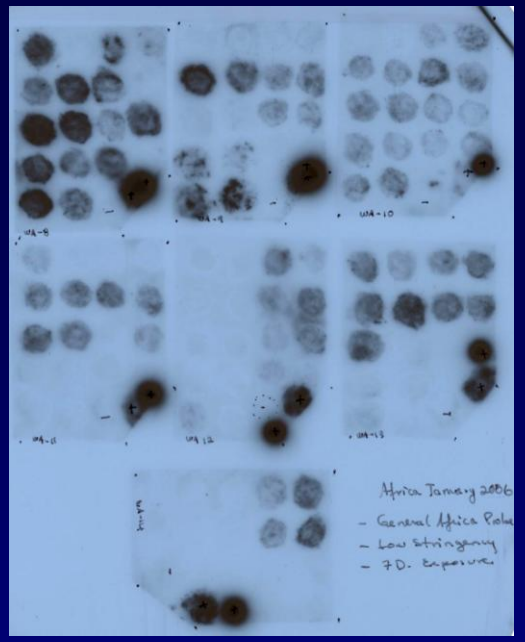
Application of the host-free period for management of whitefly-transmitted geminiviruses (WTGs) in West Africa

- WTGs have emerged as a **major constraint on tomato production** in West Africa
- Molecular characterization has revealed a **complex of at least 5 locally evolved monopartite begomoviruses** and one or more betasatellites causing symptoms of leaf curl, yellow leaf crumple and a severe symptom phenotype

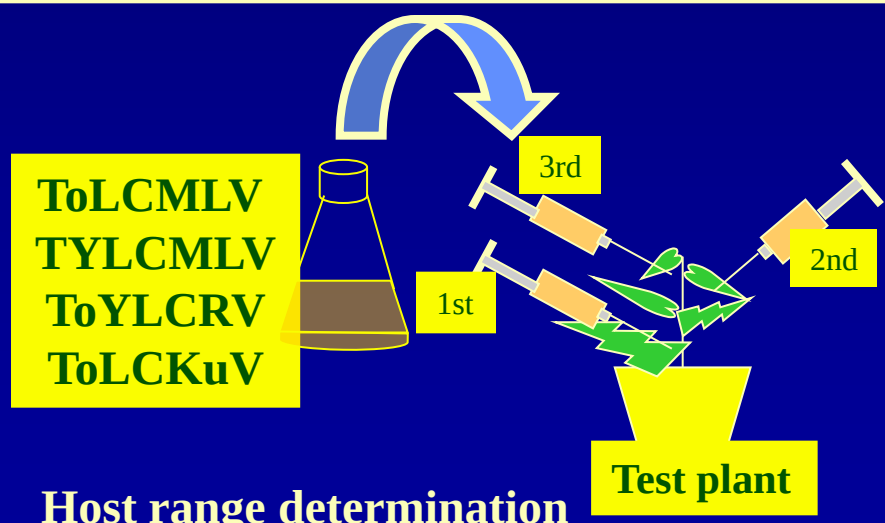


Can a host free period be part of an IPM strategy for the complex of WTGs in West Africa?

- **Squash blot (SB) hybridization and SB-PCR tests** of crops and potential hosts suggested that the West African tomato WTGs have a narrow host range
- **Host range studies performed with infectious clones** of these begomoviruses supported these results and indicated that tomato and tobacco were hosts
- Taken together with the other known biological parameters of WTGs, this suggested that a **host-free period could be an effective management strategy**



Squash blot hybridization for begomovirus detection

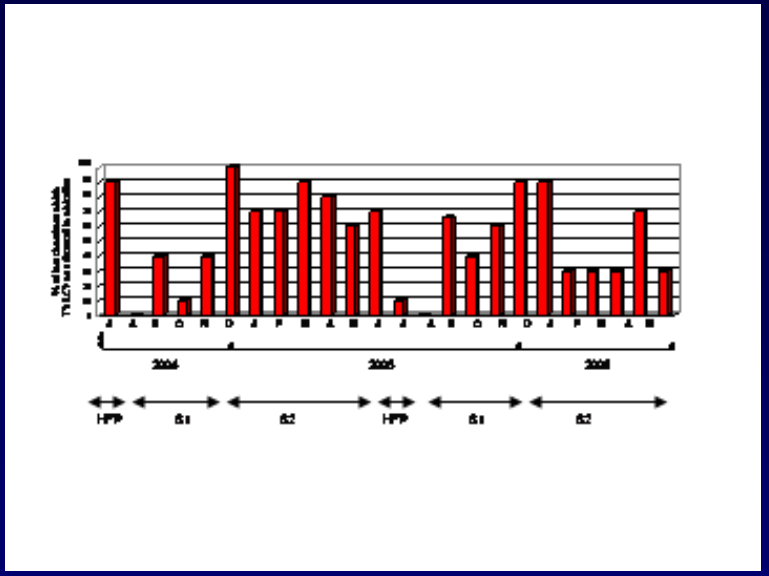


Host range determination by agroinoculation

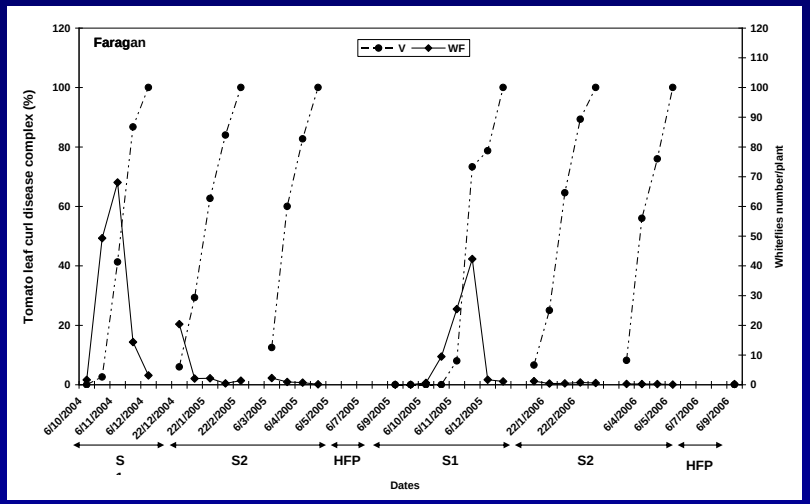
Implementation of the host free period in the Bagiuneda irrigated rice-vegetable perimeter

- The Baguineda irrigated rice-vegetable perimeter was selected as a test site
- This location was so severely impacted by WFGs that tomato production had been abandoned
- The rainy season months (June-August) were selected for implementation of the host-free period
- Meetings were conducted with chiefs of the local villages to explain why the host-free period was needed
- The host-free period was implemented along with the planting of early maturing hybrids and a regional sanitation program beginning in 2005

Application of a voluntary host-free period for management of tomato begomoviruses in West Africa



- Sanitation program initiated: old tomato and pepper plants removed after harvest
- Tomato and pepper free period implemented in June-August
- Seeds of early maturing hybrid tomatoes were distributed to selected farmers
- Monitoring program developed to assess the success of the program
  - -Development of virus symptoms
  - -Detection of virus in whiteflies
  - -Monitoring of whitefly populations



- Saw a reduction in virus levels in whiteflies, delays in development of whitefly populations and virus symptoms and high yields associated with the host-free period

Application of a voluntary host-free period for management of begomoviruses in West Africa

- This program has been ongoing for 5 years
- Has allowed for the return of tomato production to Baguineda (in fact bumper crops have created a need for storage technologies)
- The overall importance of WTGs is declining in Baguineda
- Farmers have embraced the program and are seeking to purchase seed of the early maturing hybrids
- An NGO scaled-up the program to include more farmers in Baguineda and other locations
- Host-free periods are being expanded to new areas in Mali

A host-free period can be an effective tool for control of TYLCV and other tomato begomoviruses

- Based upon knowledge of the biology of the virus
- Should be part of an IPM program (e.g., combined with an effective sanitation program)
- Sustainable and inexpensive
- Must be a regional effort
- Can be voluntary or enforced
- Could be used anywhere where these viruses are a constraint on tomato production

Acknowledgements

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