Tomato spotted wilt virus (TSWV): Update on biology and integrated management in the Central Valley of California

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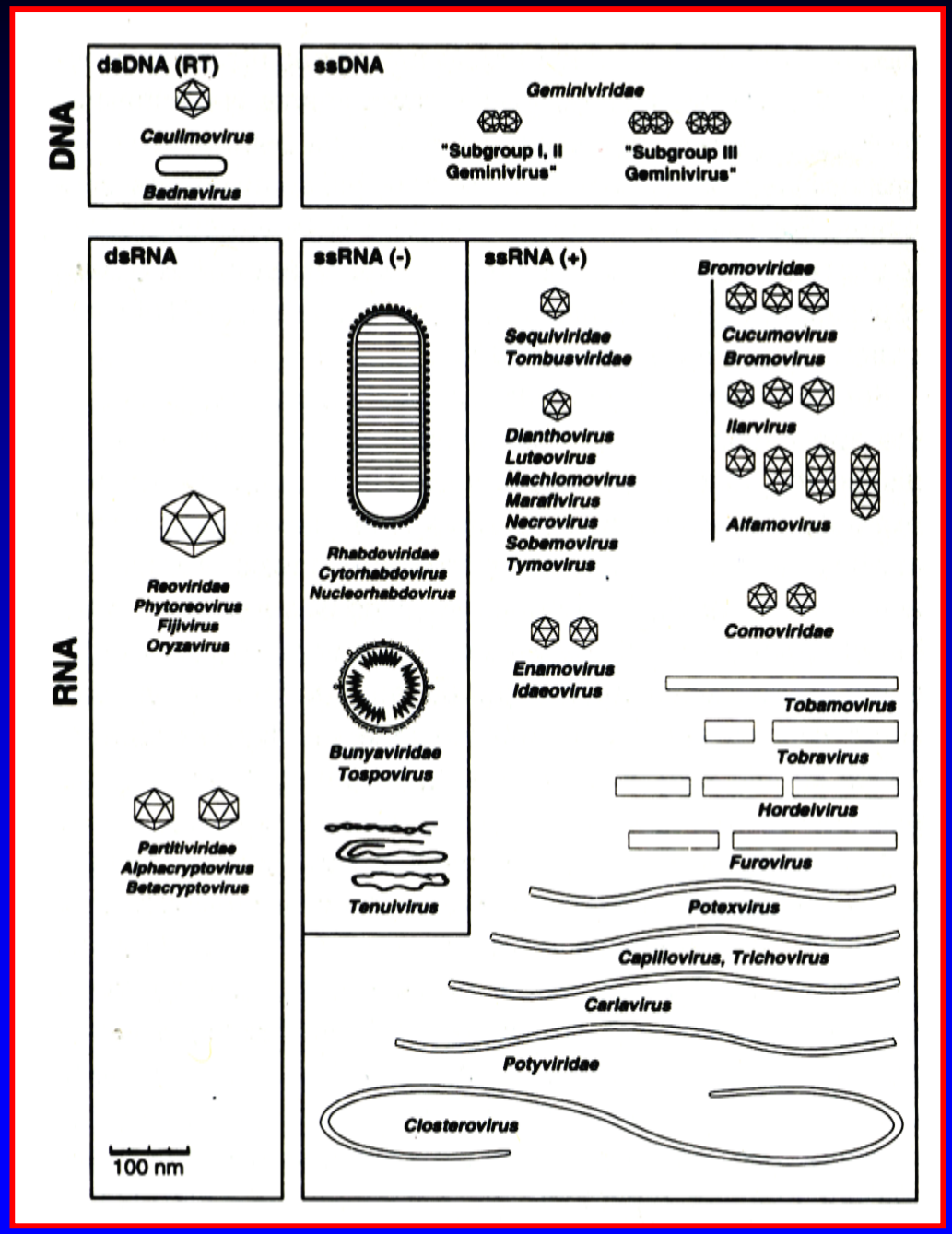
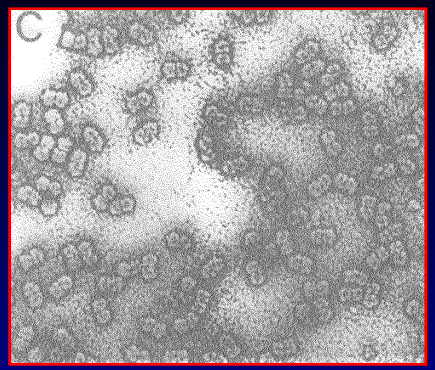
A striking diversity of viruses have evolved to infect plants



Plant Viruses



- **Parasitic genetic elements** (RNA or DNA) covered by a protective protein shell
- Viruses take over the **cellular machinery** of the plant, **spread throughout the infected plant**, and cause disease symptoms
- **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**

Tomato spotted wilt virus (TSWV): Monitoring and Management

Tomato Spotted Wilt Disease

- **Common disease of tomato in tropical and subtropical areas, such as Central America and Florida, but can also be a problem in areas with Mediterranean climates such as California**

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

- **Symptoms: bronzing and necrosis of leaves and stems, chlorotic/yellow ringspots on fruits (can be confused with *Tobacco streak virus* and other viruses)**

- **Transmitted by various species of thrips, including 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

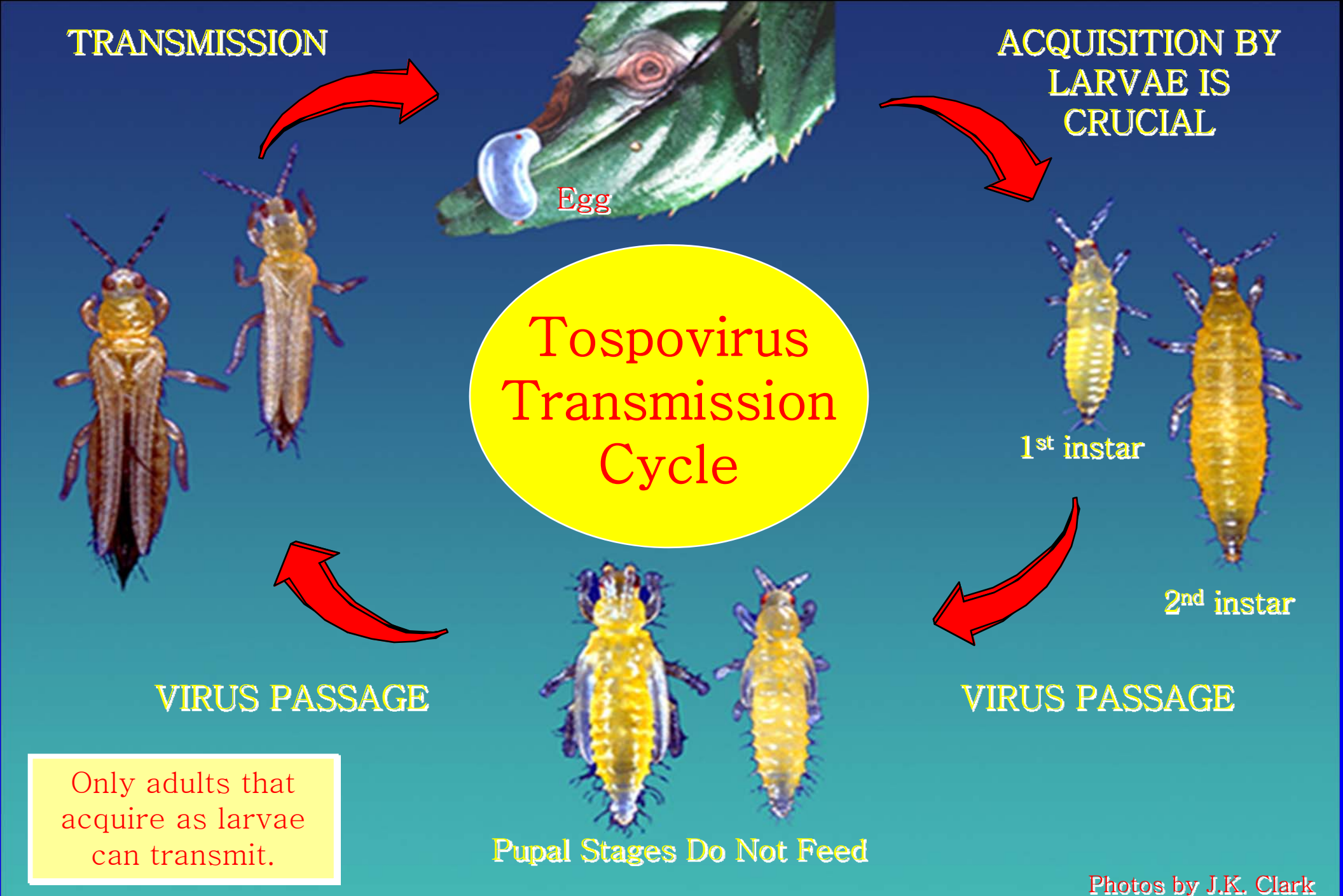
Crops/Ornamentals Susceptible to TSWV

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
Pupal Stages Do Not Feed
Only adults that acquire as larvae can transmit.
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

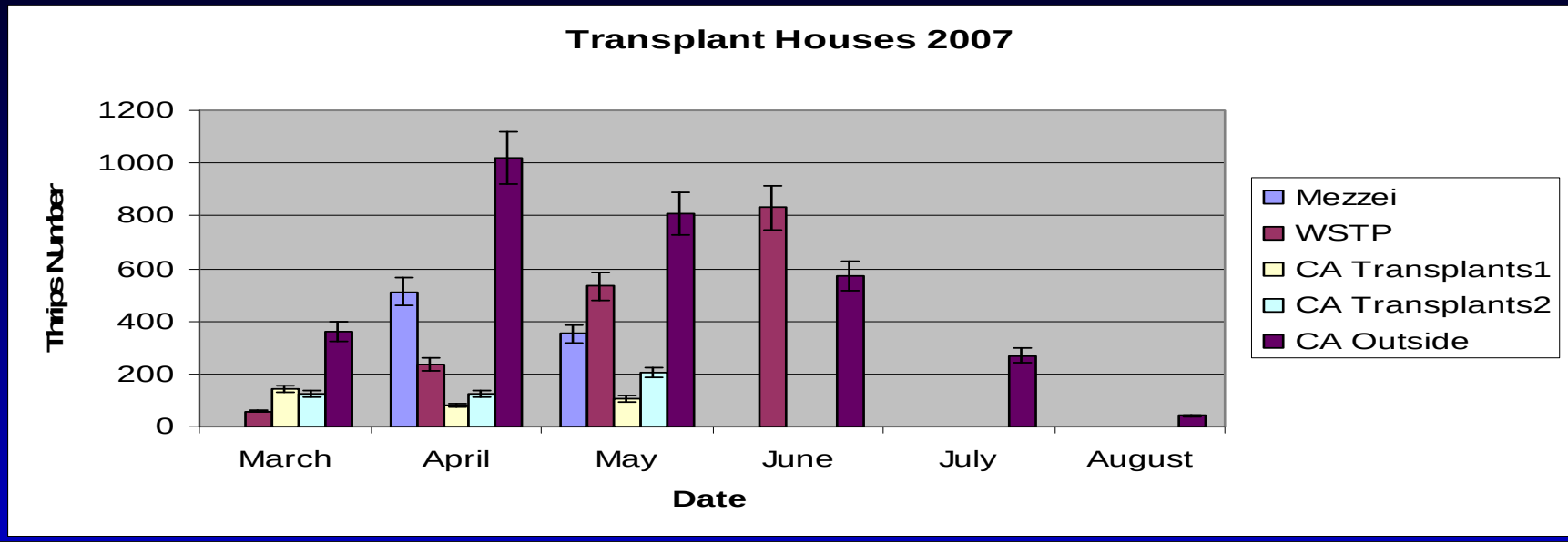
- Develop a regional integrated management program

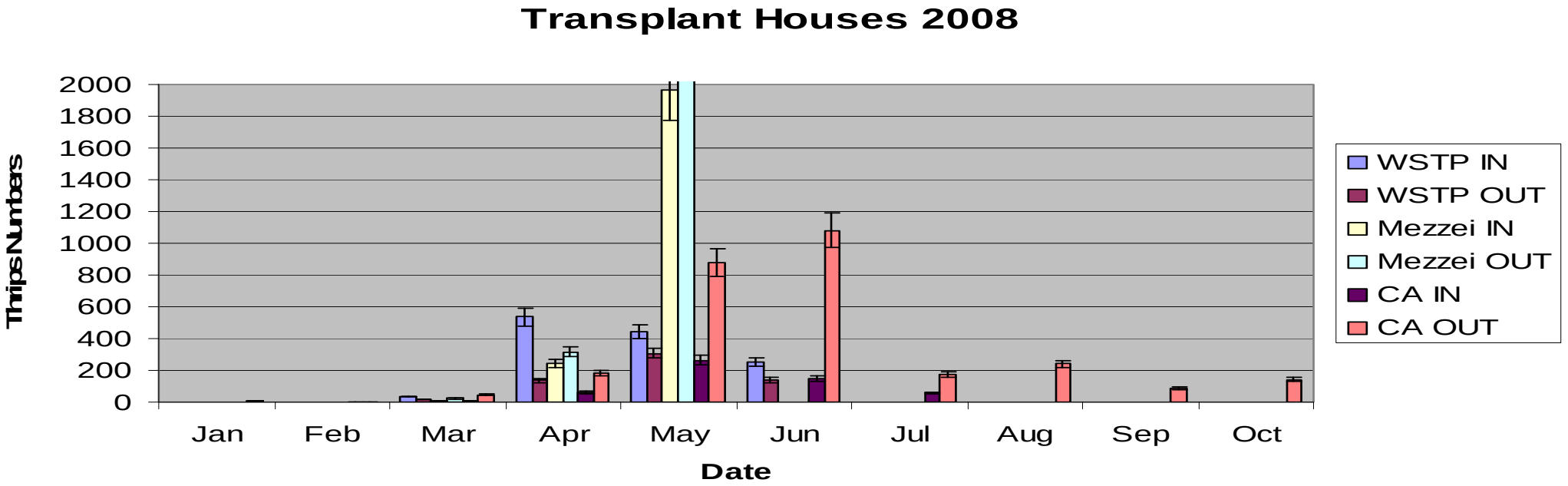
Monitoring tomato transplants

- **Transplant greenhouses**
  - -Greenhouse operations monitored for thrips and TSWV
  - -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

Thrips monitoring in tomato transplants-Results





Fava beans and Petunia plants show TSW-symptoms more rapidly than tomatoes

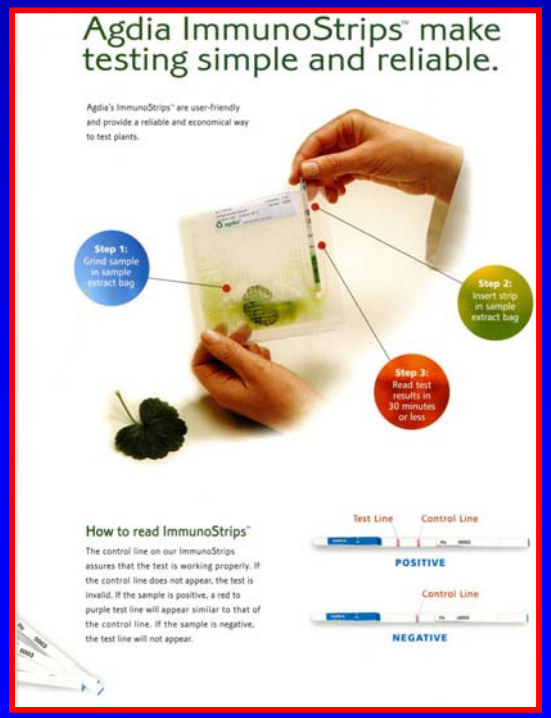
TSWV was not detected on indicator plants or in tomato transplants in any of the monitored greenhouses

Monitoring of transplants

- Relatively low thrips populations (especially in closed greenhouses) on transplants
- Overall thrips populations were higher (four-fold) in 2008 compared with 2007
- No evidence of TSWV infection of transplants
- Transplants are not a major source of thrips or TSWV for processing tomatoes

Monitoring thrips and TSWV in tomato fields

- Direct-seeded and transplanted tomato fields
- Thrips are monitored with yellow sticky cards and flower counts from 5 locations within each field
- Virus incidence determined from randomly selected rows (total 50 yards/location for 5 locations/field)
- TSWV infection confirmed in selected plants with immunostrips

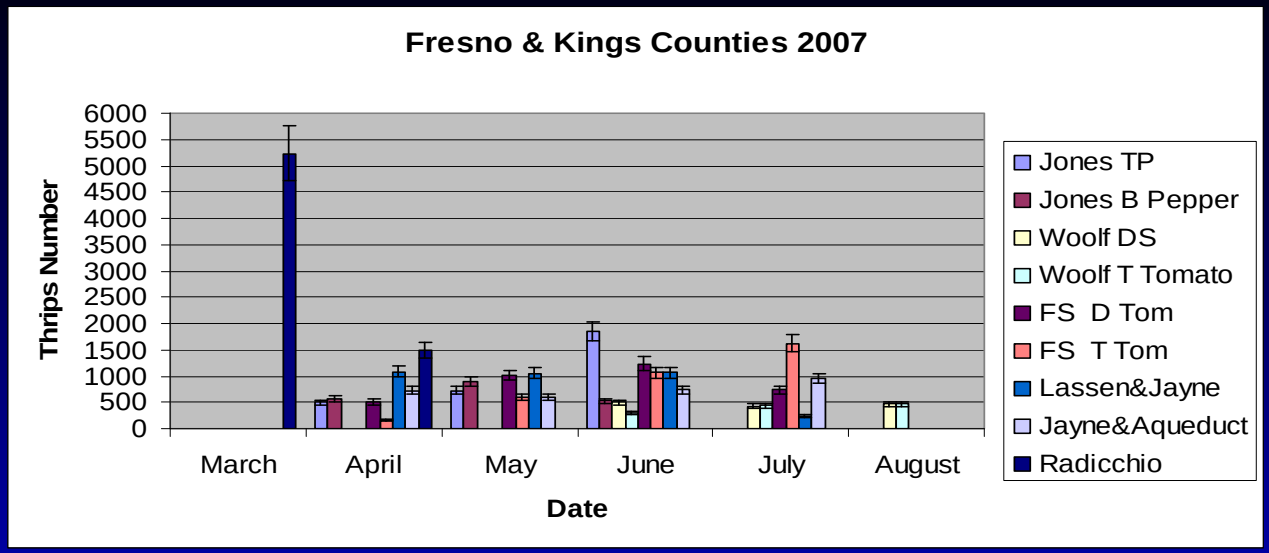


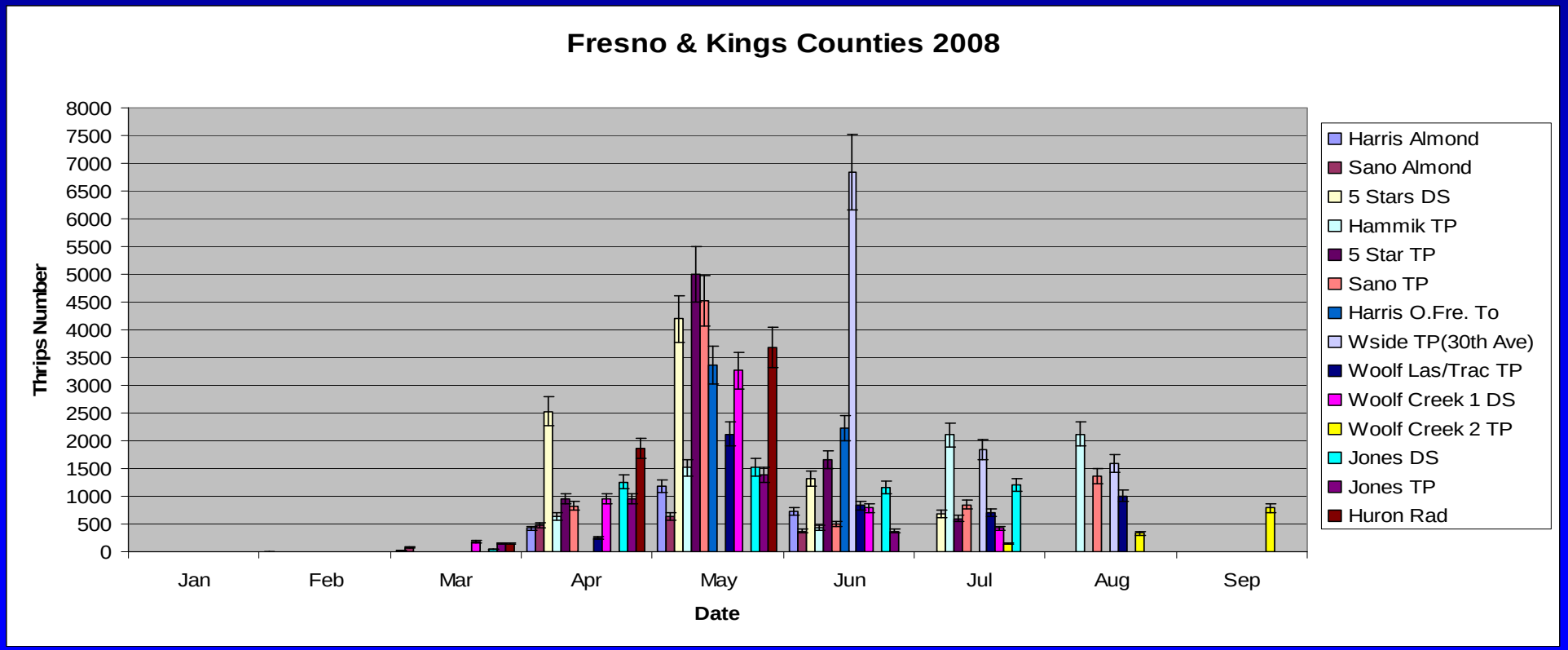
Fields monitored-2008

Fresno & Kings Counties	Locations	Merced County	Locations
Harris Almond	Coalinga	LG1 Winter Rad	Le Grand Ranch
Sano Almond	Firebaugh	LG2 Winter Rad	Le Grand Ranch
Almond 1,2 and 3	S Huron	CD1 Winter Rad	Childs Ave
Hammik-TP	Firebaugh	CD2 Winter Rad	Childs Ave
5 Star-TP	Five Points	CW1 Winter Rad	Chowchilla
5 Star-DS	Five Points	AT1 Winter Rad	Athlone / S Mush Rd
Sano-TP	Firebaugh	LG3 Spring Rad	Le Grand Ranch
Harris Organic Fresh Market	Coalinga	CD3 Fresh Market-TP	Childs Ave/ Arboleda
Westside (30th Ave)-TP	West Side	CD4 Fresh Market-TP-L	Childs Ave
Woolf Las/Trac-TP	S Huron	LG4 Processing-TP	Le Grand Rd
Woolf Creek 1-DS	W Huron	LG5 Fresh Market-TP-L	Le Grand Rd
Woolf Creek 2-TP	W Huron	MN1 Processing-TP	Minturn / B. Hollow
Jones-DS	NE Kettleman City	MN2 Fresh Market-TP-L	Minturn Rd
Jones-TP	NE Kettleman City	GT1 Processing-TP	Gillette / Burchell
Huron Rad	S Huron		

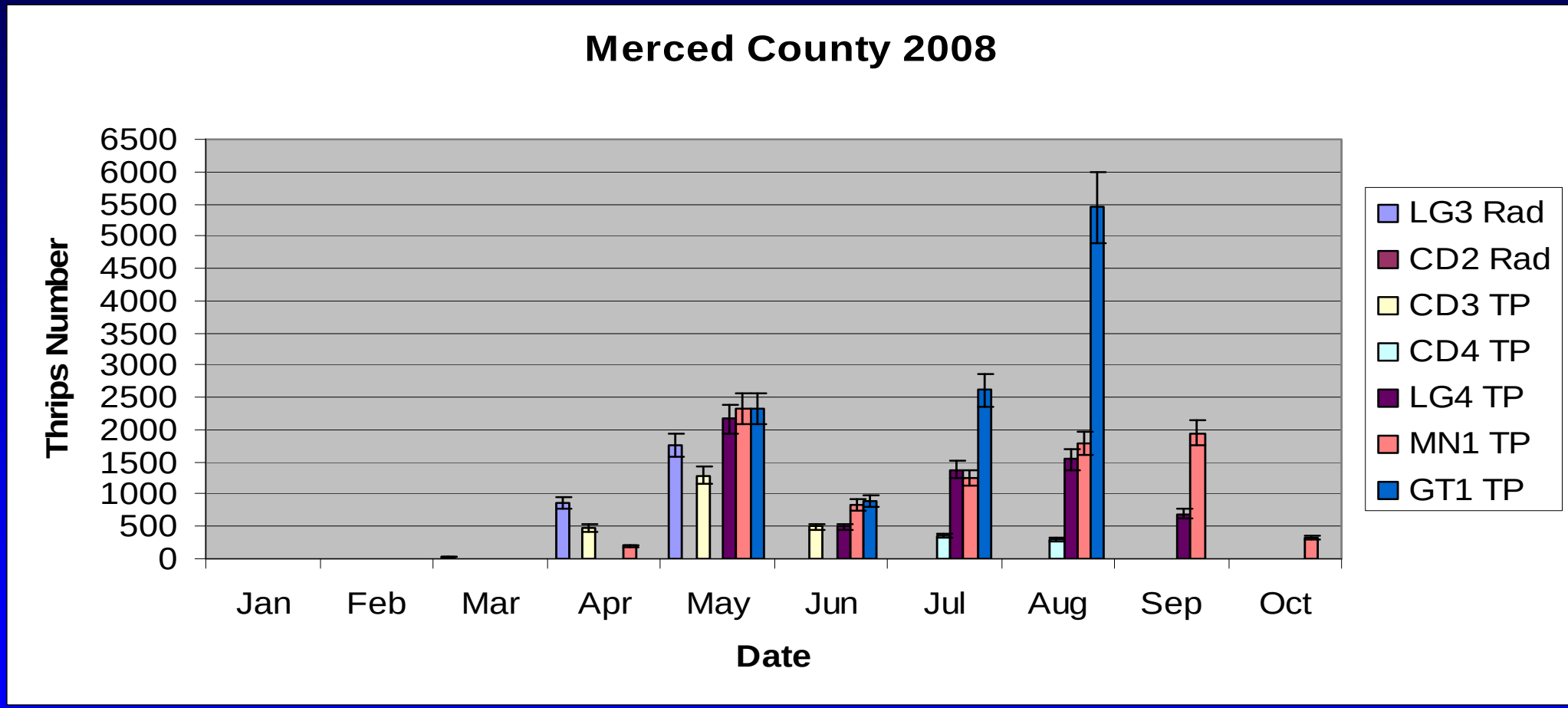
TP, transplanted processing tomato; DS, direct seeded processing tomato; Rad, radicchio; L, late planted

Thrips monitoring: yellow sticky cards

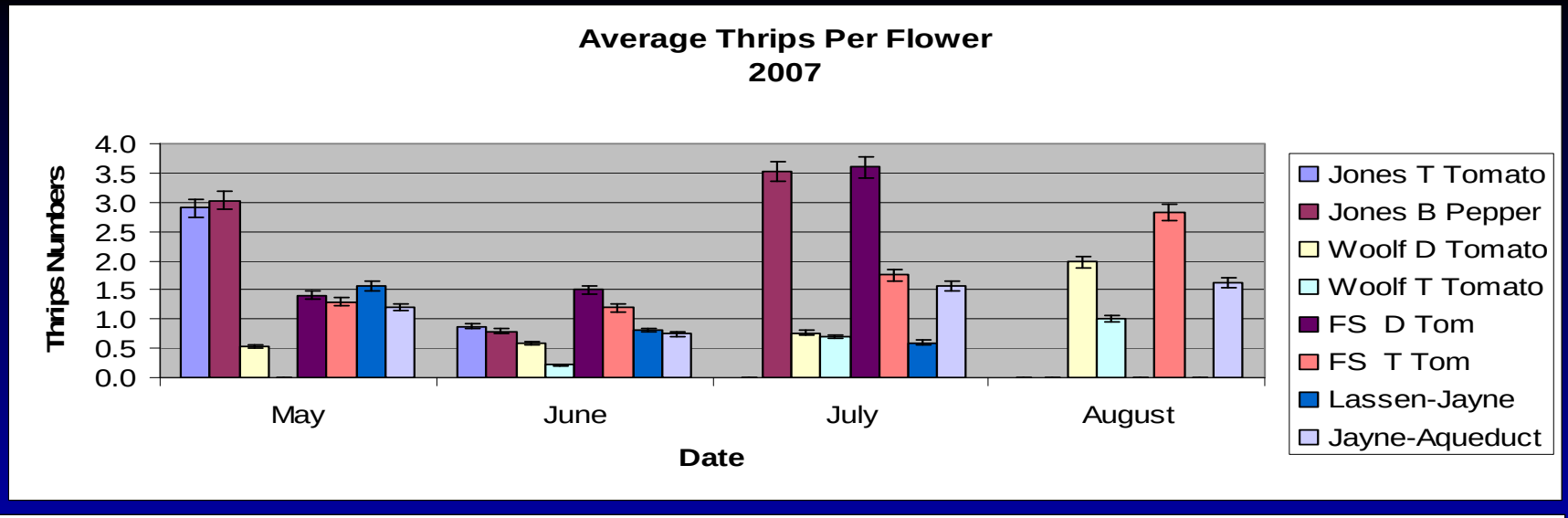


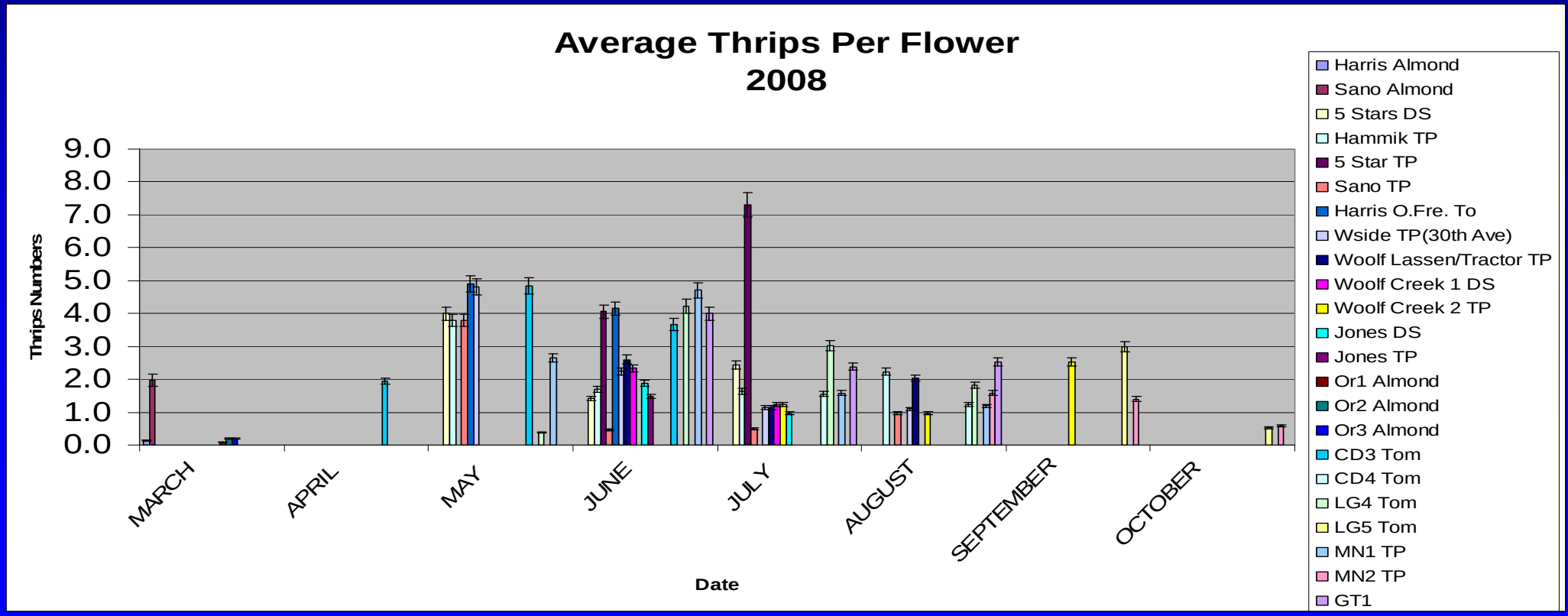


Thrips monitoring: yellow sticky cards



Thrips monitoring in flowers

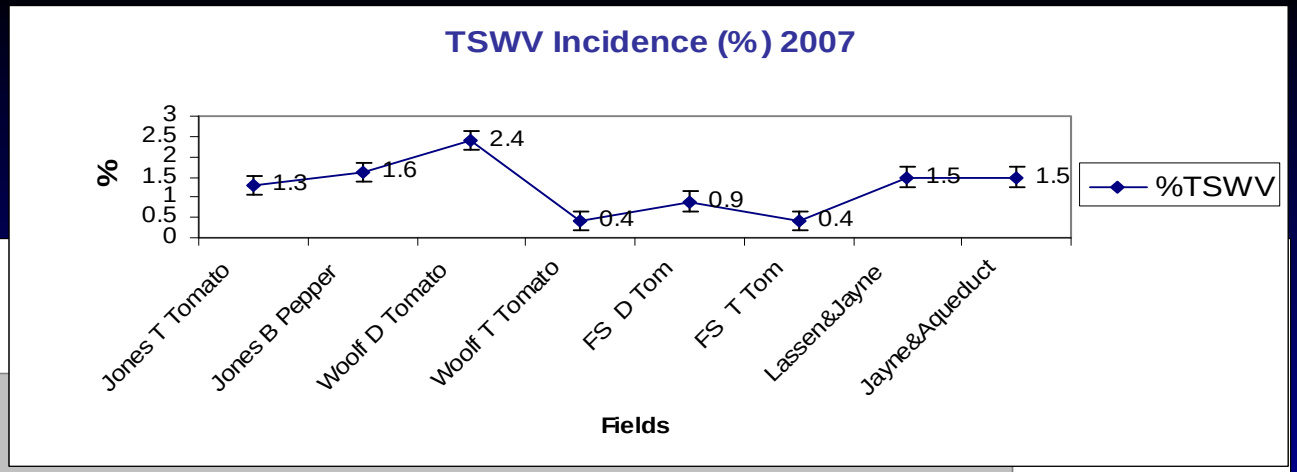


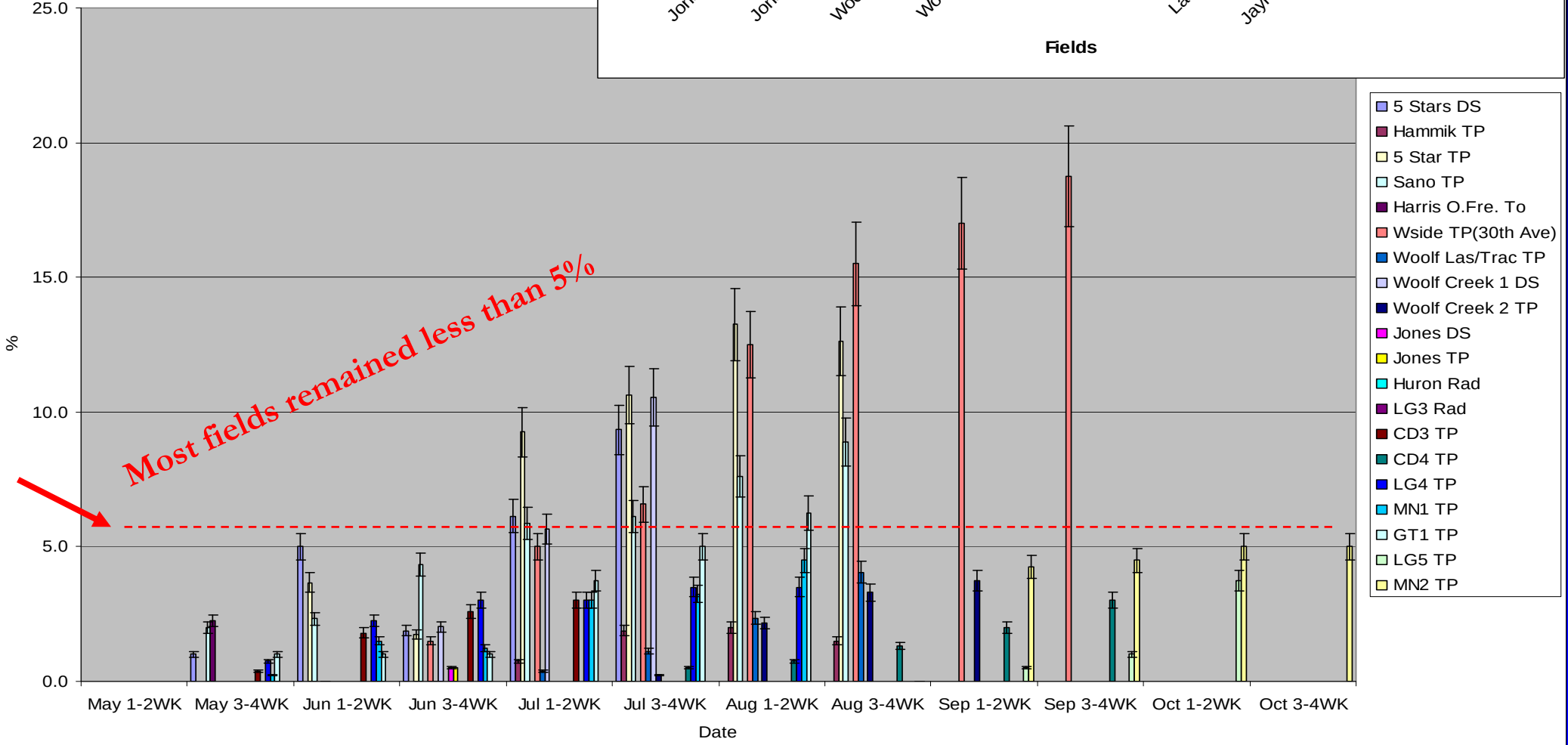


Results-Thrips populations

- Thrips populations **begin to increase in March/April**; **peaked from May-July**; and slowly declined until late fall (October) to winter when populations are lowest
- In **2007, populations were moderate, whereas in 2008 populations were twice to four-fold as high**
- Detection of larvae in tomato flowers indicates **thrips reproduction on tomato**
- All were identified as **western flower thrips**

TSWV Incidence (%) 2007 and 2008





Results-TSWV incidence

- In 2007, TSWV was first detected 20 April in a direct seeded field, whereas in 2008, TSWV first appeared mid-May
- In 2007, spotted wilt appeared in most fields but late and at low incidences (>1%-3%)
- In 2008, overall TSWV pressure was greater, especially in later planted fields (incidences ranged from 0%-15%), and ID was complicated by higher incidences of curly top virus
- TSWV incidence was slightly greater in direct-seeded versus transplanted fields
- In 2007 and 2008 overall economic losses due to TSWV in monitored fields was minimal

Monitoring tomato fields-Grower alerts

- Growers were promptly advised on the detection of thrips and TSWV in tomato crops via CTRI in 2007 and 2008
- This allowed for implementation of thrips management strategies (primarily chemical control), which is thought to slow the spread of virus (possibly by reducing the number of virus-carrying adults) and the build-up of thrips populations

TSWV-Inoculum Sources

- **Winter surveys** of areas with high TSWV to look for **reservoir hosts,** including weeds, winter crops and perennials (almonds)
- Monitored **spring lettuce crops** for spotted wilt
- Focus on the potential of **radicchio to serve as a bridge crop** between tomato crops

Other sources examined in 2008

Almonds

- -thrips populations were low in almond orchards (yellow sticky cards) and in flowers
- -TSWV not detected in thrips from almond (almond is not a reported host for TSWV)

Weeds

- -a variety of common weeds were collected throughout the growing season and in areas known to have TSWV outbreaks
- -most samples were negative for TSWV, with an incidence of <0.1%
- -weeds that were positive included groundsel, London rocket, malva, prickly lettuce, sowthistle

Weed survey results for TSWV incidence (Fresno and Merced counties)

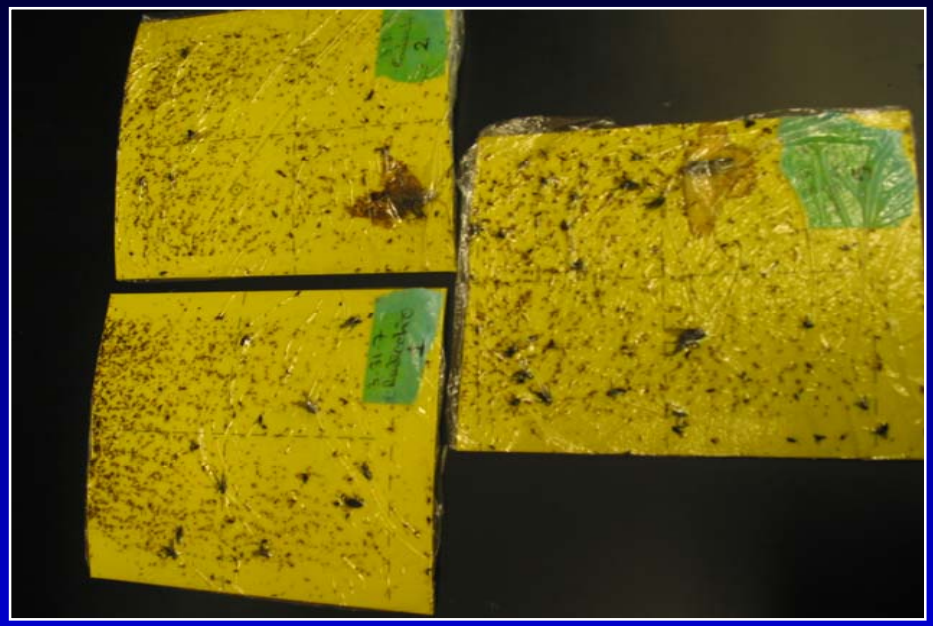
Weed	Tested (+)	Weed	Tested (+)
Barnyard grass	25 (0)	Lambs quarters	63 (0)
Black nightshade	25 (0)	Malva	110 (1)
Bindweed	25 (0)	Mustard	60 (0)
Bur clover	25 (0)	Nettle	25 (0)
Common sunflower	25 (0)	Pigweed	25 (0)
Dodder	25 (0)	Prickly lettuce	90 (2)
Fiddle neck	25 (0)	Purslane	25 (0)
Ground cherry	25 (0)	Russian thistle	25 (0)
Groundsel	40 (1)	Sowthistle	60 (1)
Jimsonweed	25 (0)	Tree tobacco	25 (0)

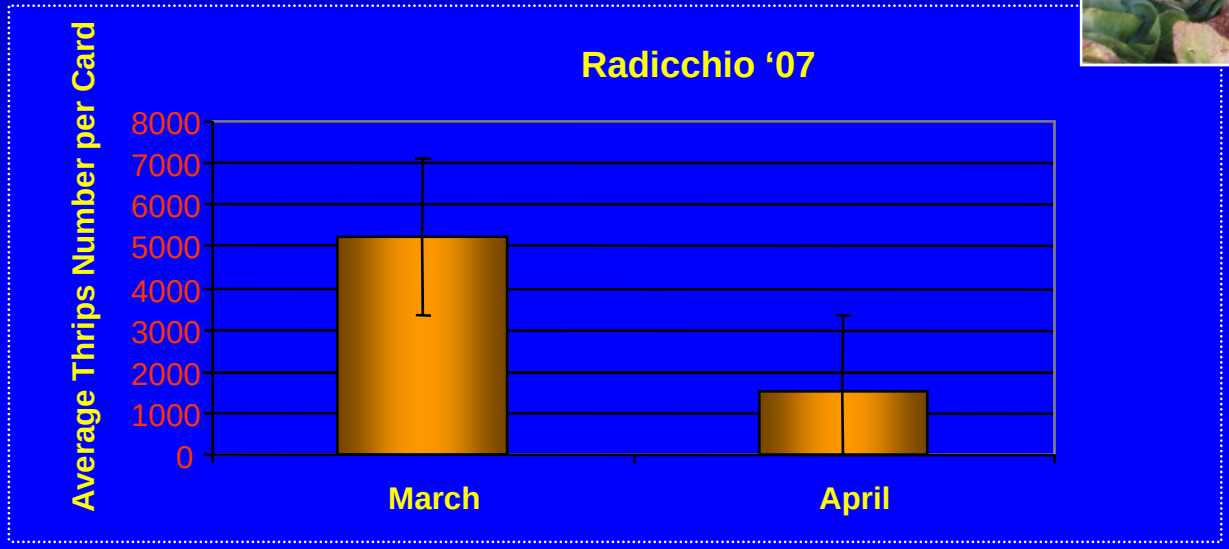
(+) number of plants tested positive for TSWV by immunostrips and/or PCR

TSWV in Lettuce

Detected in Fresno in spring lettuce in 2007 and 2008, but was sporadic and no economic losses

Radicchio - a reservoir crop for TSWV





TSWV in Peppers

-a highly susceptible host that can amplify thrips and TSWV

Detection of TSWV in thrips

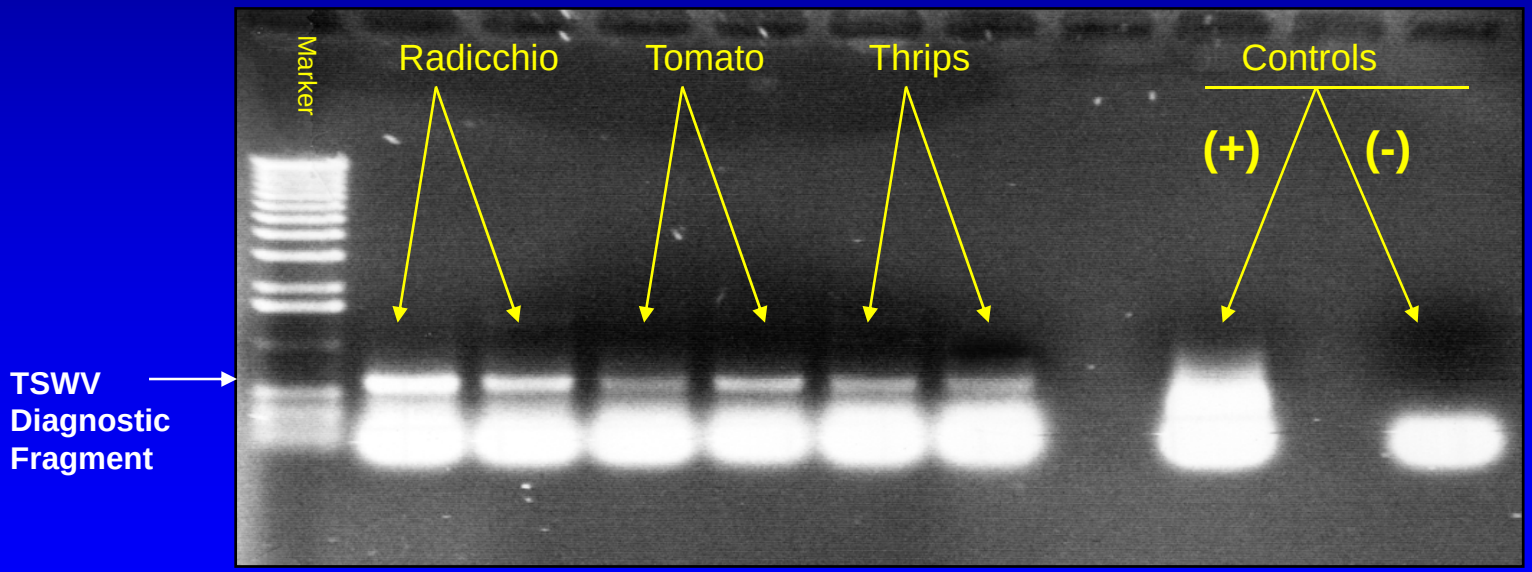
- An test (the RT-PCR test) has been developed that allows for detection of TSWV in thrips
- Can detect TSWV in thrips from sticky cards or plants
- Can detect TSWV in a single insect

Adult thrips

Larval thrips

The RT-PCR test allows for detection of TSWV in thrips

- This will help determine when virus-carrying thrips are present
- Could be used to help determine if viruliferous thrips overwinter and can be inoculum sources early in the growing season



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

- Preliminary results indicate that **early in the season** many thrips are not carrying the virus
- Consistent with the **thrips picking up virus from crop plants infected early in the season** (from thrips from weed, ornamental or bridge hosts)
- By mid-season (July) TSWV is being detected in more thrips samples
- Consistent with **early efforts to suppress thrips populations**

Chemical Control of Thrips

- It is important that thrips management be implemented prior to or immediately following initial TSWV findings
- Critical to reduce the number of virus-carrying adults by controlling larvae early in the season
- Thrips insecticide trials have been conducted at Westside
- Based on 2007 and 2008 trials the best materials were: Dimethoate, Lannate, Radiant, and Mustang+Beleaf
- However, the effect was not long-lasting (7-10 days)
- Neonicotinoids (e.g., imidicloprid, thiamethoxam) are not effective

Adult thrips

Larval thrips

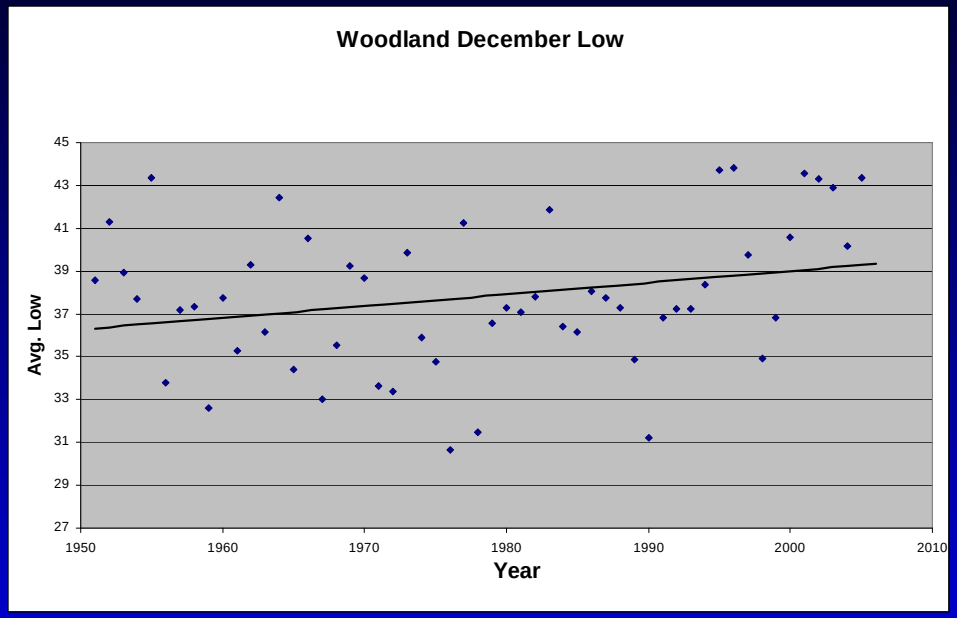
Biology of thrips/TSWV in the Central Valley

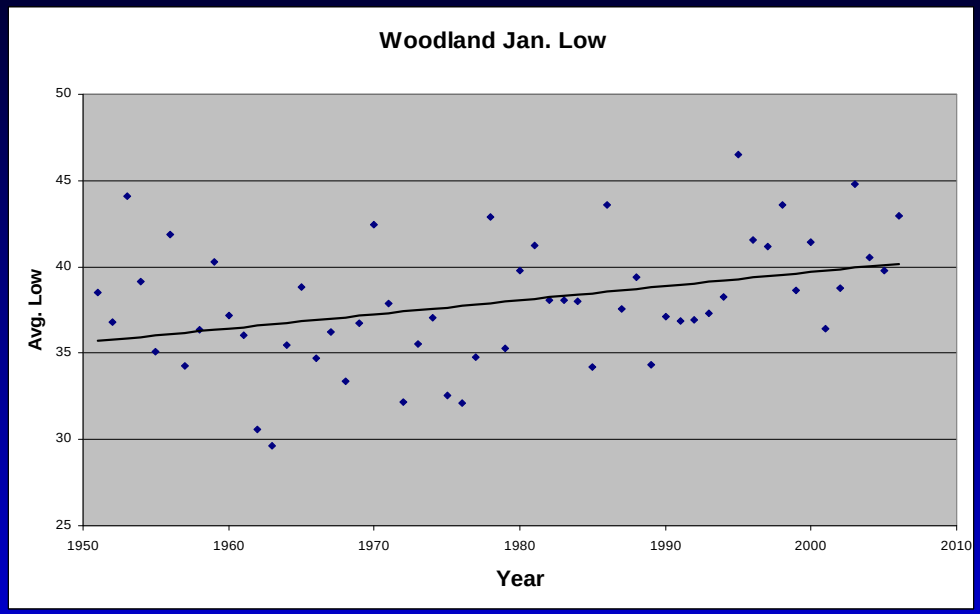
- **Low populations of thrips persist overwinter** and in association with weeds and winter (bridge) crops
- **TSWV does not seem to overwinter well in weeds or other winter crops** (almonds, onion and wheat), but it can be present in bridge crops such as lettuce and radicchio
- **During the growing season**, TSWV **builds-up in susceptible crops**, mostly tomato and peppers; thrips increase on many hosts, including alfalfa, onion, wheat.
- Thus, it is important that **thrips management be implemented prior to or immediately following initial TSWV** findings to minimize disease pressure, especially on late-planted crops
- Critical to **reduce the number of virus-carrying adults by controlling larvae early in the season**

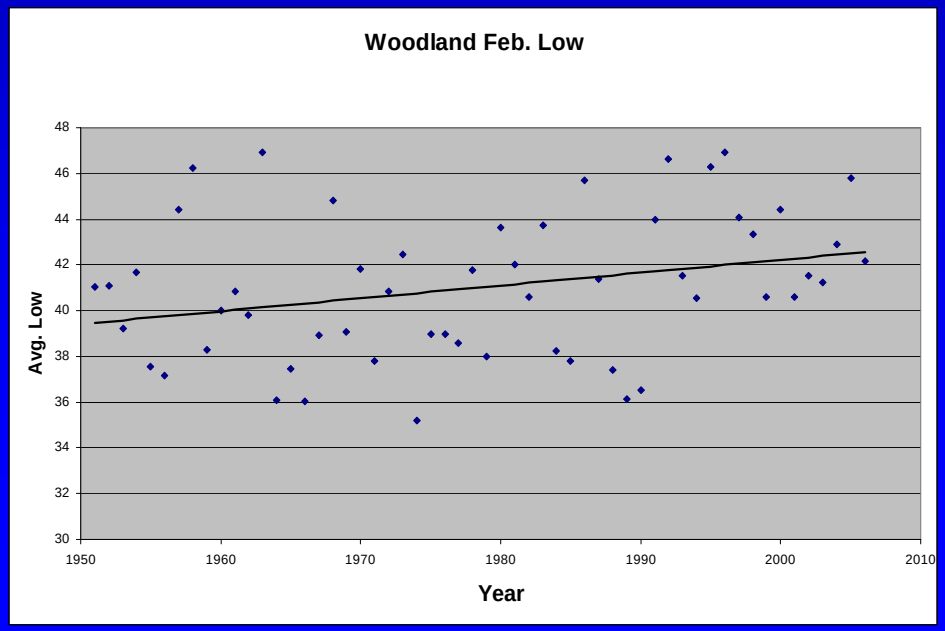
Integrated TSWV Management

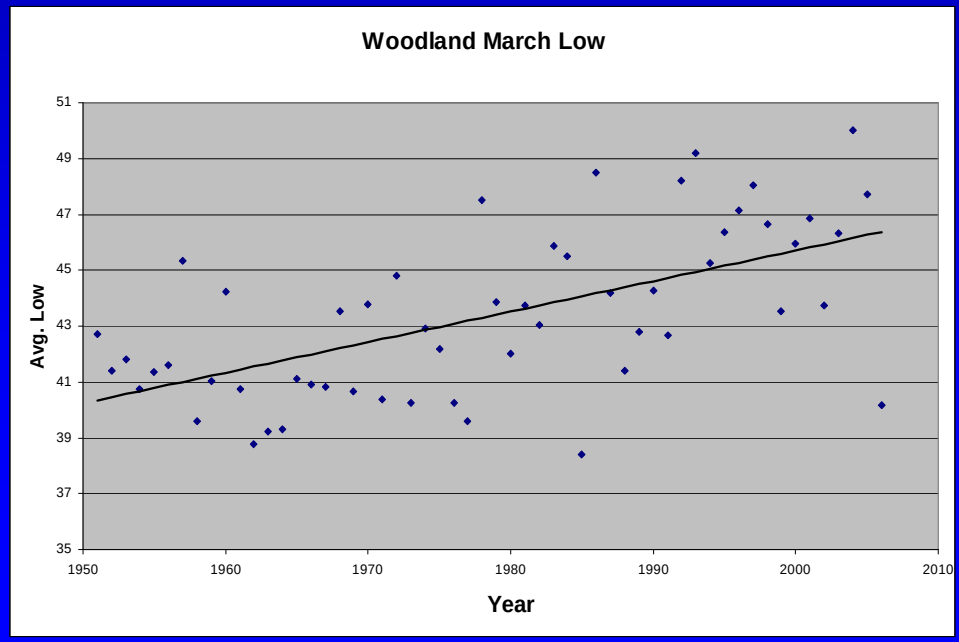
- **Before planting**
  - -Variety selection (TSWV resistant [Sw-5] varieties)
  - -Virus-free transplants
  - -Avoid 'hot spots' or fields known to have TSWV
- **During the season**
  - -Monitoring for thrips/TSWV
  - -Thrips management early (to manage larval populations)/rotate classes of materials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

Why the increase in thrips and tospoviruses in California?



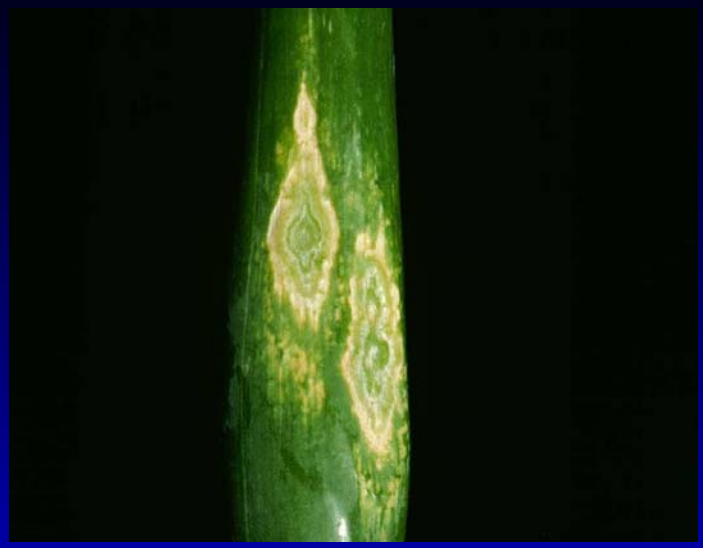






New tospoviruses are appearing in California crops

Impatiens necrotic spot virus (INSV) in lettuce in Monterey County



Iris yellow spot virus (IYSV) in many onion-growing areas

Appearance of a new tomato-infecting virus in 2008

Appearance of a new tomato-infecting virus in 2008

- Appears to be a **new ilarvirus**
- Most similar to ***Parietaria mottle virus***, an ilarvirus that causes leaf and stem necrosis in Europe and ***Tobacco streak virus*** (TSV)

- TSV transmission occurs when **infected pollen is introduced in leaves by wounds made by thrips feeding**
- Name **Tomato necrotic spot virus** proposed

Acknowledgements

UC Davis

-Diane Ullman

-Ozgur Batuman

-Sarah Dalmacio, Rachel Heinz

UCCE

-Michelle LeStrange

-Scott Stoddard

-Tom Turini

CTRI

Transplant producers, tomato growers, and PCAs