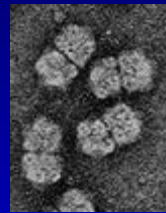


**The 2013 Outbreak of *Beet curly top virus* in tomato and other crops:
What we know and what we don't know**



Robert L. Gilbertson

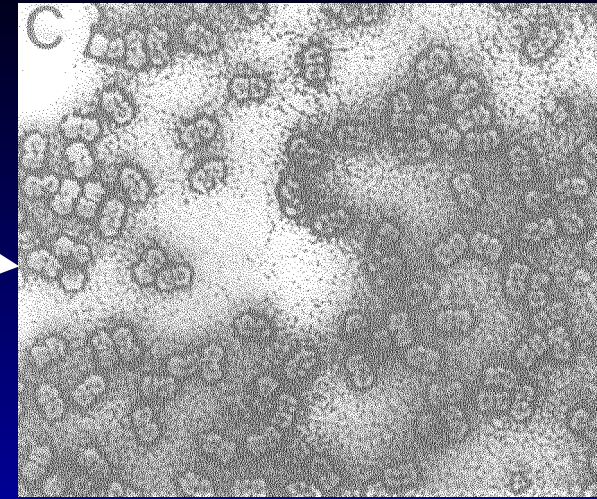
Department of Plant Pathology

University of California Davis

**North San Joaquin Valley Processing Tomato Meeting and
The California Tomato Growers Association (CTGA) Annual Meeting:
January 27, 2014**

Plant Viruses

- **Parasitic genetic elements** (RNA or DNA) covered by a protective protein shell
- Most important pathogen of animals (HIV, influenza); **second most important pathogen of plants**
- Viruses **take over the cellular machinery** of the plant and spread throughout the infected plant
- This results in the **development of various types of disease symptoms**
- **Plant-to-plant spread** of viruses most commonly occurs via **insects** (also via seed, nematodes, etc.)
- Plant viruses can be very **difficult to diagnose and control**



Plant virus particles (virions)



Plant virus symptoms

Symptoms of virus infection

- Symptoms vary considerably depending on the virus/host combination
- Most common symptom is **stunted growth**
- Most conspicuous symptom is **mosaic or mottling** of leaves
- Other symptoms include **distorted growth** and **crumpling, curling, necrosis, ringspots, and yellowing** of leaves

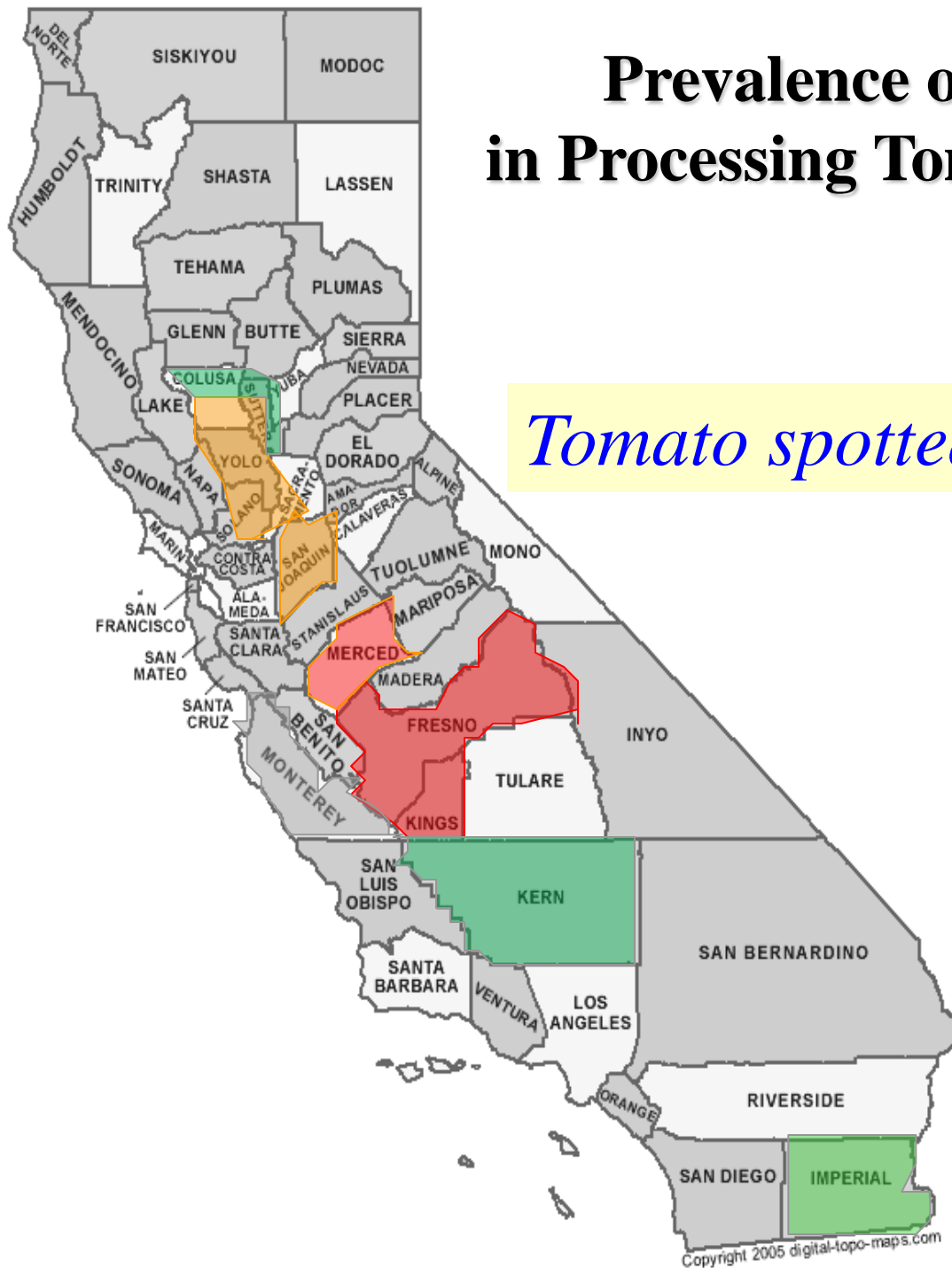


Some insect-transmitted viruses affecting tomatoes in California

- | | |
|--|--------------------------|
| • <i>Beet curly top virus</i> (BCTV) | } Leafhopper-transmitted |
| • <i>Alfalfa mosaic virus</i> (AMV) | |
| • <i>Cucumber mosaic virus</i> (CMV) | |
| • <i>Tobacco etch virus</i> (TEV) | |
| • <i>Potato virus Y</i> (PVY) | |
| • <i>Tomato spotted wilt virus</i> (TSWV) | Thrips-transmitted |
| • <i>Tomato necrotic spot virus</i> (ToNSV) | Thrips-associated |
| • <i>Tomato yellow leaf curl virus</i> (TYLCV) | Whitefly-transmitted |

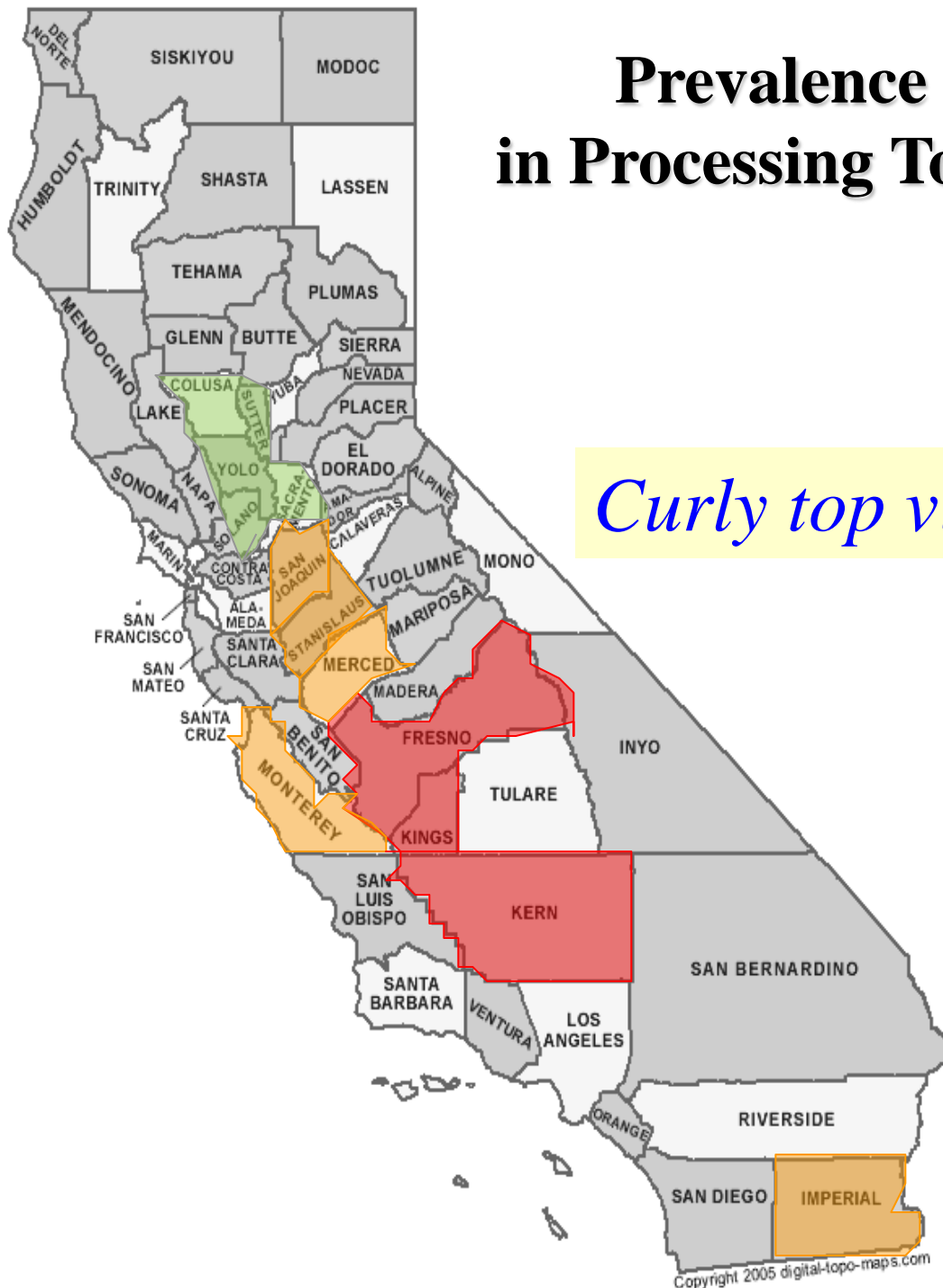
Prevalence of Virus Diseases in Processing Tomatoes of California

Tomato spotted wilt virus (TSWV)



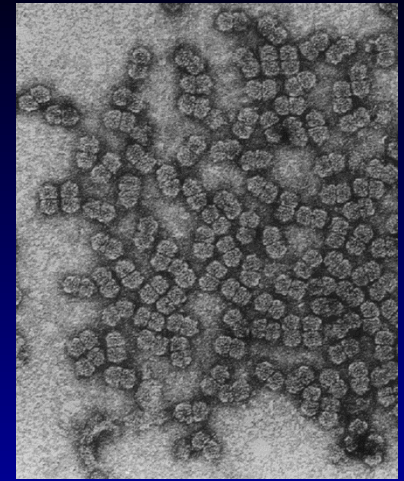
Prevalence of Virus Diseases in Processing Tomatoes of California

Curly top virus(es) (CTV)



Beet curly top virus (BCTV) belongs to the family Geminiviridae, genus Curtovirus

- All geminiviruses have a **circular ssDNA genome contained in twinned virus particles**
- Some are transmitted by **whiteflies (begomoviruses)** whereas others are transmitted by **leafhoppers (curtoviruses and mastreviruses)**
- **Curly top of tomato in California is caused by two curtoviruses:**
Beet mild curly top virus (BMCTV) and Beet severe curly top virus (BSCTV)
- The symptoms caused by these viruses in tomato are similar and they are often present in **mixed infections** in plants and leafhoppers



Curly Top Disease

- **Disease of vegetable and field crops** (beans, peppers, sugar beet and tomato)
- **Introduced into the Western United States** in the early 1900's
- Historically caused **losses to sugar beet production** in western states
- Became less of a problem with the development of **resistant varieties** and reduced sugar beet production
- **Very destructive to tomatoes**
- Remains a disease that has the **potential to cause substantial losses**, but only in certain years



Curly top symptoms: Tomato

- In tomato, plants show **stunted growth** and **upcurled leaves** with **dull green-yellow color** and **purpling of the veins**
- Plants **infected at a young age** may die
- Plants **infected later** are **stunted** with **yellow upcurled leaves** with **purple veins**
- **No necrosis** in leaves or fruits
- Fruits are **small** and ripen **prematurely**
- Early in disease development, **curly top symptoms** can be confused with **tomato spotted wilt**

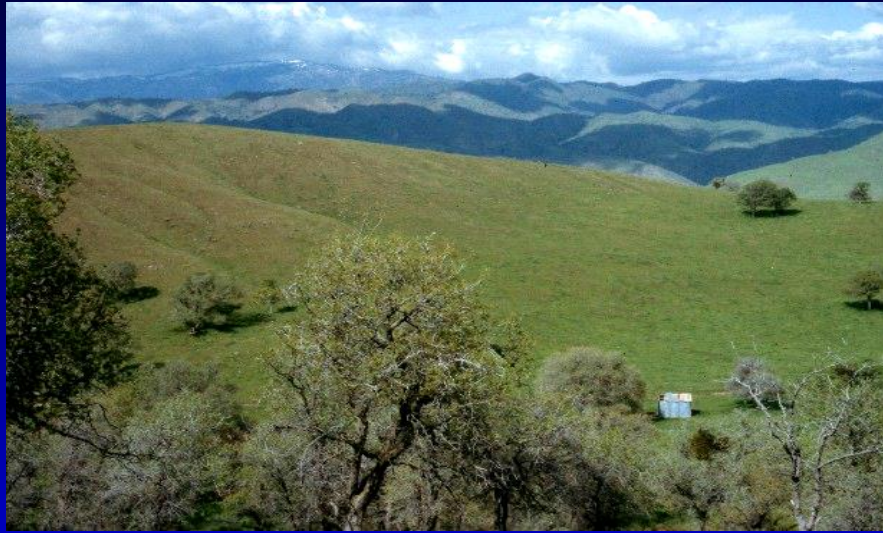


Vector: Beet leafhopper (*Circulifer tenellus*)

- Curly top viruses are only transmitted by the beet leafhopper, *Circulifer tenellus*, not mechanically or by seed
- Transmission begins early in the season as leafhoppers migrate from the foothills to the agricultural valleys, but also occurs during the growing season
- Curly top viruses are transmitted persistently (no replication in the leafhopper) and are acquired in transmitted in minutes-hours
- Tomato, pepper, lettuce and cucurbits are not preferred hosts
- Preferred hosts are sugar beets and members of sugar beet family
- Can be 3-5 generations in California



Curly Top Disease Cycle



Spring: adult leafhoppers migration



Fall: adult leafhoppers migrate for overwintering in the foothills



Curly top management

- Curly top is a **sporadic and unpredictable disease**
- **CDEFA Curly Top Control Program (CTVCB)** targets the vector by insecticide sprays based on **monitoring leafhopper populations**
- **Cultural practices** can help, such as not planting next to foothills or heavy plant populations
- There are **no commercially available curly top-resistant tomato varieties**

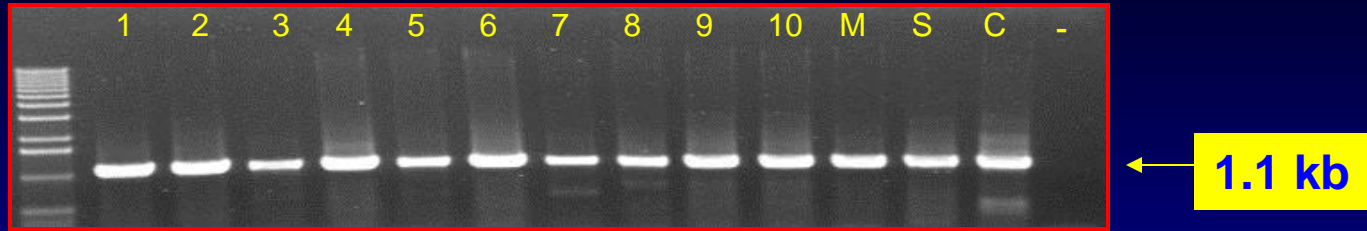


New Detection Tools for Curly Top Virus Offer an Opportunity for Improved Understanding of the Disease and Management Strategies

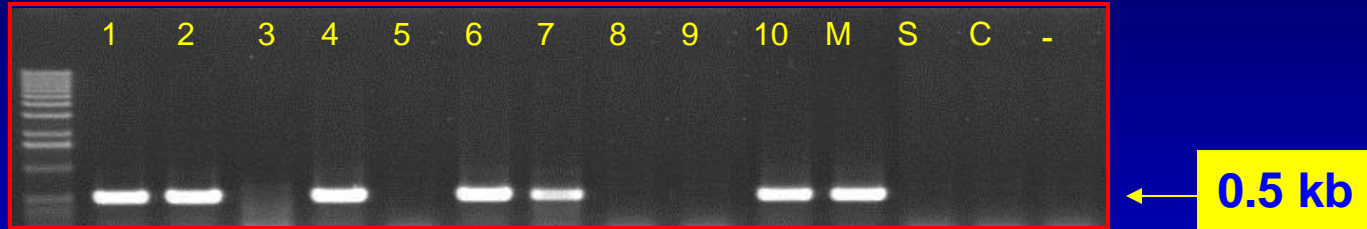
- **PCR detection in the plant**
 - rapid detection
 - ID viruses involved
 - ID host plants
- **PCR detection in the beet leafhopper vector**
 - potential predictor of curly top
 - target areas for spraying

PCR is currently the best method for detection of curly top viruses

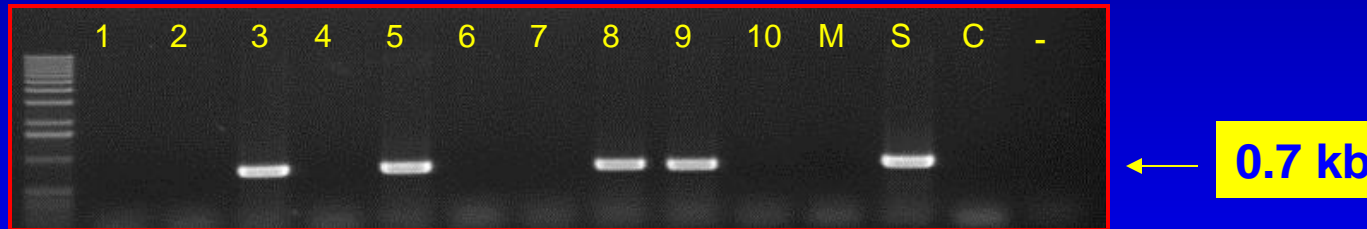
General CTV primers



BMCTV



BSCTV



BCTV

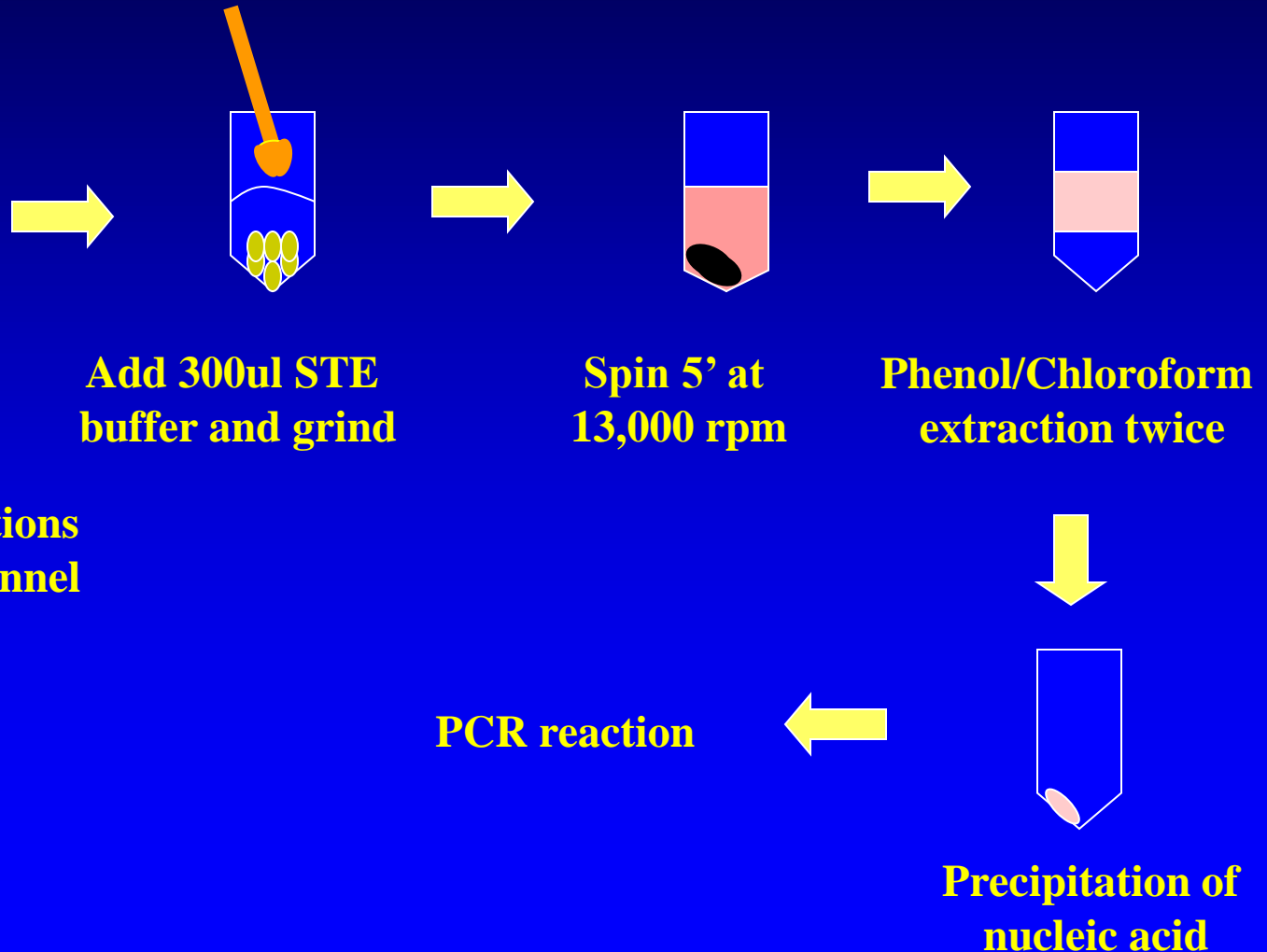


Lanes 1-6 were plant samples; lanes 7-10 were leafhopper samples; lane M was BMCTV positive; lane S was BSCTV positive; lane C was BCTV positive; lane "-" was negative control.

PCR Detection of CTVs in beet leafhoppers over time and space

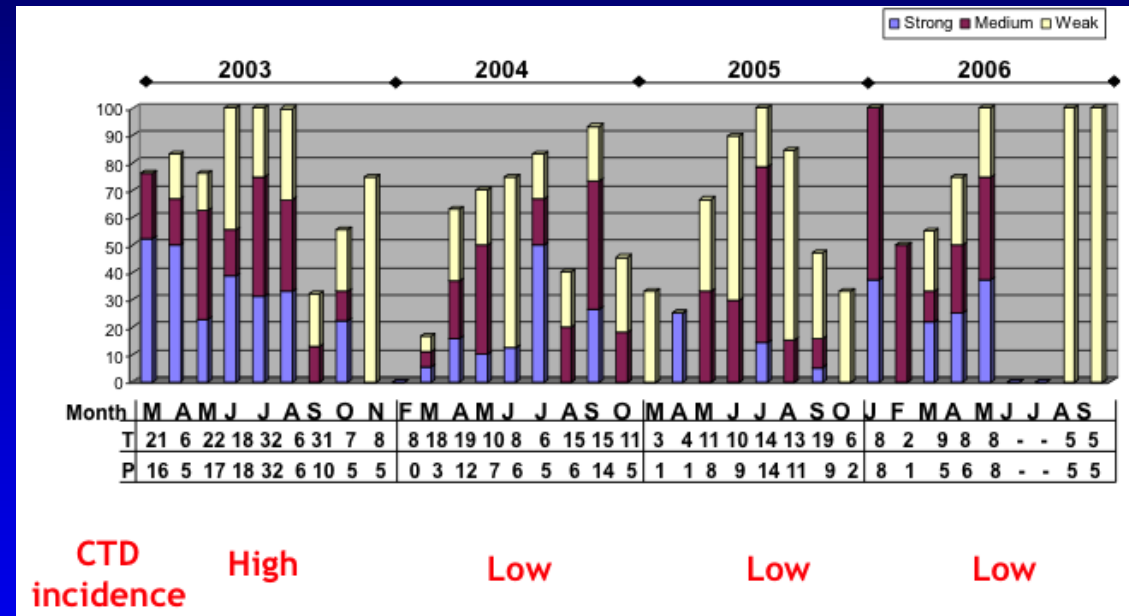


Monthly leafhopper collections
from CDFA CTVCP personnel



Curly Top Outbreaks Correlated with High Populations of Virus-Carrying Leafhoppers Early in the Growing Season

- Using **new molecular tools** for curly top virus and **leafhoppers** provided by the Curly Top Virus Control Board (CTVCB) a study was conducted to **ID factors** associated with disease outbreaks

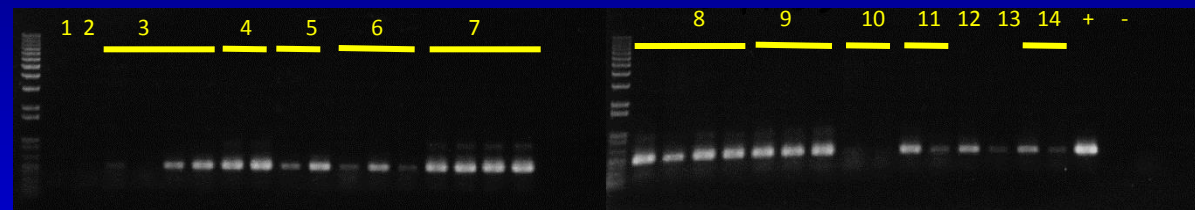


- The highest levels of curly top in tomato were correlated with **high** populations of virus-carrying leafhoppers early in the growing season (i.e., February-April)

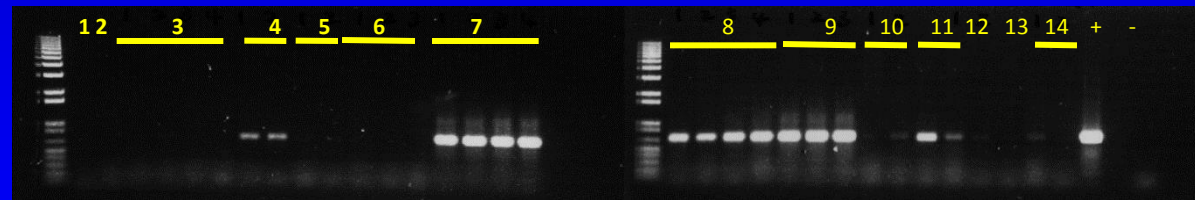
Curly Top Outbreak of 2013

- In 2013, **beet leafhopper populations** detected in the foothills by the CDEFA CTVCB were approx. **5X higher than normal**
- **High levels of BMCTV and BSCTV** were detected in leafhopper samples sent to our laboratory in March and April

Detection of curly top viruses in leafhoppers collected by the CDEFA CTVCB in 2013



BMCTV



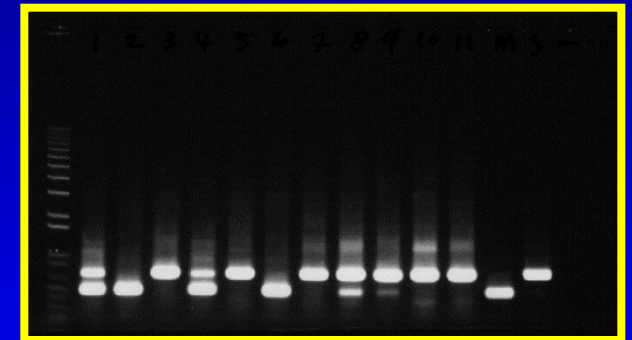
BSCTV

Curly Top Outbreak of 2013

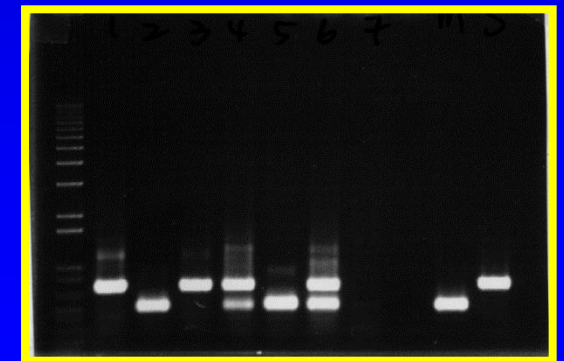
- **Tomatoes with curly top symptoms** started to be received for testing in late March and **most were positive for curly top virus**
- **High incidences of curly top** developed in many fields and losses were highest in Fresno and Kern
- **Curly top affected tomato fields were found far beyond the western foothills and also in San Joaquin County**



Tomato field with 90% curly top in Fresno Co.



Samples from Kern Co. 4/23/2013



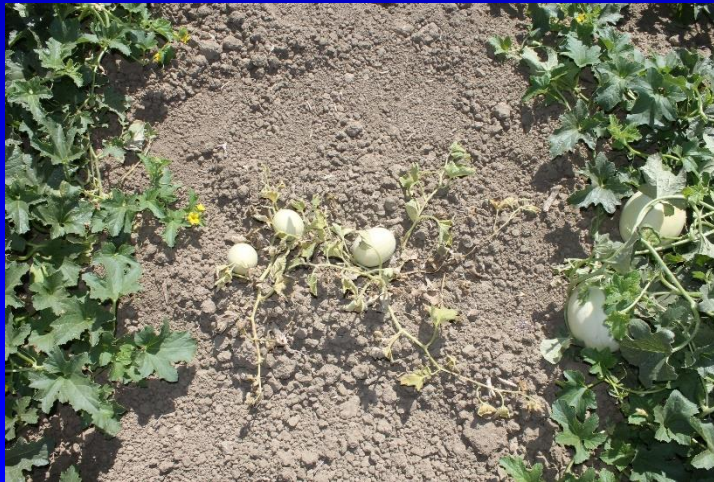
Samples from Fresno Co. 4/30/2013

Curly Top Outbreak of 2013

- **Curly top was also detected in other crops**, including cucurbits, which normally do not have the disease
- **New strains of curly top** were associated with the 2013 outbreak



Cantaloupe field in Fresno Co. with severe curly top



Honeydew melon plant with curly top



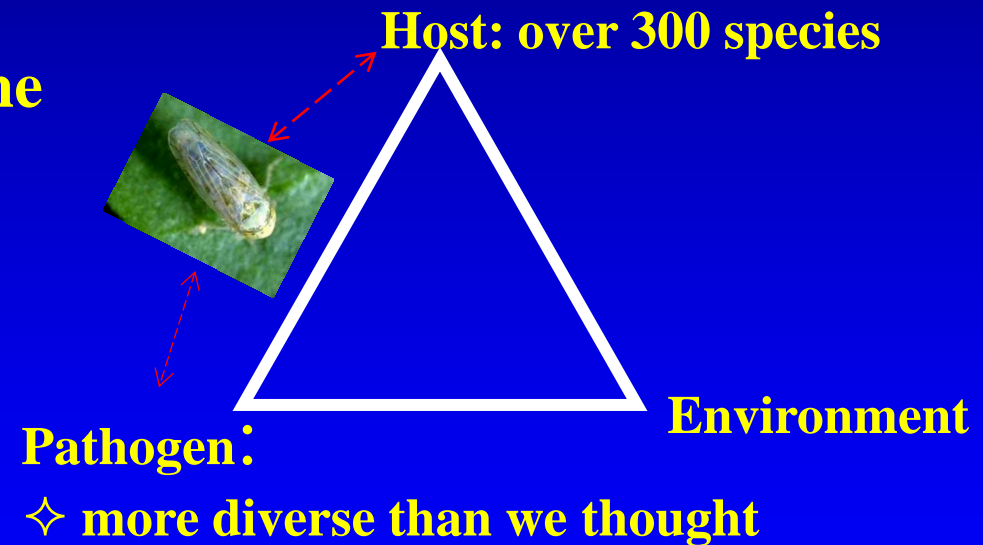
Cantaloupe plant with curly top

Why was curly top so severe in 2013?

- Favorable conditions for the **beet leafhoppers**
- Favorable conditions for the **hosts of the virus** in the foothills or the valley (in 2012 growing season before migration)
- **Changes in leafhopper behavior**, such as populations remaining on the valley floor
- **New more virulent strains of BCTV** that have a wider host range or are transmitted more efficiently

A need for improved understanding and management of curly top virus

- The 2013 outbreak may indicate a **change in some aspect of the disease triangle**
- The spray program alone was not able to **manage the disease in 2013**
- There are **increasing limitations on the spray program**
- A **comprehensive research** project to address these questions has been initiated with the goal of **applying new approaches and technologies** for the development of an **effective IPM program for curly top**



This project brings together a diverse and integrated research team

- Combines **expertise on the virus, the vector and virus epidemiology**
- Includes researchers from UC and USDA
- Will allow for **application of new technologies** and will reveal new insights, including whether changes in the virus were associated with the 2013 outbreak
- Integrated team that will address:**
 - Curly top virus:** Bob Gilbertson (UCD)
Bill Wintermantel (USDA), Li-Fang Chen (UCD*)
 - Beet Leafhopper:** Eric Natwick (UCCE)
 - Virus epidemiology:** Neil McRoberts (UCD)
 - Field aspects:** Tom Turini (UCCE)
- This team will work closely with CTVCB personnel

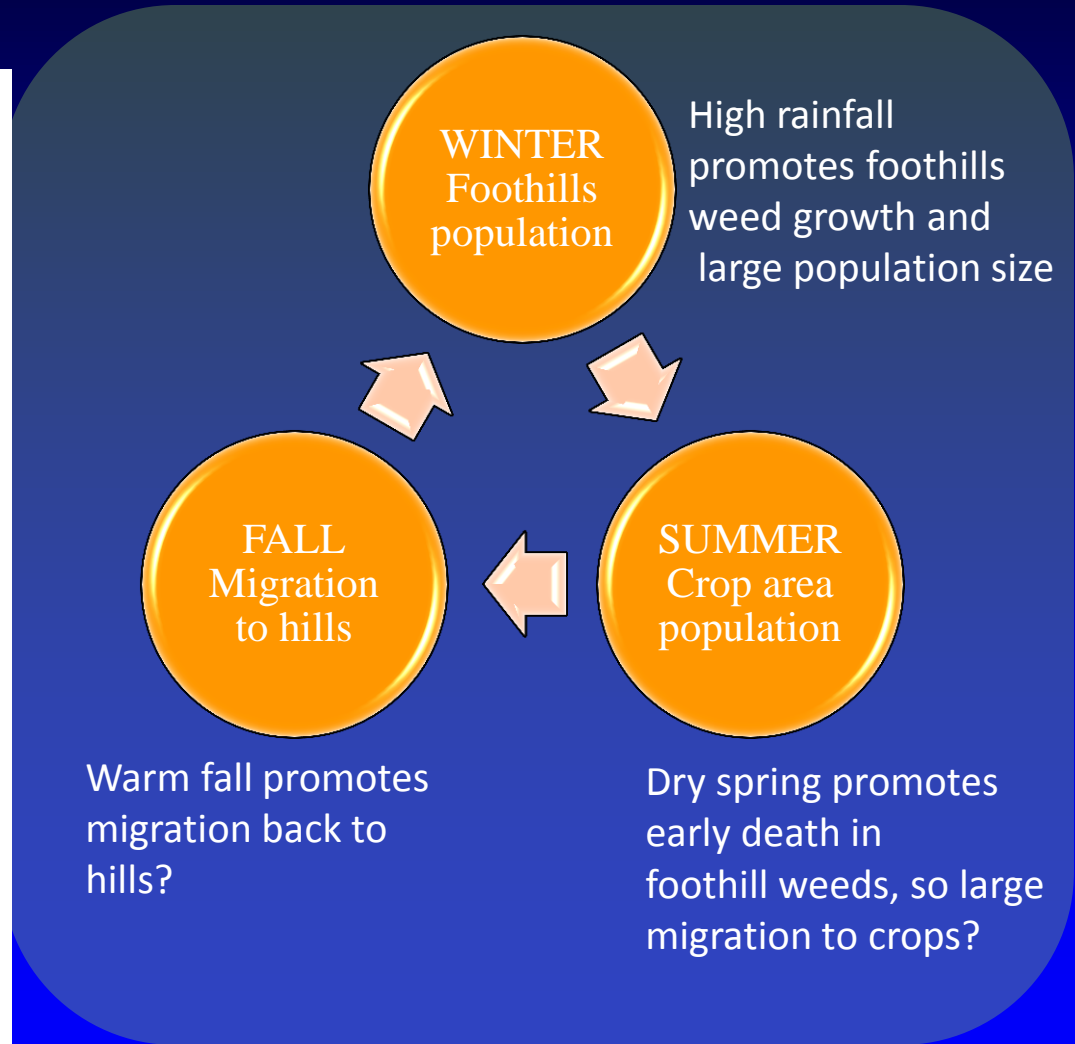
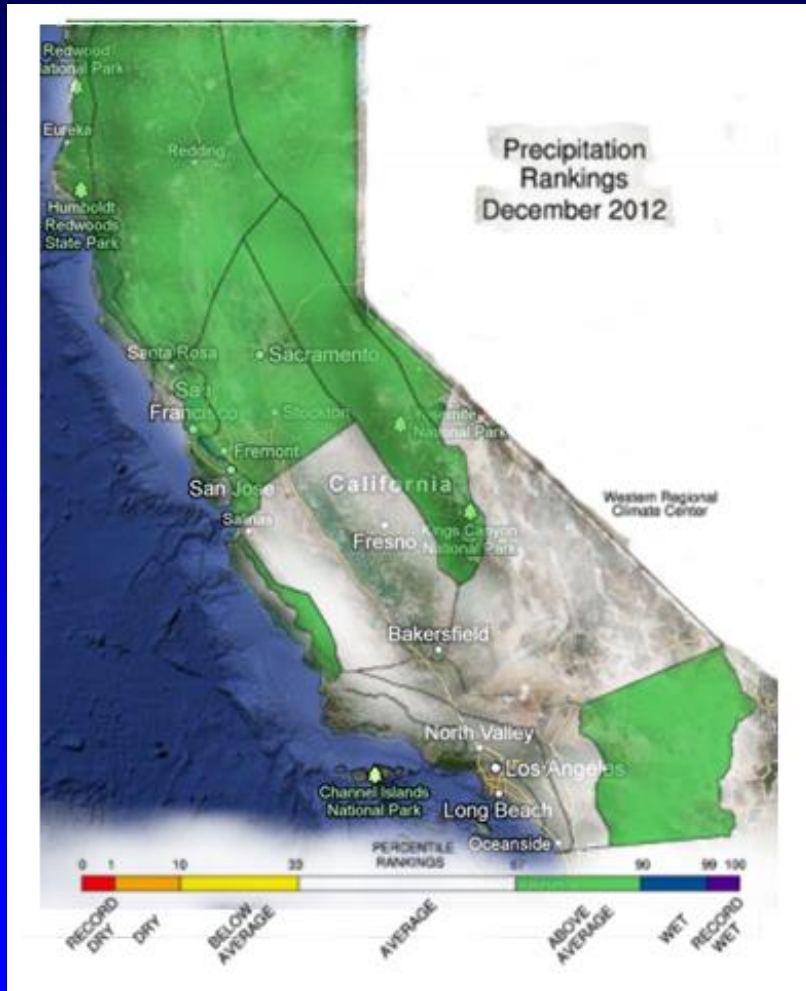
Integrated Curly Top Virus Management

- **Develop curly top resistant tomato varieties**
- **Identify deterrents to prevent leafhopper feeding on tomatoes**
- **Use the PCR method to detect curly top virus in the leafhoppers collected by the CTVCB to better predict bad curly top years and more accurately target areas for spraying**
- **Monitor beet leafhopper populations on the valley floor and search for potential inoculum sources during the winter**
- **Use an epidemiological approach to correlate environmental and weather factors with curly top outbreaks for improved prediction of bad curly top years**

Curly top resistance has been identified in a tomato line (20) possessing genes known to confer resistance to whitefly-transmitted *Tomato yellow leaf curl virus*

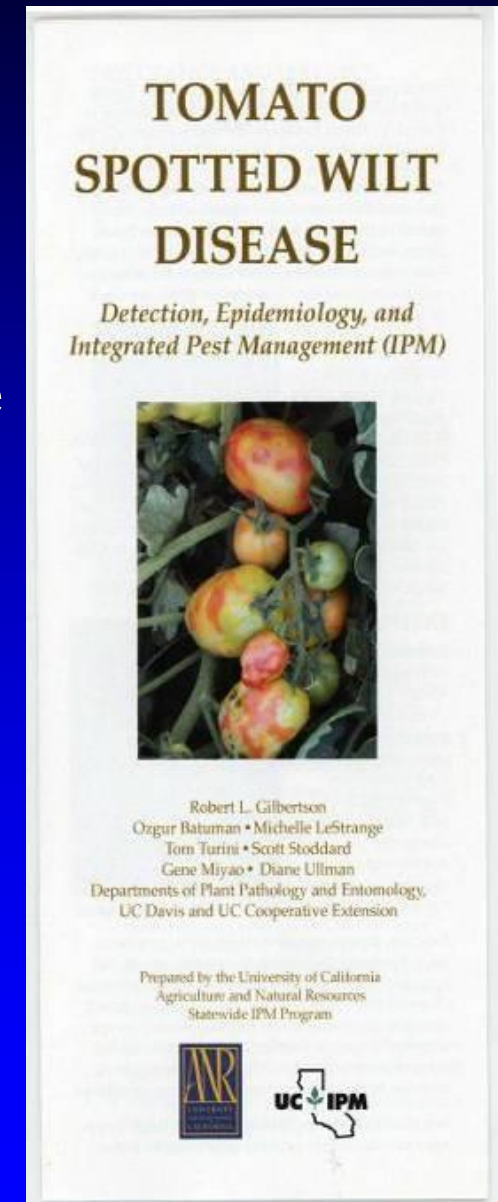
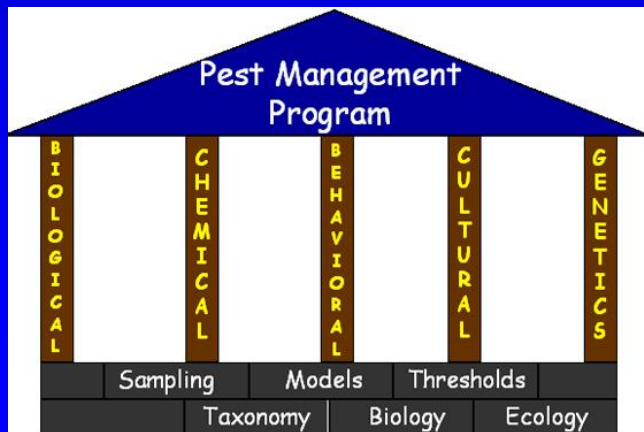


Epidemiological studies will be used to determine factors favoring high leafhopper populations



IPM for thrips and of tomato spotted wilt

- **An effective IPM package**, based upon knowledge of the biology of virus, vector and virus-vector interaction has been **developed for thrips and TSWV and made available to growers**
- **The use of all of some components of this IPM package has helped reduce economic losses due to TSWV**
- **It is critical to use the multi-pronged IPM approach and not depend only on one or two management strategies (i.e., insecticides or resistant varieties)**



IPM for thrips and TSWV

- **Before planting**
 - Calculate **risk assessment** for fields and make decisions to lower risk
 - **Varietal selection**
 - **Plant TSWV resistant varieties** (with *Sw-5* gene) especially in hot-spot areas or late-planted fields
 - Varieties without the *Sw-5* gene vary in susceptibility
 - **Field selection and planting time** (avoid hot-spots, planting near fields with bridge crops or late planting dates)
 - **Plant TSWV- and thrips-free transplants**



IPM for thrips and TSWV

- **During the season**

- **Monitor fields for thrips** (yellow sticky cards) or use predictive **degree-day model** and **manage thrips with insecticides** at early stages of crop development and when thrips populations begin to increase
- **Rotate insecticides** to minimize development of insecticide resistance in thrips
- Monitor fields for TSWV and **remove infected plants** early in development and when percent infection is low (<5%)
- **Weed control in and around fields and in near-by orchards**



Chemical Control of Thrips

- It is important that **thrips management be implemented when populations begin to increase or immediately following detection of TSWV symptoms**
- **Critical to reduce the number of virus-carrying adults by controlling larvae early in the season**
- **Best materials in trials: Dimethoate, Lannate (methomyl), Radiant (spinetoram), and Mustang (zeta-cypermethrin)+Beleaf (flonicamid)**
- **However, the effect was not long-lasting (7-10 days)**
- **Neonicotinoids (e.g., imidicloprid, thiamethoxam) were not effective**
- **Need for additional materials for thrips control (Movovento [spirotetramat] and Requiem [Chenopodium extract] are possibilities)**



IPM for thrips and TSWV

- **After harvest**
 - Promptly **remove and destroy plants after harvest**
 - **Minimize/avoid 'bridge' crops** that are TSWV/thrips reservoirs and overlap with tomato/pepper (e.g., radicchio, lettuce, fava bean)
 - **Control weeds/volunteers** in fallow fields, non-cropped or idle land and orchards



Give it a try: Read the codes with your Smartphone to visit web pages!

http://ucanr.edu/sites/TSWVfieldriskindex/Thrips_Population_Projections/

University of California
TSWV Field Risk Index and Thrips Projections

SKIP TO CONTENT SITE MAP Enter Search Terms

Home
Field Risk Index
Thrips Population Projections

- Yolo/Colusa
- Western San Joaquin Co.
- Eastern San Joaquin Co.
- Merced
- Fresno
- Kings

Thrips Population Projections

SHARE PRINT

About thrips population projections

We currently provide projections for Western Flower Thrips populations for five areas in the California central valley. Clicking on each of the links below will open a new tab/window in your browser which will display the information for the area you have chosen. Each page has the same layout. The image below shows a screenshot with some explanation of what each area of the page does. If you have trouble reading the descriptions, clicking on the image will open it in full screen mode. Use your browser's "back" button to return to this page.

Further information on the thrips projection model

The model was developed in collaboration with Dr Len Coop of Oregon State University's [Integrated Plant Protection Center](#) (IPPC). The IPPC hosts the [USPEST](#) web service which is a multi pest multi model information on pest development and disease risk for the contiguous United States using a network of weather stations.

Use the menu on the left side of the screen to see the current population development projections for each area.

A brief interpretation of the current situation and advice about when to expect thrips activity, to help with scheduling insecticide sprays

Yolo/Colusa area

Yolo/Colusa background information
These projections for the Yolo/Colusa area are the result of the central valley model based on data from station CQ205 in Colusa. The live weather widget displays conditions at Shoupsland (station CQ205) is not on the National Weather System network. The USPEST icon appeared in Green/Blue

Thrips population projections 2/13/2012
The population projections currently have the first generation of adults (post winter hatching) in the second week of March. Eggs have been observed and reported for the first time in the field since the start of the second generation of adults hatching up through May. Critical temperatures for the first 2 generations of the life cycle to the 5th so insect development will continue at a steady pace.

Weather widget, Showing live weather. Clicking on "NWS" in full screen mode. Clicking on "NWS" in

Thrips population projections showing expected dates major developmental stages



http://ucanr.edu/sites/TSWVfieldriskindex/Field_Risk_Index/

University of California
TSWV Field Risk Index and Thrips Projections

SKIP TO CONTENT SITE MAP Enter Search Terms

Home
Field Risk Index
Thrips Population Projections

Field Risk Index

SHARE PRINT

Field Risk Data Form

California TSWV risk assessment

This form gathers data about the risk of damaging TSWV levels occurring in processing tomato crops. The data entered in the form are sent to a web-based spreadsheet where the risk level is calculated. This is a trial version for which the risk index will be calculated manually once a day for all data submitted the previous day. You should receive an email the day after you submit your data giving you the risk status for your field/crop. We are working on a version which will calculate the risk index and email you a response immediately.

All of the information you submit will be treated in confidence. The data may be used for research purposes by the research team for tomato disease management at UC Davis in collaboration with CTRI.

For more information please email TSWV01@gmail.com. Funding for this project was provided by the CTRI.

* Required

General information

What email address should we send your risk score to? *

Please enter an email for your risk level below.

If there is a name you normally use to identify this field please enter it in the box below

Page Last Updated: March 26, 2013

Acknowledgements

- **UC Davis**

- Li-Fang Chen
- Ozgur Batuman
- Neil McRoberts
- Diane Ullman

- **UCCE**

- Tom Turini
- Michelle LeStrange
- Gene Miyao
- Scott Stoddard
- Brenna Aegerter

