

Tomato Spotted Wilt Virus (TSWV) Field Day

(Why is TSWV the chameleon of plant viruses?)



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July 11, 2023



Processing tomatoes in California are affected by diseases caused by numerous viruses

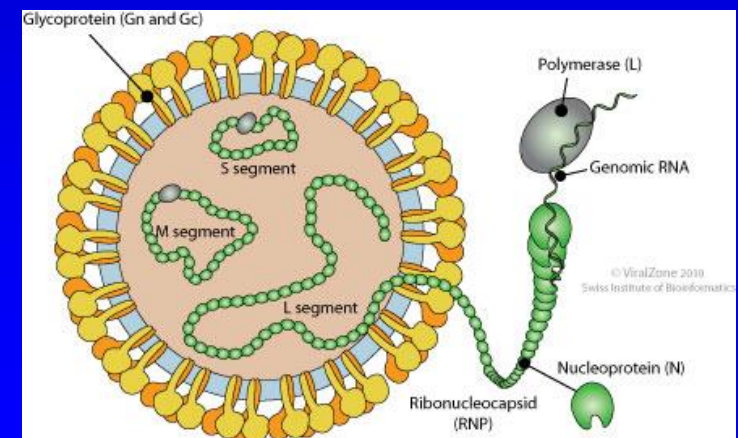
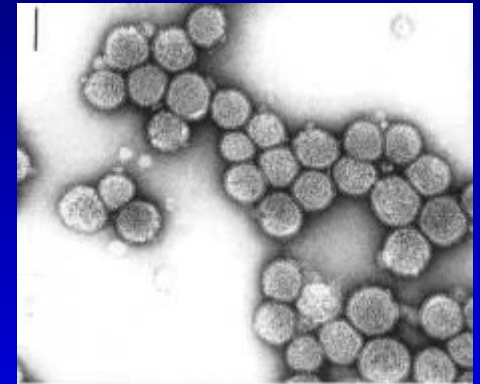
- **>10 virus diseases** affect processing tomato production
- **The importance and prevalence varies**
 - Major viruses**-BCTV and **RB TSWV**
 - Minor viruses**-AMV, PZSV, ToNSV, ToMV
 - Sleeping viruses**-BCTV (North) and ToNDV and TYLCV in the Imperial Valley)
- **New concerns** about exotic seed-transmitted viruses (ToBRFV) and viroids
- **Symptoms not sufficient for ID** and **molecular tests** are often necessary
- **Accurate ID** is critical for effective management strategies, hopefully in the context of **an IPM program**



**Unusual outbreak of curly top
In the Northern Counties in 2021**

TSWV and spotted wilt disease

- **Tomato spotted wilt virus (TSWV)** is a thrips-transmitted tospovirus (mostly **Western flower thrips** in CA)
- Not by seed or contact* or through eggs of the thrips
- In CA, crops impacted by tomato spotted wilt are **tomato, pepper, lettuce and radicchio**
- In 2005, **substantial outbreaks of spotted wilt** caused **millions in losses** to processing tomato production in Central California
- This led to a development of a collaborative project to investigate these outbreaks and make **management recommendations**



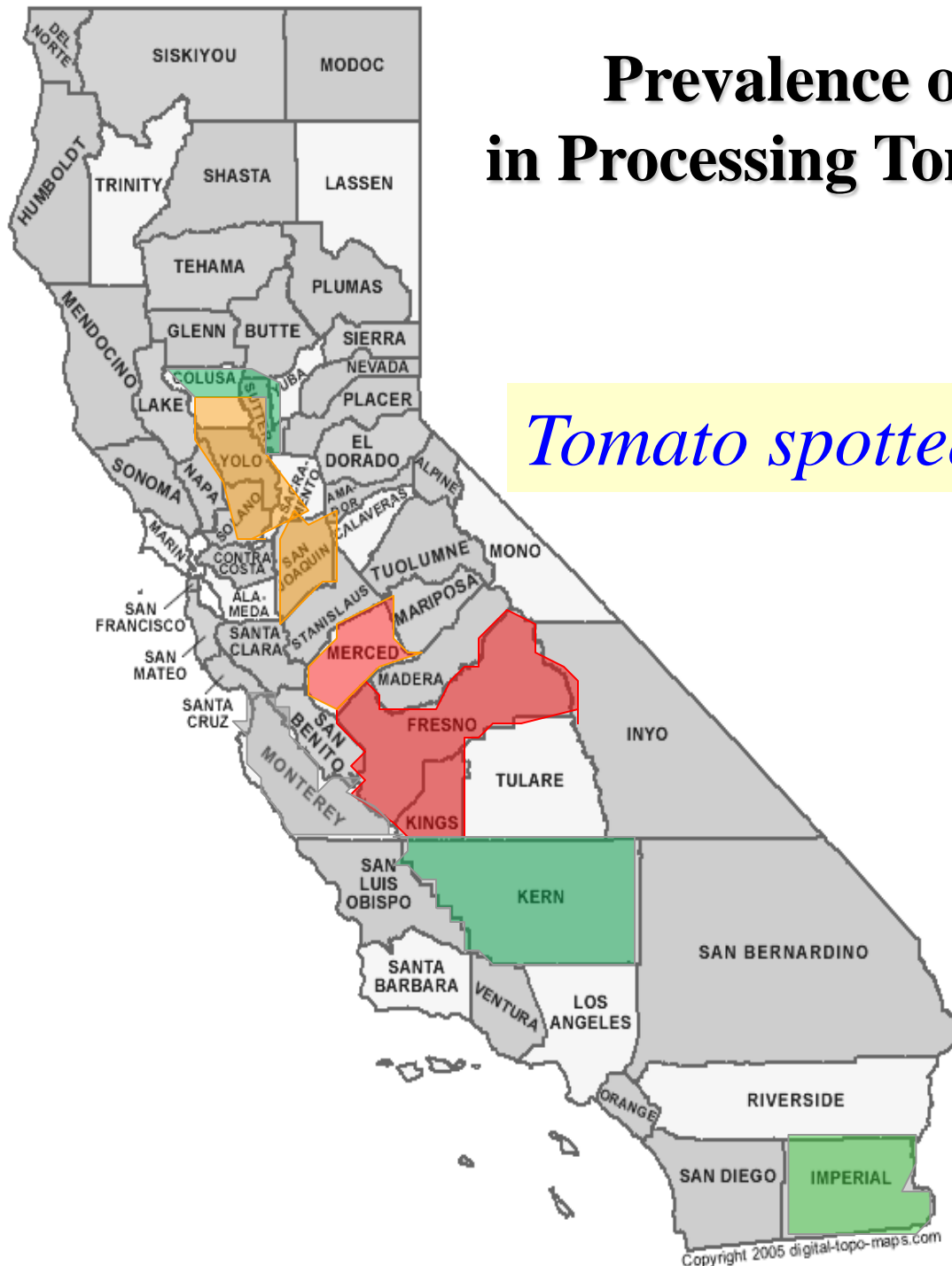
Symptoms and impact of tospovirus infection in tomato vary depending on the age of the plant when infected

- Stunting; bronzing, necrosis and yellowing of leaves and ringspots and necrosis in fruits)
- Symptoms vary depending on variety and plant age



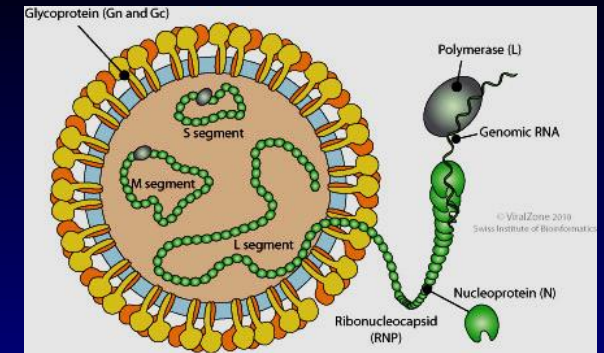
Prevalence of Virus Diseases in Processing Tomatoes of California

Tomato spotted wilt virus (TSWV)



What are tospoviruses?

- Family of plant viruses (*Tospoviridae*) having **three negative (-)-sense RNAs** (large, L; medium, M; and small, S) enclosed in a plant-derived membrane **embedded with glycoprotein spikes** (~11 species)
- Transmitted by **thrips** (~15 species); **not via thrips eggs, seed* or by contact***
- **Best known species: *Tomato spotted wilt virus* (TSWV)**, from which the family name is derived, and ***Impatiens necrotic spot virus* (INSV)**
- Cause serious **diseases of crops and ornamentals**
- **Solanaceous crops** heavily impacted, e.g., pepper, tobacco and **tomato**
- Symptoms involve **distortion, mosaic and necrosis** of leaves and **lumpiness, ringspots and blotches** on fruit

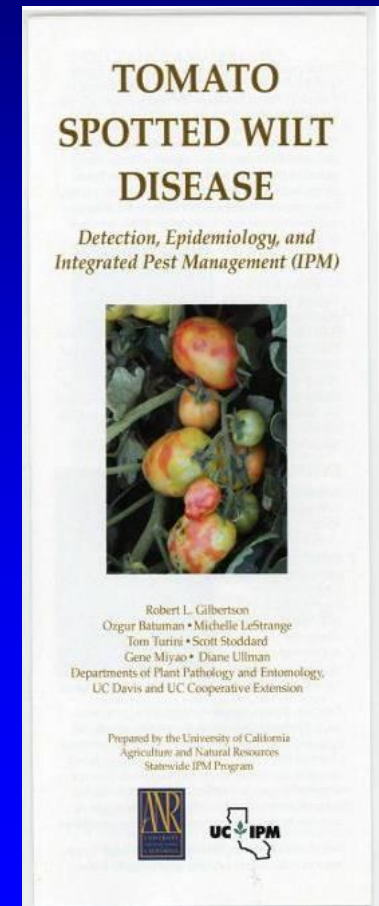


Tomato spotted wilt virus vs Impatiens necrotic spot virus

<u>Property</u>	<u>TSWV</u>	<u>INSV</u>
First identified	1919	late 1980s
Distribution	Worldwide	Worldwide (NA and Europe)
Host range	Very wide (1100 spp./90 fam.)	Wide (300 spp./80 fam.)
Economic hosts	Vegetables (Ornamentals)	Ornamentals (Emerging on vegetables)
Main thrips vector	<i>Frankliniella occidentalis</i>	<i>F. occidentalis</i>
Transmission by seed or contact	No	No

IPM for TSWV (pre-RB TSWV)

- Planting **TSWV-** and thrips-free transplants
- Growing **TSWV-resistant varieties** (with *Sw-5b* gene) *
- Monitoring for **thrips populations** (yellow sticky cards/**degree-day [DD] model**)
- Managing thrips with **rotation of insecticides**
- Roguing** of TSWV-infected tomato plants (early)
- Prompt plowing** fields after harvest
- Extensive sanitation** including weeds, volunteers and other crops



TRANSMISSION



VIRUS PASSAGE

Only adults that acquire as larvae can transmit.



ACQUISITION BY LARVAE IS CRUCIAL



1st instar

2nd instar

**Tospovirus
Transmission
Cycle**



Pupal Stages Do Not Feed

VIRUS PASSAGE

Tomato-infecting tospoviruses-biology

- Sources of tospovirus inoculum
 - Vary depending on **region and climate**
 - Reservoir hosts such as **weeds or winter bridge crops**
 - Existing crops with tospovirus infection and thrips
 - Thrips: **viruliferous adults** emerging from **overwintering pupae in the soil or coming from established crops**
- Thrips population dynamics
 - Monitor with **sticky cards**
 - Predictive **degree-day model** (generations)
 - Allows for **targeting early thrips generations** (2-3) and delaying development of viruliferous adults
 - Rotate insecticides** to avoid resistance



TSWV Field Risk Index and Thrips Projections



Clicking on each of the links in the menu on the left will open a new tab/window in your browser which will display the information for the area you have chosen.



- Home
- Thrips Population Projections for Tomato
 - Yolo/Colusa
 - Western San Joaquin Co.
 - Eastern San Joaquin Co.
 - Merced
 - Fresno
 - Kings
- Thrips Population Projections for peppers
- Fall and Spring Lettuce risks
- Tomato Field Risk Index

Thrips Population Projections for Tomato

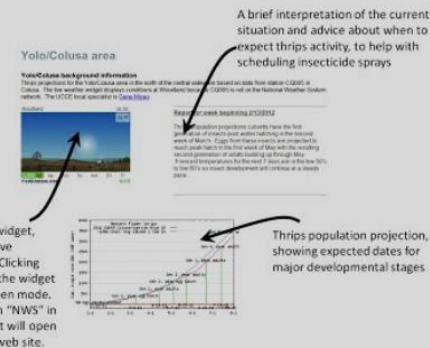
About thrips population projections

We currently provide projections for Western Flower Thrips populations for five areas in the California central valley. Clicking on each of the links in the menu on the left 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 developed and hosts the [USPEST](#) web service which is a multi pest multi model tool that provides information on pest development and disease risk for the contiguous 48 US states using a network of weather stations.

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



THRIPS/TSWV FRESNO

Thrips and TSWV updates in processing tomato for Fresno area

2018 Season - First post



Author: Neil McRoberts

Published on: April 9, 2018

General situation It has been an up and down start to the year for thrips development. Through February the relatively dry winter, and somewhat warm start to the year in the San Joaquin Valley meant we were running ahead of the 30 year average for degree day accumulation. The last couple of rain events have slowed things down, but we are still ahead of the long-term average. Temperatures in the week ahead are predicted to be in the mid 70's to low 80's F, with dip into the high 60's on Thur/Fri as a cold front passes over the region (it will probably drop some rain in the Sacramento area).

Thrips populations and TSWV risk At the moment the second post-winter adults are projected to peak at the end of the month, with the third generation peaking around May 28th. If things warm up significantly those two generations may peak a few days earlier. Currently we don't have any reports of TSWV activity in overwintering hosts and with the very low thrips populations now, the overall risk is low. Our best guess at the moment is that we won't see significant thrips/TSWV activity in tomato until the third generation this year, which will be the first one to target, depending on whether TSWV has appeared, but please speak to your local UCCE adviser for more specific advice if you are concerned.

Resistance-breaking TSWV Strains of TSWV with the ability to overcome SW5 resistance are now established in the San Joaquin Valley and you should expect to see them throughout in the Central Valley in the near future. Resistance breaking TSWV has been picked up from spring lettuce this season and there are some patchy outbreaks in that crop. Do not assume that SW5 varieties will be able to escape TSWV damage without additional disease management practices. Our advice is to target early generations of thrips entering tomato (see above) and, where possible, to rogue out infected plants showing symptoms of TSWV early in the season. Remember, the impacts of TSWV are much smaller in plants infected after fruit set, so the aim should be to delay infection as much as possible, to avoid economic impacts.

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Sw-5b gene confers resistance to TSWV

-Single dominant R gene

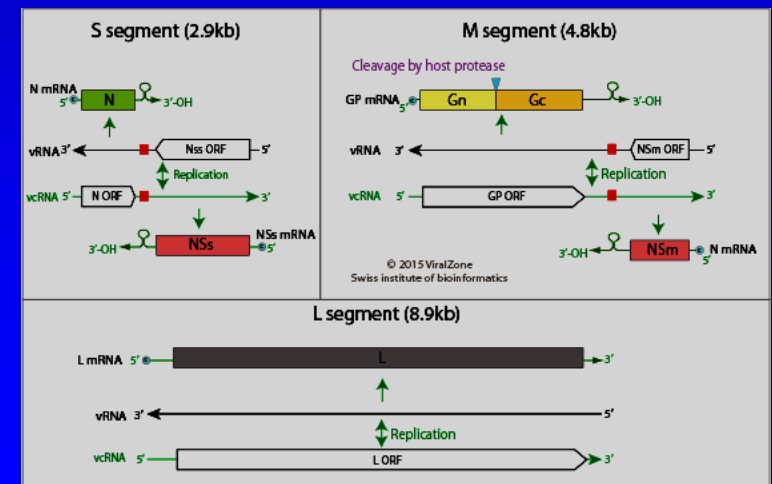
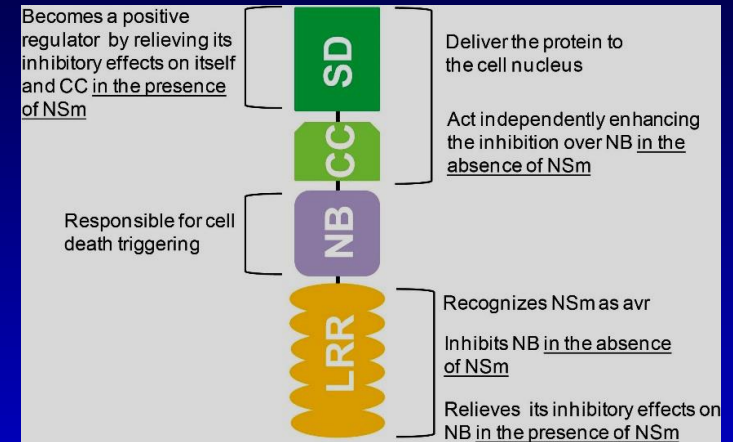
-Introgressed from the wild tomato species *Solanum peruvianum*

-The gene product (protein) recognizes that virus and triggers a defense (immune) response

-Viral effector is the movement protein (MP), encoded by the NSm gene on the M RNA

-Is present in most (all?) processing tomato varieties grown in California

-Tremendous selection pressure on the virus



Appearance of a resistance-breaking strain of *Tomato spotted wilt virus* in the Central Valley of California in 2016

- In the spring of 2016, typical and severe symptoms of TSWV were observed in Sw-5 fresh market tomatoes in Fresno Co.
- Immunostrip and RT-PCR/sequencing tests confirmed TSWV infection
- Suggested the emergence/introduction of a resistance-breaking (RB) strain
- RB strains have been reported from Europe (Spain and Italy) and have been associated with specific amino acid changes in the viral movement protein (NSm), including the 'YPT/N' marker



Identification of Fresno TSWV RB strain

Typical tospovirus symptoms



Test for TSWV with immunostrips

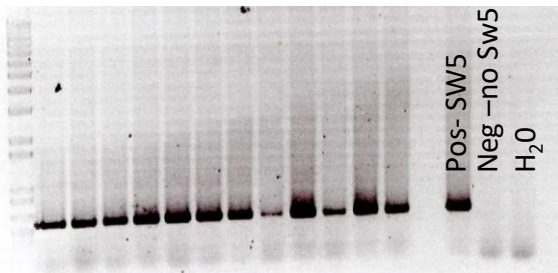


Confirm TSWV by RT-PCR



Confirm RB strain by RT-PCR of NSm gene and sequencing

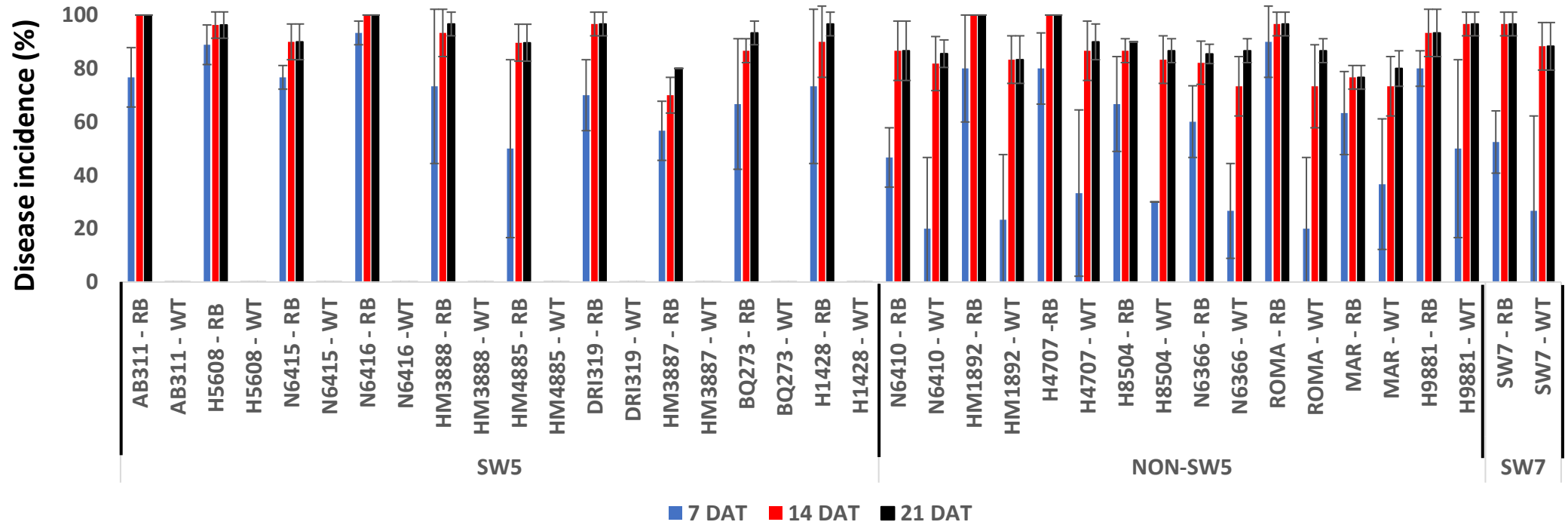
Confirm tomato is a resistant variety by PCR for SW-5



Amino acid (aa) sequence

Fresno RB strain	←	<p>MDTSKGKILLNTEGTSSFGTYESDSITESEGYD</p> <p>LSARMIVDTNHHISNWKNDLFVGNQNA</p> <p>NKVIKI YPTWDSRKQYMMISRIVIWVCP</p>	←	<p>aa substitution C to Y at 118 position or T to N at 120 position</p>
WT strain	←	<p>MDTSKGKILLNTEGTSSFGTYESDSITESEGYD</p> <p>LSARMIVDTNHHISNWKNDLFVGNQNA</p> <p>NKVIKI CPTWDSRKQYMMISRIVIWVCP</p>	←	<p>no aa substitution in 118 or 120 position (CPT)</p>

Response of tomato varieties with and without the Sw-5 gene to inoculation with the wild-type and RB strains of TSWV



Detection of resistant breaking (RB) and wild type (WT) of *Tomato spotted wilt virus* (TSWV)



total RNA extraction with the RNeasy Qiagen kit **30 min (1 - 5 samples)**

1 h + 30 min (synthesis of cDNA using Random primers) Loop Mediated Isothermal Amplification (LAMP)

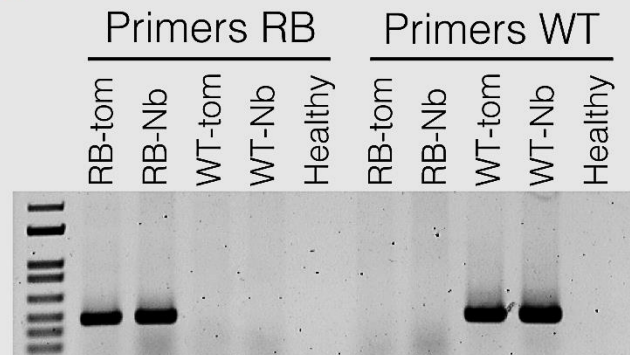
Polymerase chain reaction (PCR)

2 h

94C x 20 sec
60C x 20 sec
72C x 1:2 min | 30X

Agarose gel electrophoresis

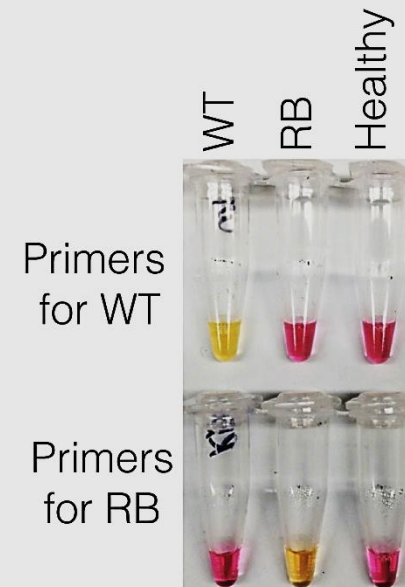
45 min



Total time: 5 hours

Loop Mediated Isothermal Amplification (LAMP)

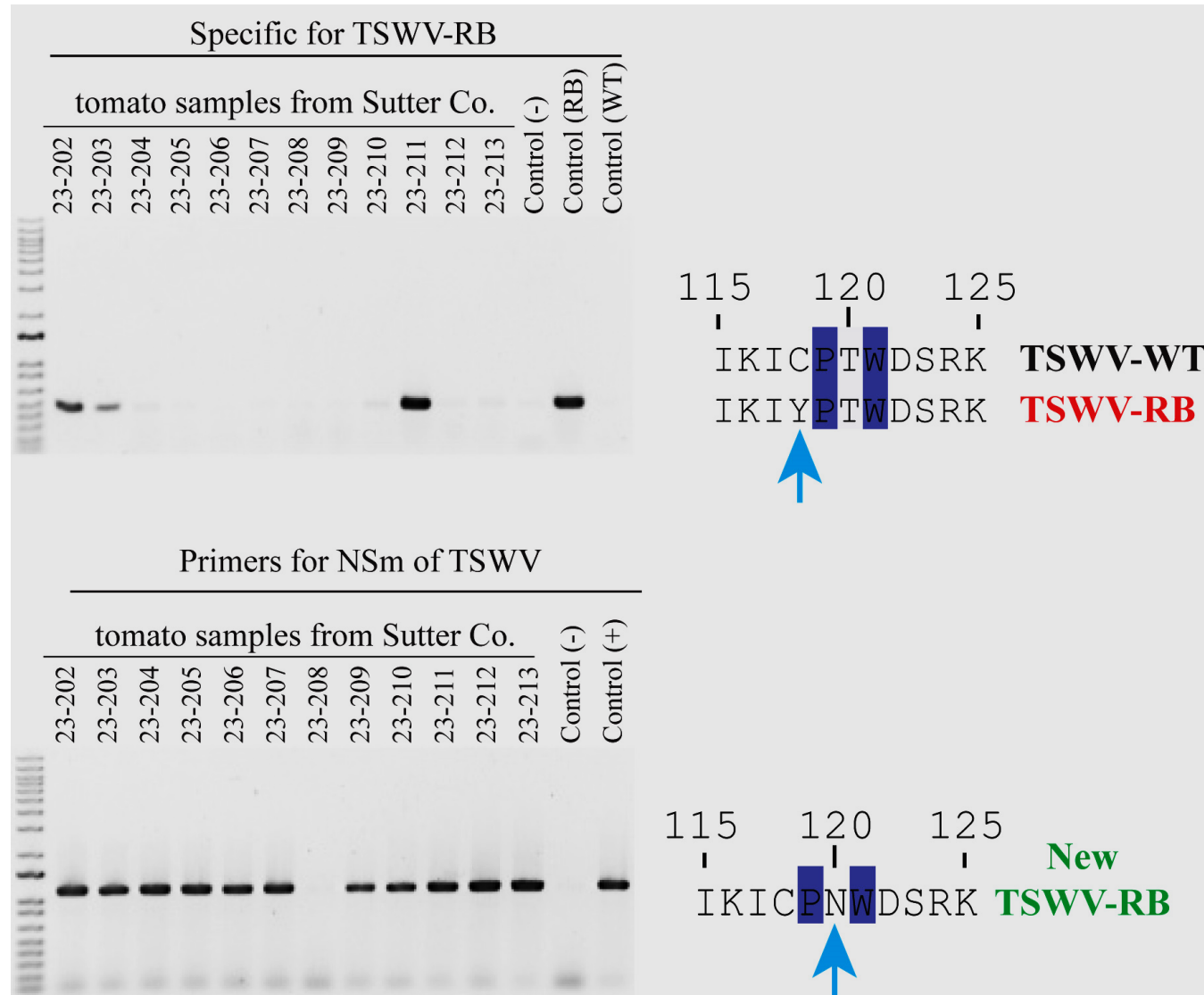
60 min



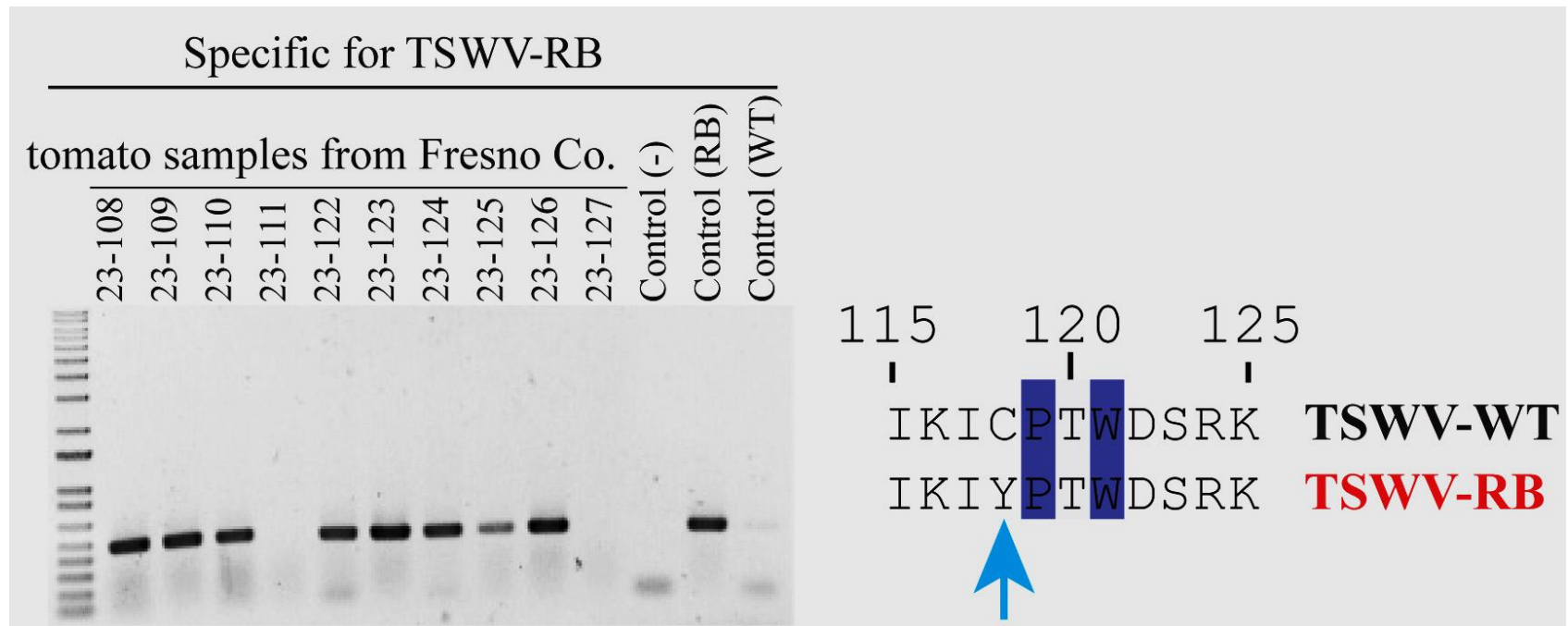
67C x 50 min

Total time: 1.5 hours

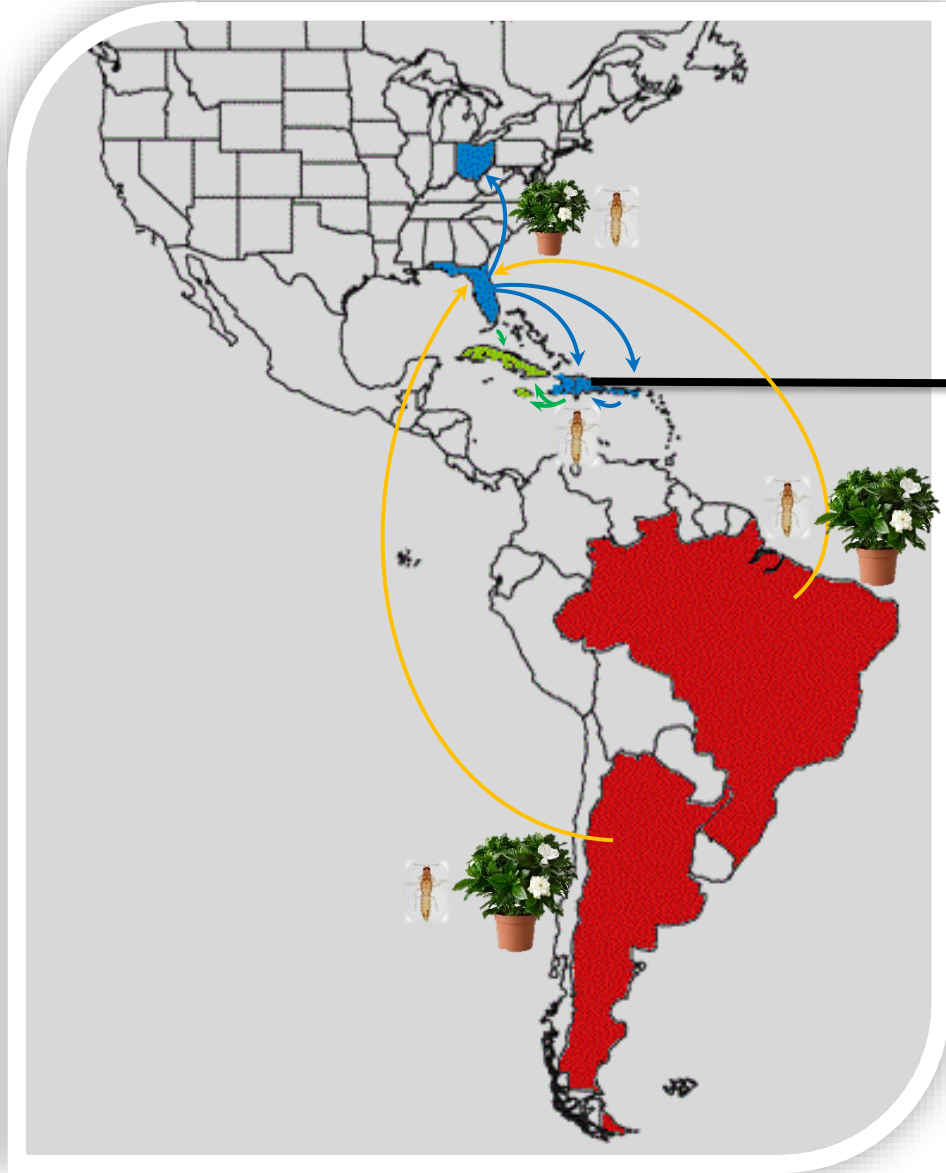
Tomato samples collected in Sutter County-2013



Tomato samples collected in Fresno County



Introduction of TCSV into the Caribbean and Southern USA



Pepper



Tomato



Tobacco



Outbreak of *Tomato chlorotic spot virus* (TCSV) in the Dominican Republic



Weed Host Reservoirs of TCSV and Thrips

IPM of RB-TSWV

- **Before the growing season**

- Weed management (especially prickly lettuce and sowthistle)
- Avoid/monitor bridge crops (e.g., lettuce, radicchio)
- Field placement and time of planting (early)

- **During the growing season**

- Plant clean transplants
- Monitor thrips populations (directly with yellow sticky cards or with DD models) and **manage thrips populations early** (2nd-3rd generations)
- Effective diagnostics
- Removal of infected plants if possible

- **After the growing season**

- Sanitation
- Avoid or manage thrips/TSWV in bridge crops

- **Long term**

- Identify **new sources of resistance**
- New and improved insecticides for thrips management**

Research Team

UC Davis

- **Dr. Tomas Melgarejo**
- **Dr. Maria Rojas**
- **Dr. Monica Macedo**
- **Margaret Cespedes**
- **Dr. Neil McRoberts**
- **Dr. Diane Ullman**

UCCE

- **Farm Advisors: Tom Turini** (Fresno County), **Scott Stoddard** (Merced), **Brenna Aegerter** (San Joaquin), **Amber Vinchesi** (Colusa, Sutter and Yolo) and **Gene Miyao**

