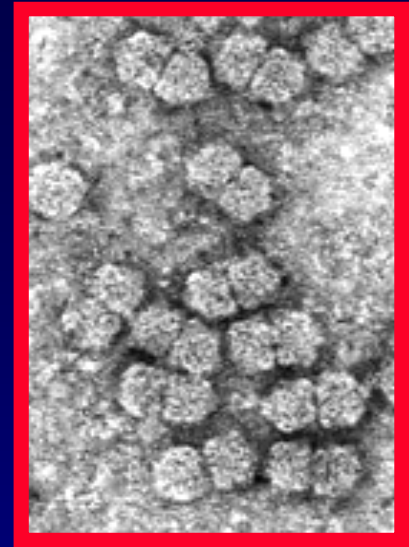


**Update on the introduction of Tomato
yellow leaf curl virus (TYLCV) into
California: Implications for California
tomato production**

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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 (> 200 species)
- Resistance not available in many crops



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.
- 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**



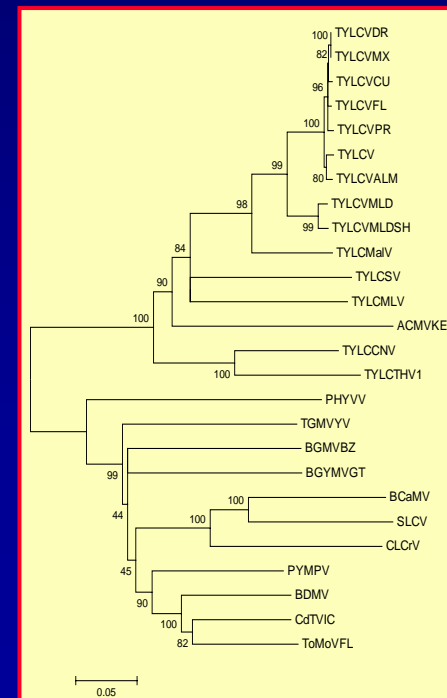
First detection of TYLCV in California: March 2007 in Brawley, CA (Imperial Valley)

- Unusual virus-like symptoms were observed in tomatoes grown 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 is almost identical to TYLCV-MX; and these are **all isolates of TYLCV-Israel**
- Because plants were established from seed, the virus was **probably introduced via viruliferous whiteflies or by movement of infected plants**
- Quarantine measures imposed by CDFEA
- CDFEA/Imperial County Ag Commissioners/UC Davis continue to survey for TYLCV in Imperial County
- Also detected in southern Texas and Arizona



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 symptoms: stunted, erect growth



TYLCV symptoms: stunted, upcurled and crumpled leaves with yellowing at the edges and in between the veins



TYLCV symptoms



Symptoms of other viruses can mimic those of TYLCV




A tomato transplant infected with *Tomato mosaic virus* showing TYLCV-like symptoms

Detection of TYLCV in weeds from the Imperial Valley

Sample	General	TYLCV	CuLCrV	Sequence results
Malva-1	+	+	+	<i>Tomato yellow leaf curl virus (TYLCV)</i>
Malva-2	+	-	+	<i>Cucurbit leaf crumple virus (CuLCrV)</i>
Malva-3	+	+	+	TYLCV
Wrights' ground cherry (WGC)	+	-	+	CuLCrV
WGC	+	-	+	CuLCrV
WGC	+	+	+	TYLCV

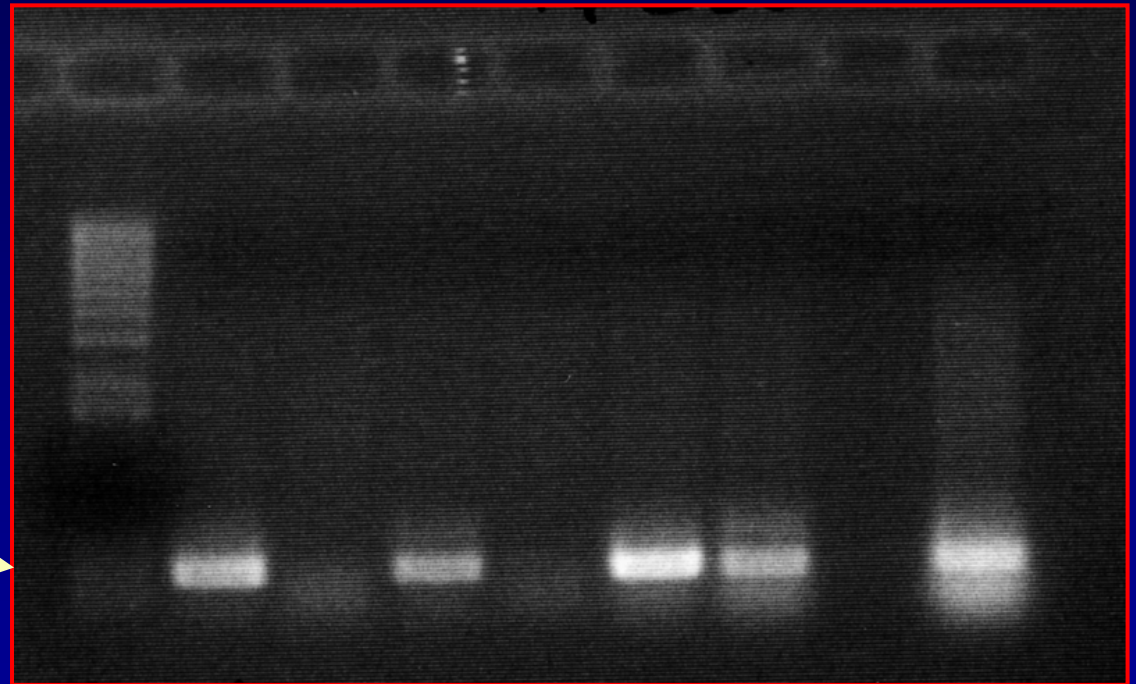
Amplification of a diagnostic DNA fragment with PCR and TYLCV primers



TYLCV infections can be confirmed with a rapid and specific PCR test

(-) (+)

Amplification of a diagnostic DNA fragment with PCR and TYLCV primers



The genetic sequence of this PCR-amplified DNA fragment can be determined
To further confirm the identification of TYLCV

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, some common bean cultivars as well as many **weeds** (most 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 in plants 2-3 weeks after inoculation**



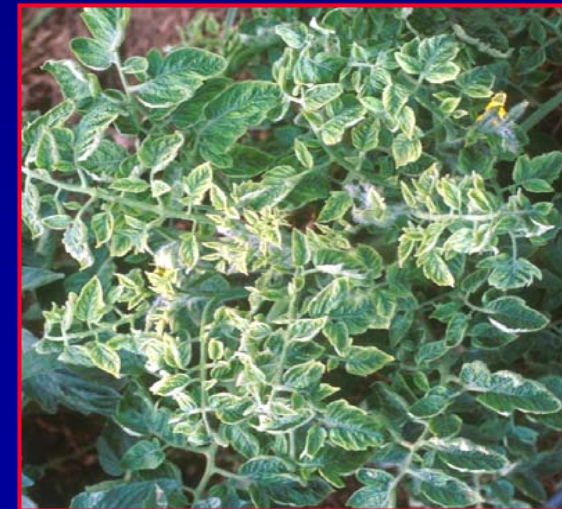
- **Long distance spread**

- 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**



Is TYLCV established in California?

- **TYLCV was detected in the Imperial and Coachella Valleys**
 - In tomato transplants in a commercial greenhouse in Riverside Co. in 2008 and 2009
 - In tomato plants in home gardens in the Imperial Valley in multiple locations in 2008
 - In 2 of 3 commercial fields surveyed in Imperial County in June 2008
 - In a commercial tomato field in Indio (Riverside Co.) in December 2008
- **TYLCV was not observed/detected** in processing or fresh market tomato fields in Fresno, Kern, Kings and Merced or Yolo Counties in 2008; **except in a single plant in a late-planted field in Merced County**



**California
counties
in which
TYLCV has
been detected**

**Imperial Co.
Riverside Co.
Merced Co.**



California counties in which *Bemisia* is established:



Imperial Co.
Riverside Co.
San Diego Co.*

Bemisia was not detected
in tomatoes in 2008:

Fresno Co.
Merced Co.
Kings Co.
Kern Co.*



What will the situation be in 2009?

- **TYLCV was detected in tomatoes from a homeowners garden collected in Imperial County at the end of March**
- **TYLCV was detected in the field and in homeowners gardens in the Imperial Valley in May 2009**
- **Further evidence that the virus is probably established in Imperial County**
- **Management strategies should be developed to restrict the spread of the virus**

How is TYLCV infecting tomatoes in California?

- **Imperial and Riverside Counties**

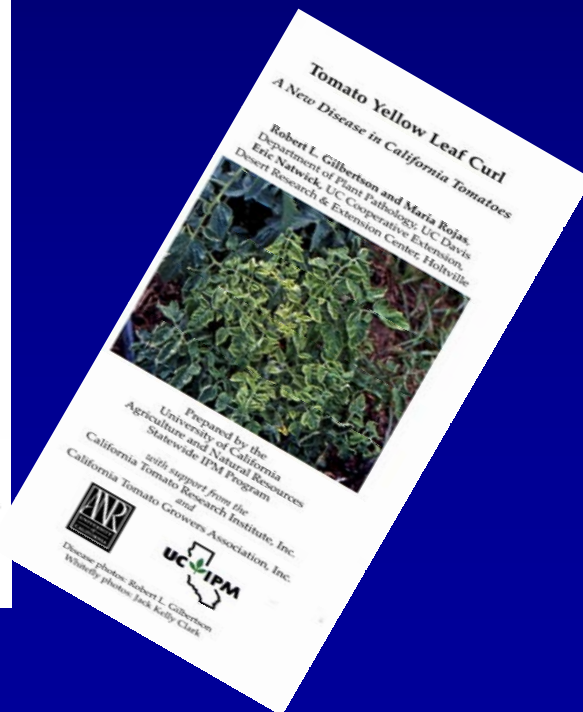
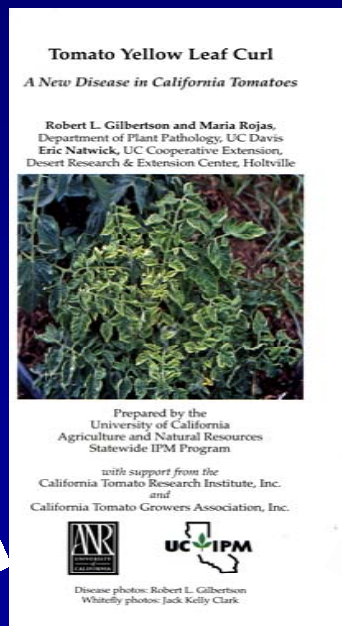
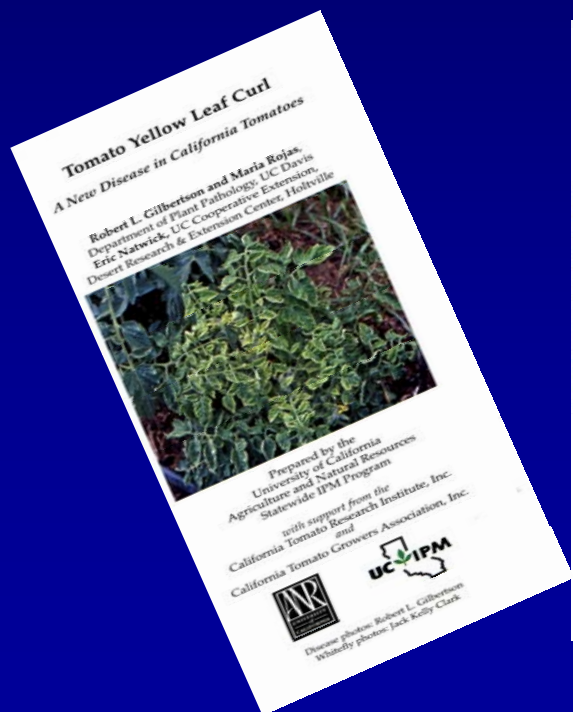
- via whiteflies acquiring virus from reservoir hosts such as weeds (e.g., *Datura* spp. and *Malva* spp.)
- infected transplants or volunteer tomatoes

- **Merced County**

- the single infected plant found in a late season fresh market tomato field was most likely an infected transplant

What to do now in California-short term

- Continue to monitor tomatoes in California for TYLCV and whiteflies (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.



What to do now in California-short term

• 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 using CDFA recommendations:
 - treat** with systemic neonicotinoid (e.g., imidacloprid)
 - monitor** for whiteflies
 - monitor** for plants with virus-like symptoms
 - test** plant and whitefly samples 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 (most are susceptible)**
- 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 or more of the **TYLCV resistance genes (Ty-1, Ty-2, Ty-3 or Ty-4)** into California varieties
- Continue **educational efforts** to familiarize growers, PCAs and industry personnel with TYLCV symptoms
- Develop an appropriate regulatory plan to **prevent the spread and establishment of TYLCV**

