Tomato spotted wilt and tomato yellow leaf curl: Update on the current status of these insect-transmitted viral diseases

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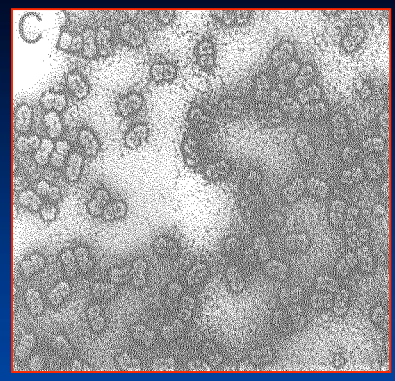
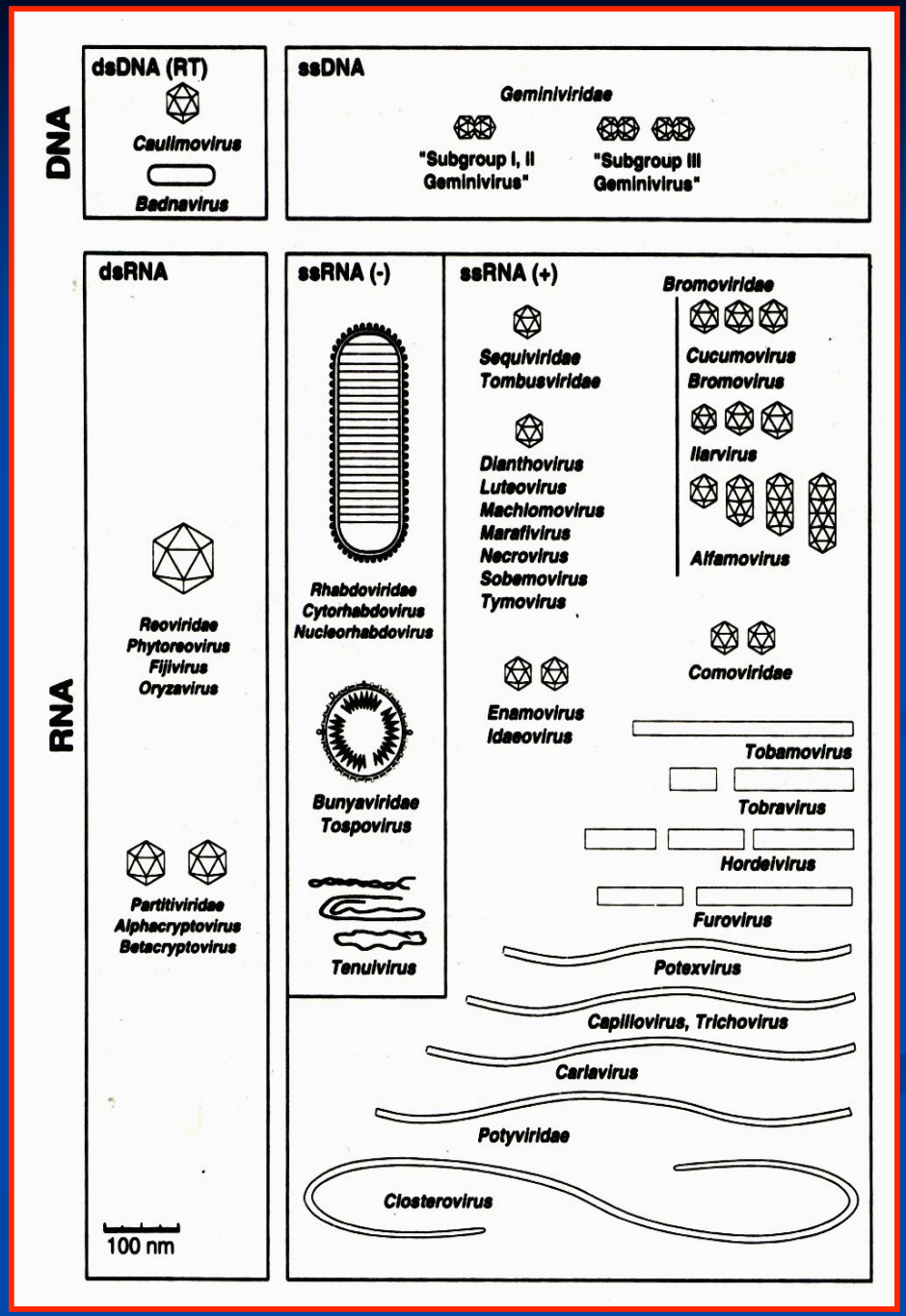
Plant Viruses



- Parasitic genetic elements (RNA or DNA) covered by a protective protein shell
- Viruses take over the cellular machinery of the plant and spread throughout the infected plant
- Plant-to-plant spread of viruses most commonly occurs via insects (also via seed, nematodes, etc.)
- Plant viruses are very difficult to diagnose and control

A striking diversity of viruses have evolved to infect plants



Tomato spotted wilt virus (TSWV): Analysis and Management

Tomato Spotted Wilt Disease

- Common disease of tomato in **tropical and subtropical areas**, such as Mexico, Florida and California
- Caused by ***Tomato spotted wilt virus*** (TSWV) and other related viruses (e.g., ***Impatiens necrotic spot virus***, INSV)
- **Symptoms:** bronzing and necrosis of leaves and stems, chlorotic/yellow ringspots on fruits (can be confused with *Tobacco streak virus* and *Tomato bushy stunt virus*)
- Transmitted by **various species of thrips**, especially the Western flower thrips (*Frankliniella occidentalis*)

Tomato spotted wilt symptoms in tomato in leaves include bronzing, wilting, and necrotic spots and veins

Tomato fruit shows diagnostic ringspots on green and red fruits

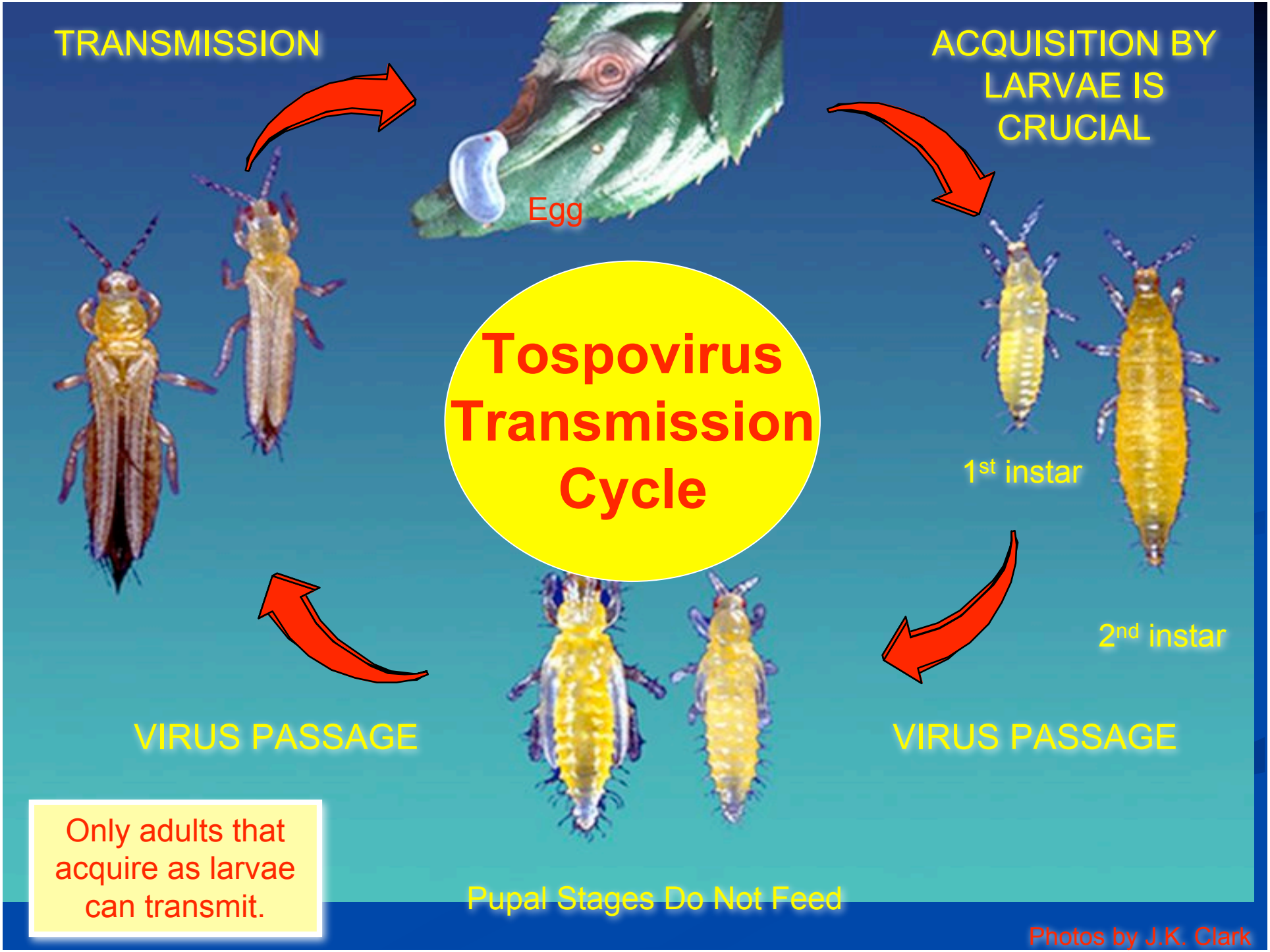
Crops/Ornamentals Susceptible to TSWV

Beans
Calendula
Celery
Cilantro/Coriander
Cole Crops
Dahlia
Eggplant
Gerbera
Gladiolus
Lettuce
Nasturtium
Oregano
Peas
Pepper
Petunia
Sages
Spinach
Sunflower
Tomato

Weeds susceptible To TSWV

Bind weed
Black nightshade
Burr Clover
Chickweed
Cocklebur
Hairy Fleabane
Lambs Quarters
Malva
Miners Lettuce
Nettleleaf Goosefoot
Purslane
Redroot Pigweed
Shepherd's Purse
Slender Pigweed
Sow Thistle
Swine Cress
Yellow Sweet Clover

Richard Smith, Vegetable Crop and Weed Science Farm Advisor,
Monterey County


TRANSMISSION
ACQUISITION BY LARVAE IS CRUCIAL
Egg
Tospovirus Transmission Cycle
1st instar
2nd instar
VIRUS PASSAGE
VIRUS PASSAGE
Only adults that acquire as larvae can transmit.
Pupal Stages Do Not Feed
Photos by J.K. Clark

CTRI Project objectives

- Develop an understanding of when and where TSWV gains entry into California processing tomatoes

  -Monitor thrips populations and virus incidence on transplants and in transplanted and direct-seeded fields

- Identify potential inoculum sources
  - -Crop plants, weeds, ornamentals
  - -Focus on areas having outbreaks

- Assess various thrips control strategies

- Develop a regional integrated management program

Monitoring tomato transplants

- **Transplant greenhouses**
  - -Greenhouse operations were monitored in 2007
  - -Yellow sticky cards for monitoring thrips
  - -Indicator plants and visual inspection for TSWV

- **Results: Relatively low thrips populations (especially in closed greenhouses) and no evidence of TSWV infection of transplants**

Monitoring tomato fields

- Direct-seeded and transplanted
- Thrips to be monitored with yellow sticky cards and flower counts placed at 5 locations within a field
- Virus incidence determined from 50 yards of row, randomly selected, from 5 rows/location (250 yards of row assessed/field)
- TSWV infection confirmed in selected plants with immunostrips

Monitoring tomato fields-Results

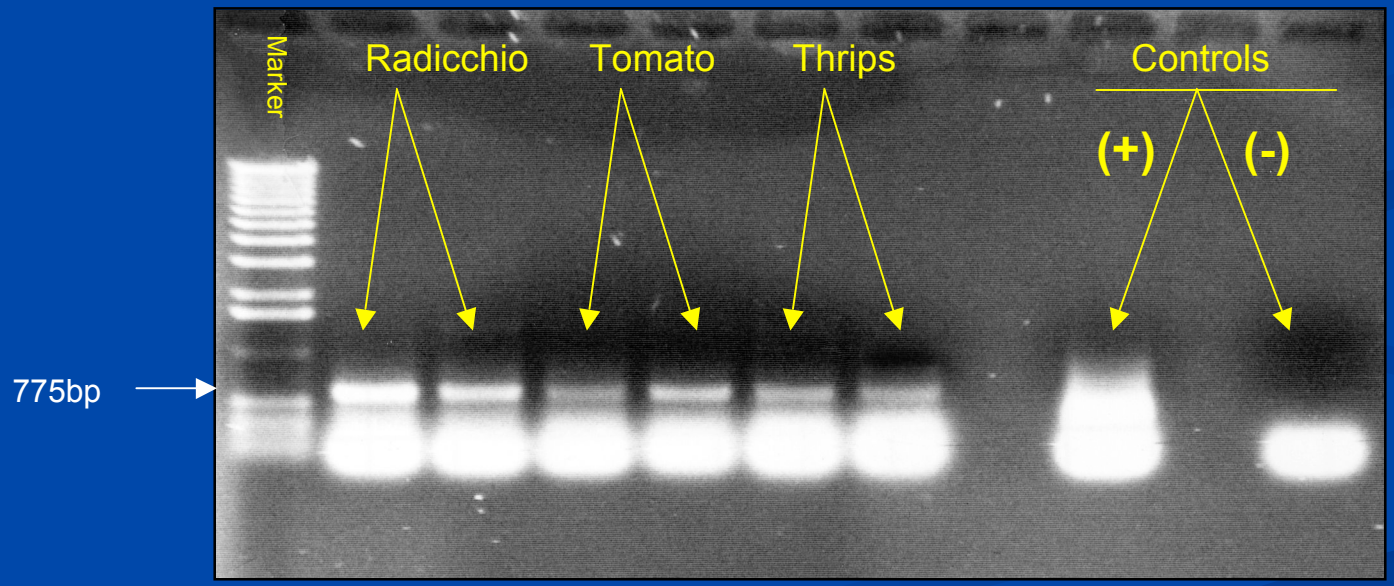
- Thrips populations lower in March/April and peaked from May-July; overall populations low to moderate in 2007
- All were identified as Western flower thrips
- TSWV first detected 20 April at in direct seeded L&J field
- Spotted wilt appeared in all fields, but later and at low incidences (<1%-3%)
- Disease appeared earlier and was slightly higher in the direct-seeded fields
- Larvae were detected in tomato flowers, indicating thrips reproduction

Monitoring tomato fields-Grower alerts for the 2007 growing season

- Growers were promptly advised on the detection of thrips and TSWV in tomato crops via CTRI
- This allowed for implementation of thrips management strategies (primarily chemical control), which seemed to slow the spread of virus (possibly by reducing the number of virus-carrying adults) and the build-up of thrips populations

We can detect the presence of TSWV in thrips by RT-PCR

- Could help determine when virus-carrying thrips are present
- Technically challenging
- Need to be able to tests thrips recovered from sticky cards



Inoculum Sources-Results

- In spring of 2007, radicchio plants from a field in Fresno near newly planted tomato fields showed with stunted growth and spotting, yellowing, and mosaic
- All were positive for TSWV infection
- These symptoms were not observed in 2007 spring lettuce
- Limited testing of weeds has given negative results

Thrips control

- It is important that thrips management be implemented immediately following initial TSWV outbreaks
- Critical to minimize the number of virus-carrying adults (remember only larvae can acquire the virus and become virus-carrying adults)
- Thrips insecticide trials are being conducted at Westside
- Best materials were: Assail, Dimethoate, Lannate, Radiant, and Mustang+Beleaf
- However, the effect was not long-lasting (7-10 days)

Adult thrips

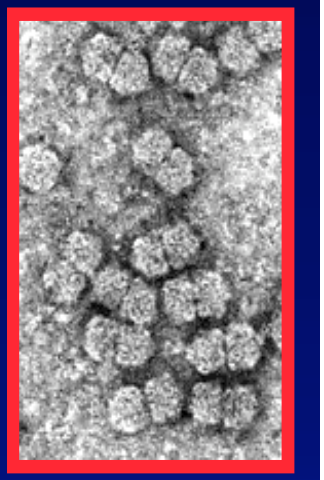
Larval thrips

Integrated TSWV Management

- **Before planting**
  - **-Variety selection (TSWV resistant [Sw-5] varieties)**
  - **-Virus-free transplants**
  - **-Avoid 'hot spots' or fields known to have TSWV**
- **During the season**
  - **-Monitoring for thrips/TSWV**
  - **-Thrips management early (to manage larval populations)/rotate classes of materials used**
  - **-Use of plant defense activators (Actigard)?**
  - **-Reflective mulches, roguing?**
- **After harvest**
  - **-Prompt sanitation**
  - **-Avoid 'bridge' crops that could carry the TSWV or thrips over the winter (e.g., radicchio)**
  - **-Reservoir (weed host) management**
  - **-This should be done on a regional basis**

Update on the introduction of *Tomato yellow leaf curl virus* (TYLCV) into California: Implications for California tomato production

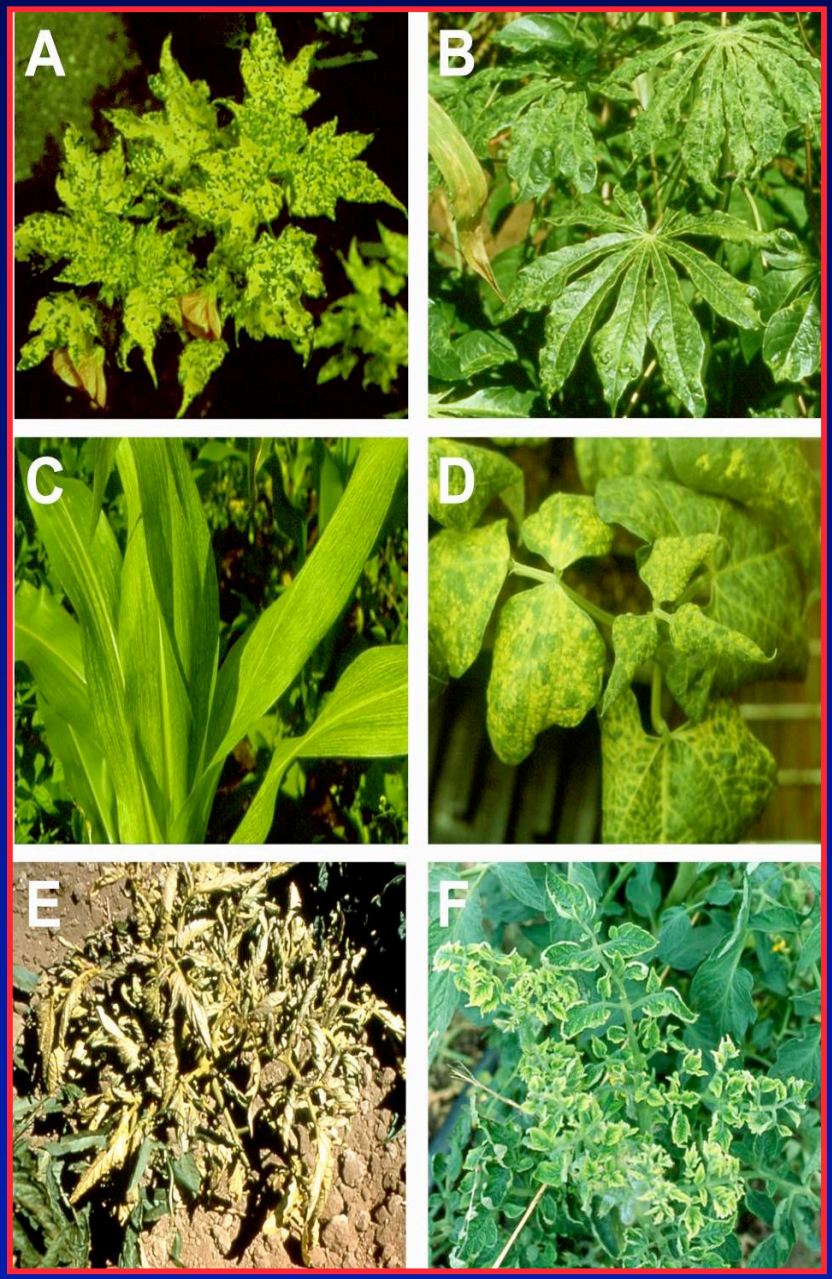
What are geminiviruses?



- A family of plant viruses (*Geminiviridae*) characterized by having:
  - -twinned icosahedral virions
  - -circular ss-DNA genome
  - -transmitted by whiteflies (*Bemisia tabaci*) or leafhoppers
- Largest group of plant viruses (> 130 species)
- Resistance not available in many crops

Geminivirus diseases of economic importance

- Maize streak
- African cassava mosaic
- Bean golden mosaic
- Beet curly top
- Tomato yellow leaf curl
- Squash leaf curl
- Cotton leaf curl



Tomato yellow leaf curl virus (TYLCV)

- TYLCV is one of the most devastating viruses of tomato due to the severe disease symptoms and yield losses it causes
- It was originally described from Israel around 1940
- It has since spread throughout the Mediterranean basin and, in the early 1990s, it was inadvertently introduced into the New World (the Dominican Republic)
- It has now spread to the southeastern U.S. (Florida), throughout the Caribbean Basin and Mexico
- In 2005-06, TYLCV was found throughout northern Mexico and caused severe losses
- In 2006 TYLCV was reported from Texas and Guatemala

TYLCV symptoms

- Stunted growth, abnormal erect or upright growth and bushy ('bonsai') appearance of the plant
- Leaves are stunted and small and show upward curling and crumpling along with strong yellowing at the edges and in between the veins
- Flowers often fall off before fruit set, greatly reducing yields. Yield losses of 100% can be experienced)

TYLCV biology

- **Host range**
  - -TYLCV is primarily a virus of tomato
  - -It will infect other members of the tomato family like certain tobacco species and peppers as well as many weeds (many of which do not show obvious disease symptoms)

- **Transmission**
  - -TYLCV is transmitted by various biotypes of the sweet potato whitefly, *Bemisia tabaci.* It is not transmitted by the greenhouse whitefly (*Trialeurodes vaporariorum*)
  - -It is not transmitted via seed or mechanically (by touch)

TYLCV biology

- **Whitefly transmission**
  - -Whiteflies acquire and transmit TYLCV as fast as 5-10 minutes
  - -The insect retains the virus for life (persistent transmission)
  - -The virus does not replicate in the insect vector and it is not passed onto progeny
  - -disease symptoms appear 2-3 weeks after inoculation

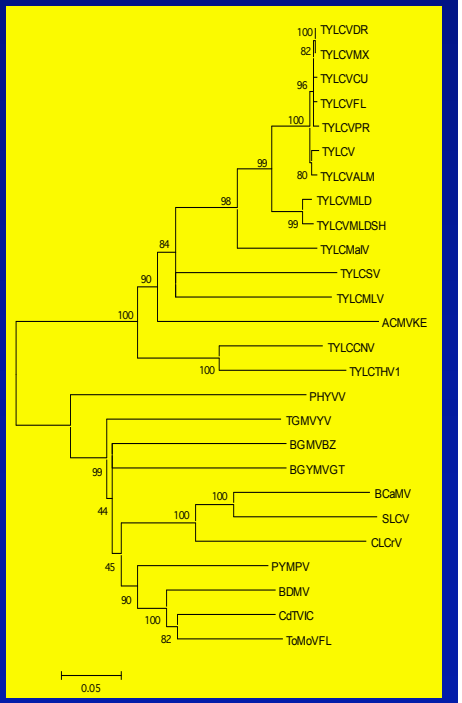
- **Long distance spread**
  - -movement of infected plants, especially tomato transplants
  - -migratory whitefly forms move 5-7 miles, but it is thought that movement over longer distance can occur via winds

First detection of TYLCV in California: March 2007 in Brawley, CA (Imperial Valley)

- Unusual virus-like symptoms were observed in a non-commercial greenhouse on a high school campus in Brawley, CA in March 2007 by Dr. Eric Natwick
- Large populations of *B. tabaci* associated with these plants
- Symptoms looked like TYLCV and this was confirmed upon PCR with specific primers and DNA sequencing
- The tomato plants were started from seed and no plants were brought into the greenhouse

First detection of TYLCV in California: March 2007 in Brawley, CA (Imperial Valley)

- Complete sequence of an isolate indicates TYLCV-CA almost identical to TYLCV-MX
- Because plants were established from seed, the virus was probably introduced via viruliferous whiteflies
- Quarantine measures imposed by CDFA
- CDFA and Imperial County Ag Commissioners office have surveyed for TYLCV in Imperial County
- TYLCV appears to have been contained in an area around the initial outbreak
- Also detected in southern Texas and Arizona



TYLCV was detected in tomatoes and weeds in California at the end of 2007

- TYLCV was detected in a semi-commercial planting of tomatoes in Niland, CA (Imperial) and in transplants in Thermal, CA (Riverside) in December 2007
- In both cases, plants were locally established from seed, indicating that the virus was probably introduced via viruliferous whiteflies, perhaps coming from reservoir hosts (e.g., weeds)
- TYLCV also was detected in perennial jimson weed (*Datura meteloides*) and in whiteflies
- These plants have now been destroyed and CDFA is conducting surveys to assess any further spread

What is the present outlook for TYLCV in California?

- There are a number of reasons why TYLCV may not become established in the main tomato-producing counties of California
  - -CDFA/Ag Commissioners Office efforts to contain the outbreak
  - -The whitefly vector is not typically found in many California tomato-growing areas due to the cold winter temperatures
  - -There is a natural ~3 month tomato-free period in California

- We have tools for rapid detection of the virus in plants and whitefly vectors

What to do now in California-short term

- Continue to monitor tomatoes in California (i.e., Imperial and San Diego counties, but also Kern and Fresno)
- TYLCV flyer has been distributed to help identify the virus and provide information and contacts for questions/testing
- Transplants
  - -Avoid bringing in transplants from areas known to have established TYLCV (Mexico, Florida, Texas, etc.)
  - -Take proactive measures with transplants grown in southern California/Yuma, AZ
    - -treat with systemic neonicotinoids (e.g., imidacloprid, thiamethoxam, acetamiprid)
    - -monitor for whiteflies and virus-like symptoms
    - -have plant and whitefly samples tested for TYLCV
    - -final treatment with a contact insecticide prior to transport

What to do now in California-longer term

- Assess the relative susceptibility and response (symptoms) of major California varieties
- Conduct surveys to better understand the distribution of *B. tabaci* in key tomato growing areas
- Evaluate the adaptation and properties of TYLCV-resistant varieties
- Breeding efforts to incorporate one of more of the TYLCV resistance genes (*Ty-1*, *Ty-2* or *Ty-3*) into California varieties
- Continue educational efforts to familiarize growers, PCAs and industry personnel with TYLCV symptoms

Acknowledgements

- ***Tomato spotted wilt virus*** **(TSWV)**

  -Ozgur Batuman
  -Robert Gilbertson
  -Michelle LeStrange
  -Chuck Rivara (CTRI)
  -Tom Turini
  -Diane Ullman

- ***Tomato yellow leaf curl virus*** **(TYLCV)**

  -Kathy Costa (CDFA)
  - Jolene Dessert and Connie Valenzuela (Imperial Valley Ag Commissioner's Office)
  - Tatsuya Kon
  - Eric Natwick
  -Maria Rojas