Tomato Spotted Wilt Virus
Management Update
South Sacramento Valley Processing Tomato Production Meeting
January 9, 2013

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Problem: Increased incidence of thrips and TSWV in processing tomatoes in California

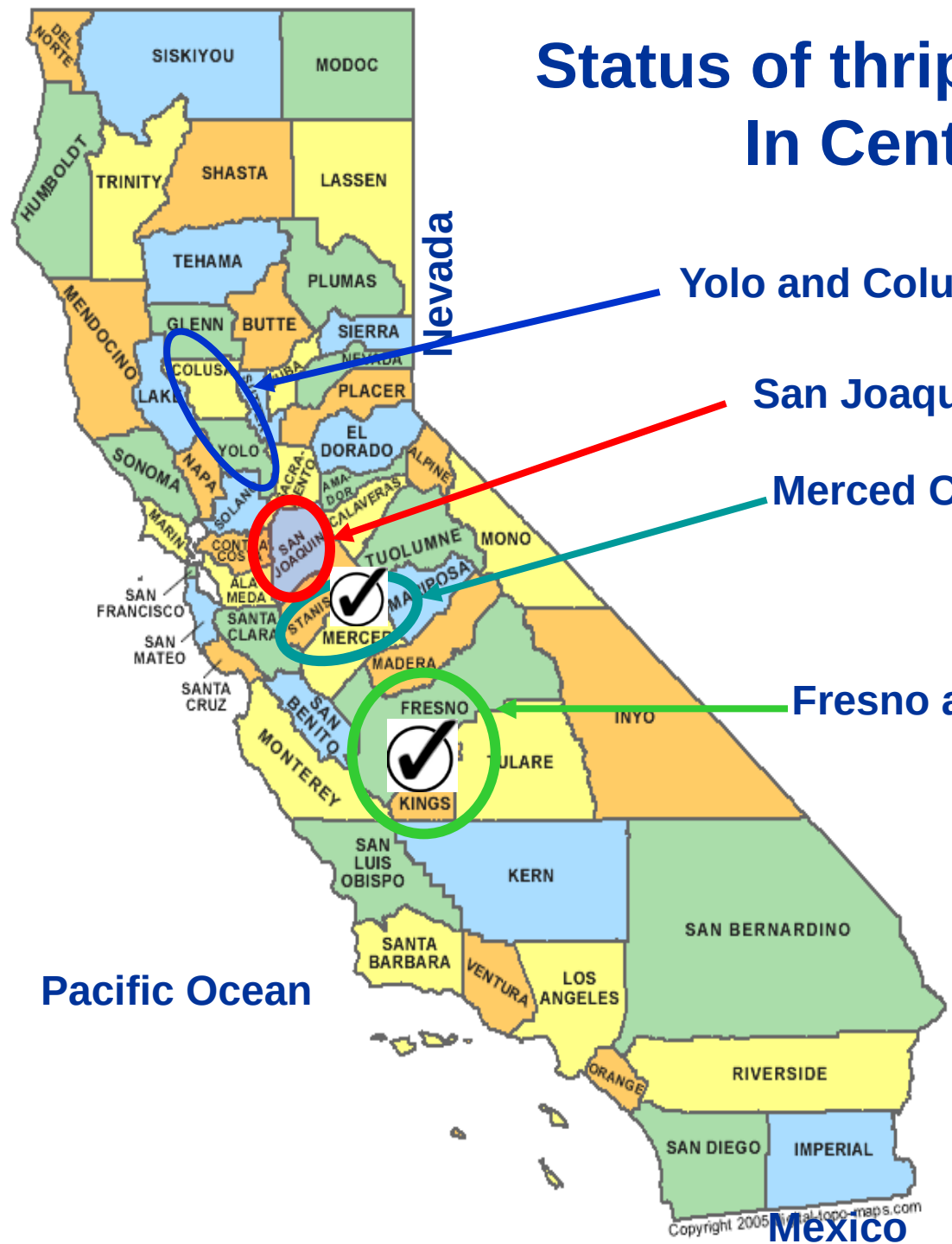
Western flower thrips (*Frankliniella occidentalis*)

Tomato spotted wilt disease caused by *Tomato spotted wilt virus*

Overall Objectives of TSWV Project

- Develop an understanding of when and where thrips and TSWV gain entry into California processing tomatoes
- Determine dynamics of thrips populations and spotted wilt disease development
- Identify potential inoculum sources (vegetables and tree crops, weeds, ornamentals, etc.)
- Assess various thrips control strategies
- Apply knowledge of thrips and TSWV to develop a regional integrated pest management (IPM) program
- Minimize economic losses due to thrips and TSWV

Status of thrips/TSWV monitoring In Central California



Yolo and Colusa Counties (2009-13)

San Joaquin County (New location)

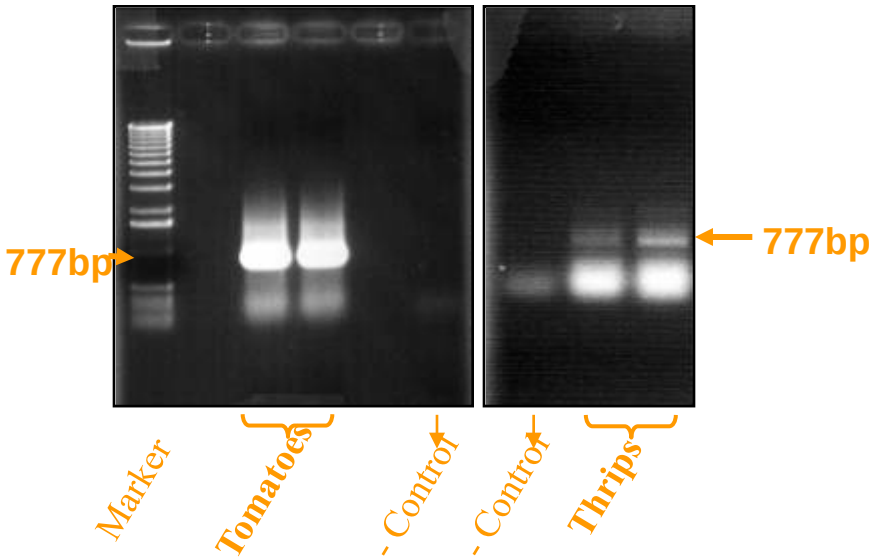
Merced County (2008-2012)

Fresno and Kings Counties (2007-2012)

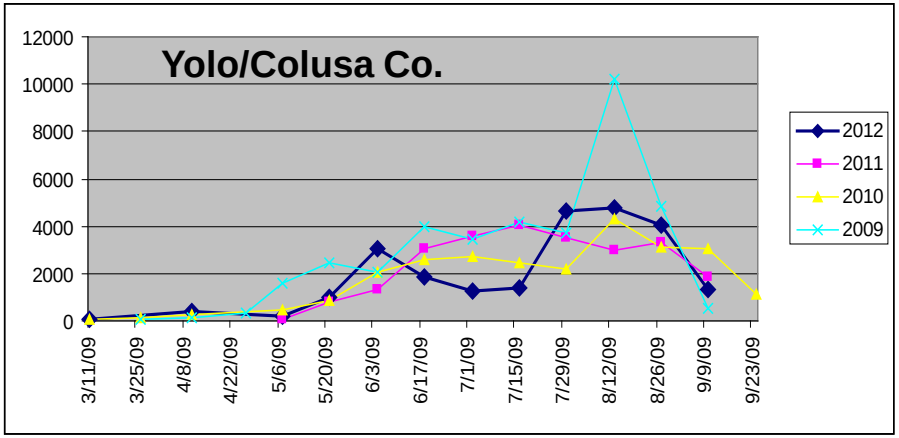
>200 monitored fields since the start of the program

Monitoring thrips and TSWV in tomato fields

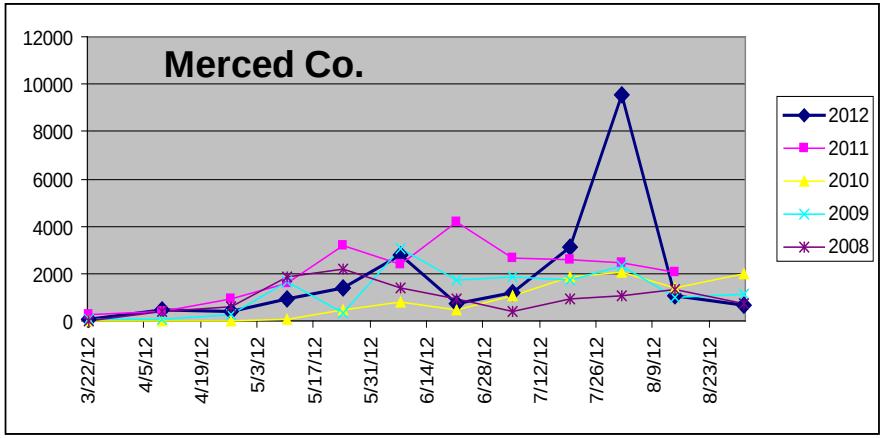
- Thrips are monitored with yellow sticky cards and flower counts
- Virus incidence is determined by visual inspections
- TSWV infection is confirmed with immunostrips or RT-PCR



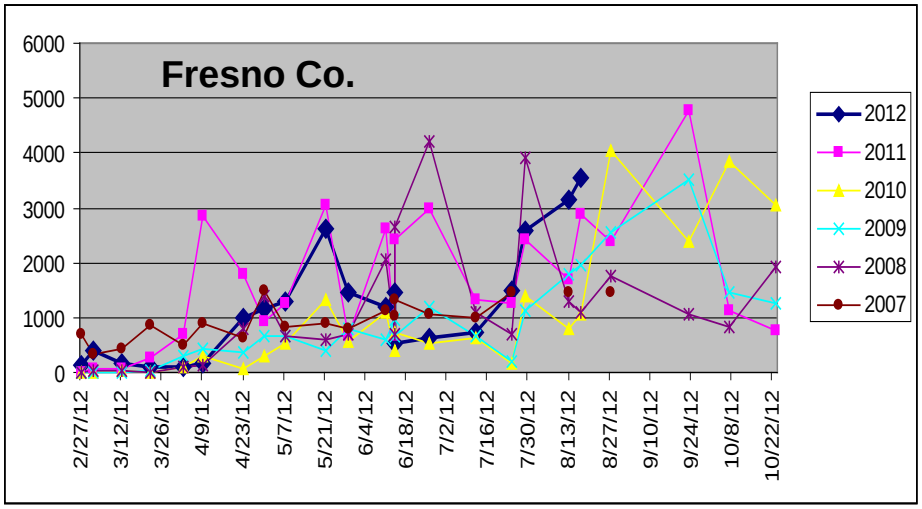
Average Thrips Populations per Yellow Sticky Card



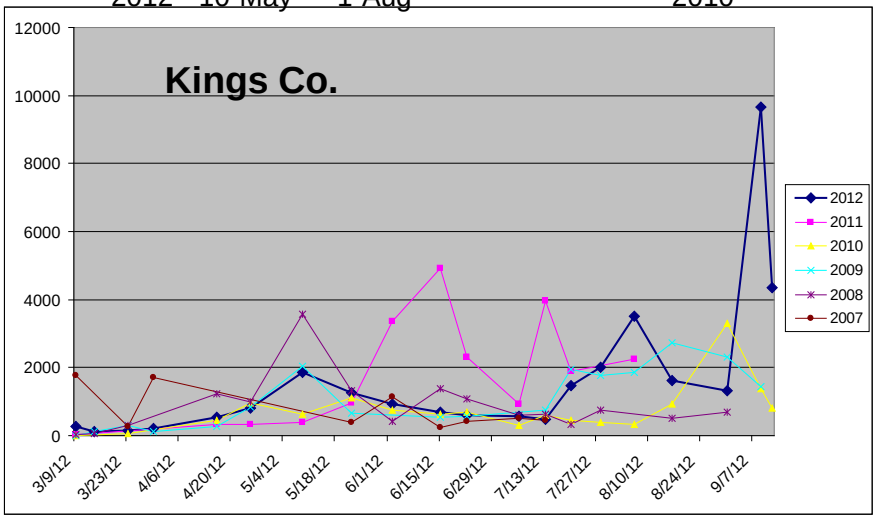
	Build up	Peak	Drop	Highest in the peak
2009	8-May	14-Aug	11-Sep	2009
2010	21-May	13-Aug	23-Oct	2012
2011	26-May	14-Jul	24-Sep	2010
2012	17-May	13-Jun	6-Sep	2011



	Build up	Peak	Drop	Highest in the peak
2008	4-Apr	16-May	10-Oct	2012
2009	6-Apr	15-May	2-Oct	2011
2010	14-May	23-Jul	5-Oct	2009
2011	12-May	21-Jul	15-Oct	2008
2012	10-May	1-Aug		2010



	Build up	Peak	Drop	Highest in the peak
2007	6-Apr	25-May		2011
2008	9-Apr	29-May	20-Oct	2008
2009	19-Mar	22-Jul	11-Aug	2010
2010	3-May	21-Jul	21-Oct	2012
2011	11-Apr	18-Aug	23-Sep	2009
2012	23-Apr	17-Aug		2007



	Build up	Peak	Drop	Highest in the peak
2007	31-Mar	29-Jun	August	2012
2008	3-Apr	1-May	October	2011
2009	14-Apr	11-Aug	October	2008
2010	23-Apr	26-Aug	November	2010
2011	12-May	16-Jun	November	2009
2012	25-Apr	9-Sep		2007

TSWV in 2012: Did we dodge a bullet in the Northern Counties?

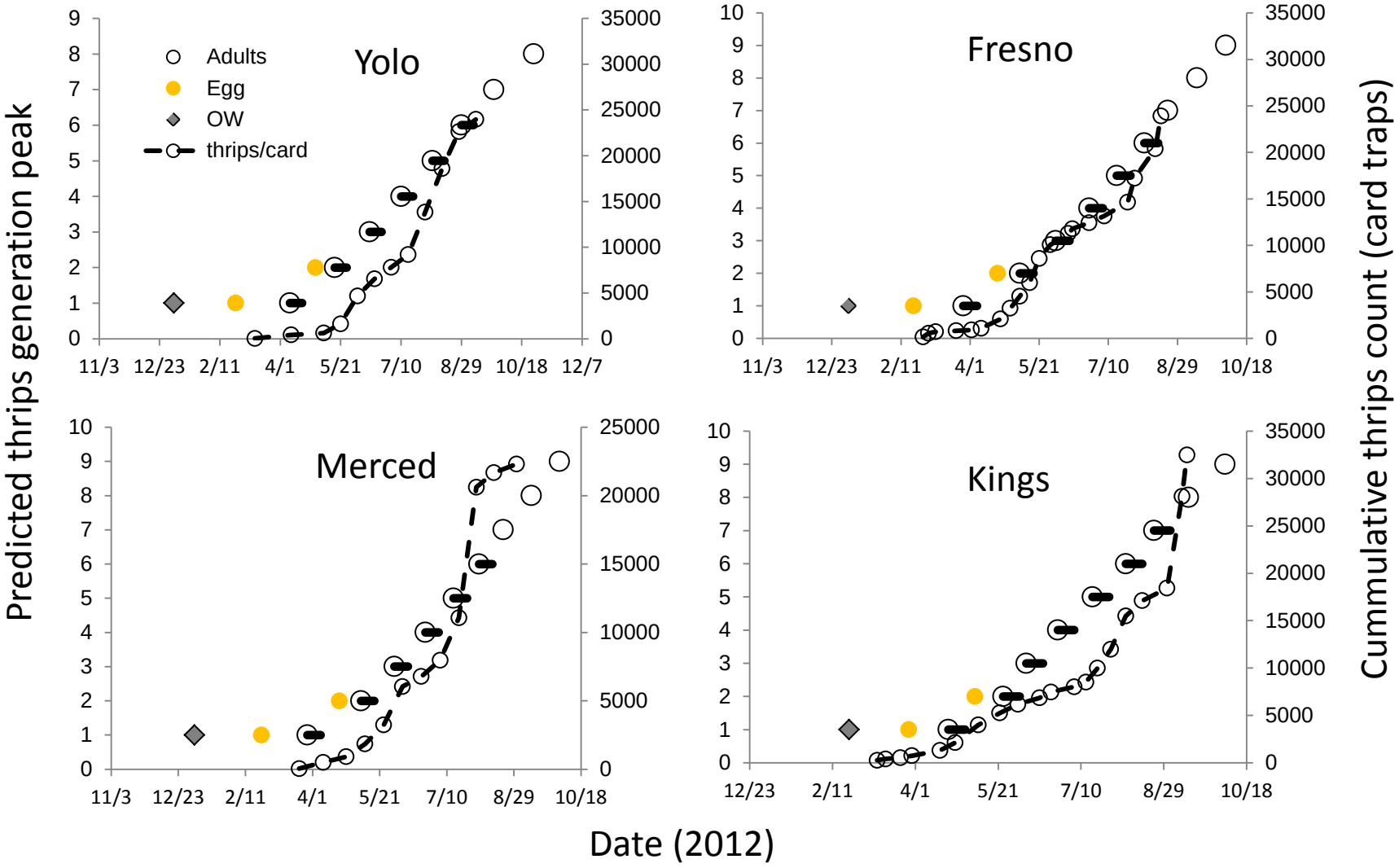
- **Fresno/Kings Co.**
  - **-First symptoms: 14 April in Fresno and late May in Kings**
  - **-Incidences low to moderate: Fresno (0-14%) and Kings (0.5-7%)**
- **Merced Co.**
  - **-First symptoms: early May**
  - **-Low incidences (0-2%)**
- **Northern Counties (Colusa, Solano, Sutter and Yolo)**
  - **-First symptoms: early May**
  - **-Rapid thrips build-up in May**
  - **-TSWV was widespread and at high incidences early in the season**
  - **-Growers and PCA implemented thrips management**
  - **-Final TSWV incidences were low to moderate (0-12%)**

- **Overall incidence of TSWV in Fresno, Kings and Merced was the lowest since the beginning of the project; however, widespread incidences in northern counties and San Joaquin County and high incidences in fresh market fields in the I-5 corridor show the continued potential for TSWV outbreaks in tomatoes in the Central Valley**

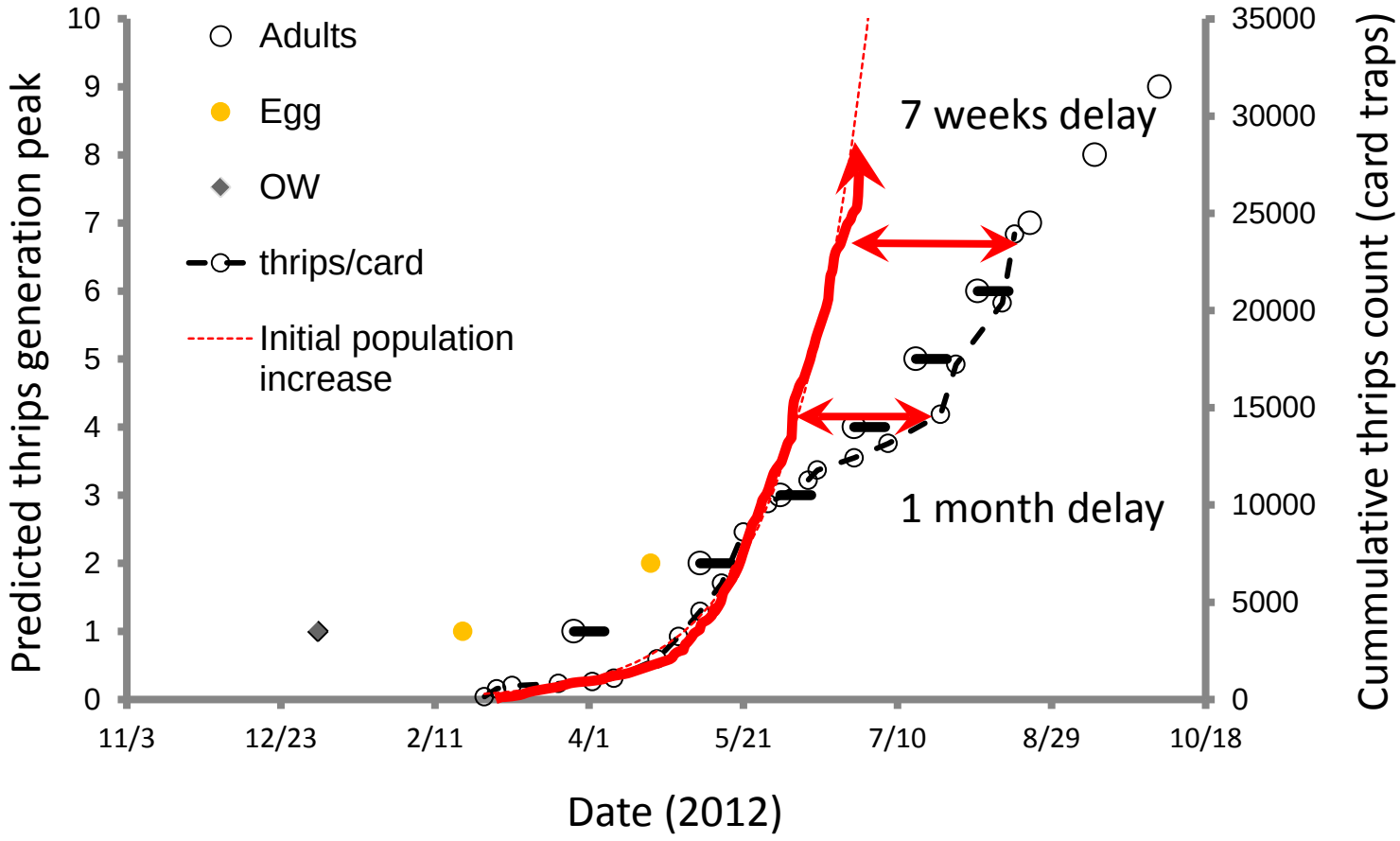
Development of a model for predicting thrips populations

- Current program involves direct monitoring efforts and grower alerts to allow for optimal timing of thrips management
- Developed a degree-day model to predict when thrips populations will begin to develop to allow growers to time spray applications
- Comparing the actual thrips counts with the predictions made by the model
- Long-term goal is to replace direct monitoring with the predictive model and develop an effective approach for providing growers information to know when to know when to spray

Overview of 2012 model and population data



Fresno example: Early control delays thrips' build-up



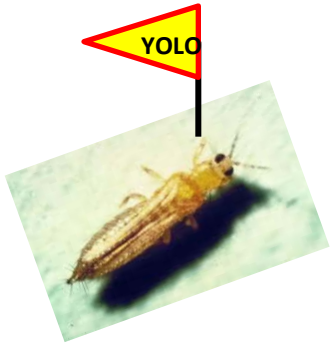
Thrips predictive model

- Qualitative predictions of the model were in good agreement with the actual numbers
- Model is slightly ahead of the actual populations
- Do not know the actual numbers or rate of increase
- Need to test delivery methods (e.g., through CTRI, internet or via smart phones [currently being developed in Florida])
- Need to continue to validate and back-up the predictive model

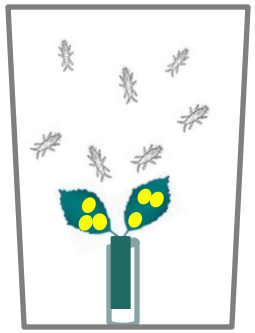
Do thrips populations vary in their capacity to vector TSWV?

- **A direct correlation does not exist between thrips populations and TSWV incidence, e.g., populations are often higher in Yolo County than Fresno County but TSWV incidence is higher in Fresno**
- **Tested the hypothesis that the thrips populations in the Fresno may be better at transmitting TSWV**

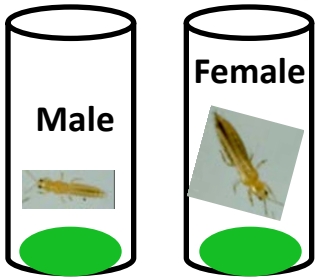
Assessment of TSWV transmission efficiencies for populations of *Frankliniella occidentalis* from Fresno and Yolo counties



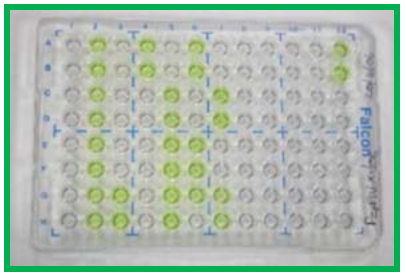
Thrips colonies



Virus acquisition



Virus transmission



ELISA tests

Differences Exist in Fresno and Yolo Thrips Populations in TSWV Transmission Efficiency

TSWV-Fresno isolate				TSWV-Yolo isolate			
Fresno Thrips		Yolo Thrips		Fresno Thrips		Yolo Thrips	
Male	Female	Male	Female	Male	Female	Male	Female
45% (8)[a]	42.5% (8)	40% (7)	25.7% (7)	42% (5)	32% (5)	26% (5)	18% (5)
43.8%		**32.9%**		**37%**		**22%**	

[a] Numbers in parentheses represent replicates of independent experiments

Conclusions

- **Differences exist in the transmission efficiencies of *F. occidentalis* populations from Fresno and Yolo Counties**
- **Fresno thrips population was more efficient at transmitting TSWV isolates from Fresno and Yolo (43.8% for TSWV-Fresno and 37% for TSWV-Yolo) than the Yolo thrips population (32.9% for TSWV-Fresno and 22% for TSWV-Yolo)**
- **Adult male adult thrips transmit TSWV more efficiently than adult female thrips**
- **Relevance**
  - **May explain why fields in Yolo can have higher thrips populations than in Fresno but less TSWV incidence**
  - **Continued high levels of thrips and TSWV may lead to co-evolution of thrips populations/TSWV isolates with higher transmission efficiencies**

Challenge: Where are the thrips and TSWV coming from early in the season?

- TSWV reservoirs vary depending on region
  - -Fresno/Kings: weeds (prickly lettuce and sowthistle), lettuce, radicchio
  - -Merced: radicchio and weeds (?)
  - -Colusa/Yolo: fava beans, lettuce, radicchio and weeds (?)
- Thrips reservoirs
  - -Fresno/Kings: onions and wheat
  - -Merced: radicchio, alfalfa
  - -Colusa/Yolo: onions, alfalfa and wheat

Roadside or indigenous weeds: all locations

Radicchio in Merced

Weed survey results for TSWV incidence during 2012

Weed [a]	Tested (+)	Weed [a]	Tested (+)
Black nightshade	10 **(1)**	Curlydock	22 (0)
Bindweed	58 (0)	Malva	68 (0)
Flaree	30 (0)	Datura	10 (0)
Pineapple weed	24 (0)	Monocots	18 (0)
Sowthistle	134 **(7)**	Shepherd's purse	3 (0)
Prickly lettuce	85 **(2)**	Fiddler neck	5 (0)
Russian thistle	16 (0)	Pigweed	8 (0)
Buckhorn Plantain	8 (0)	Turkey mullein	15 (0)
Wild radish and Mustard	30 (0)	Other common weeds	38 (0)

Total : 10/602

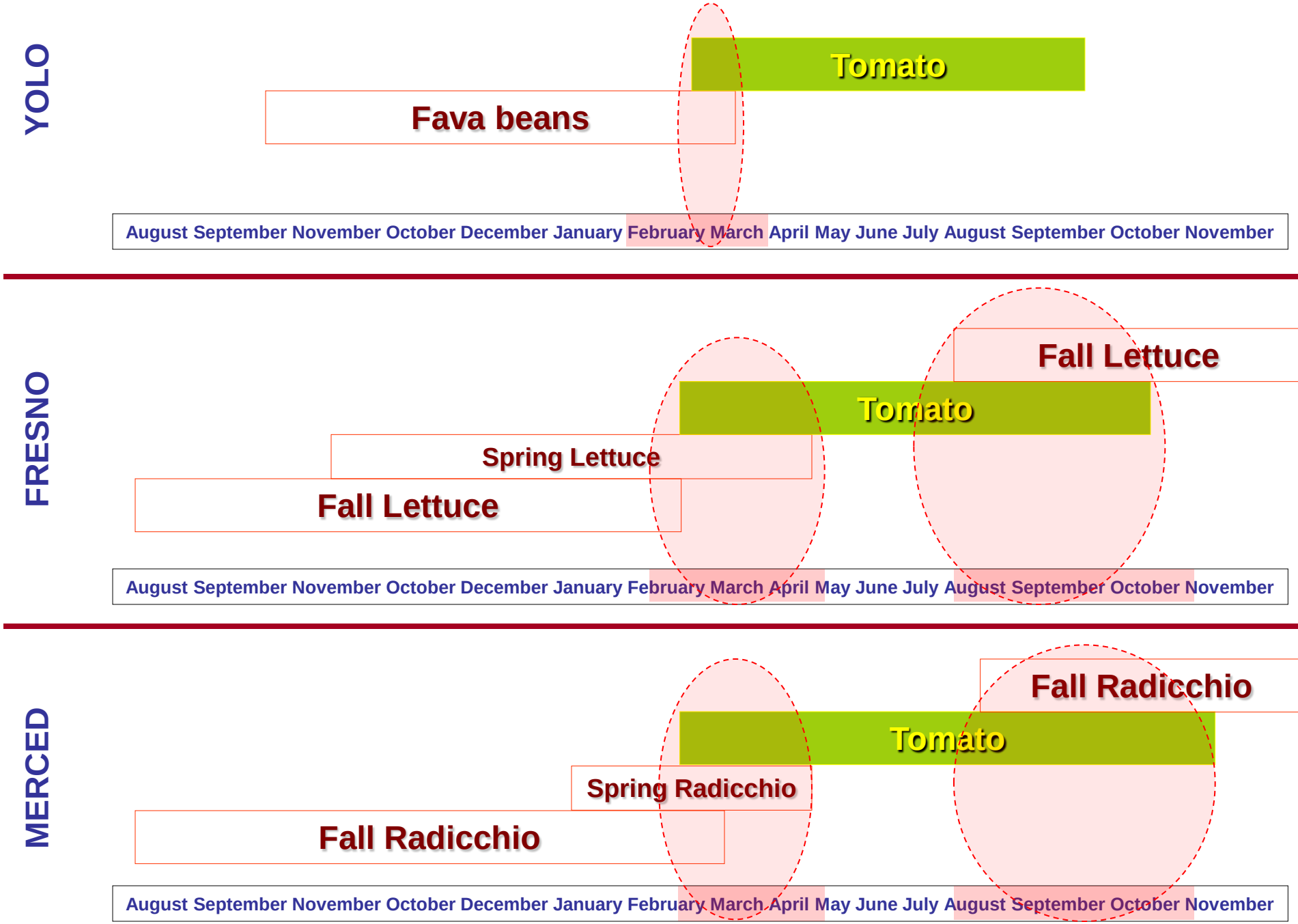
(+) number of plants tested positive for TSWV by immunostrips and RT-PCR.
a, Total weed samples from all counties

Bridge crops

- **Bridge crops are those grown during winter (tomato-free) months and that serve as potential sources of TSWV (radicchio, lettuce and fava bean) or thrips (alfalfa, onion and wheat) for spring-planted tomatoes**
- **Bridge crops 2012**
  - **-Fresno-low TSWV in spring lettuce (<1%)-not a major inoculum source? (note that high rates of TSWV in fall lettuce did not carry over into spring lettuce); one radicchio field had a high rates of TSWV but was harvested before tomatoes were planted**
  - **-Merced-radicchio was free of TSWV and had low thrips populations**
  - **-Colusa/Yolo-two fava bean fields with ~3% TSWV were identified and associated with early TSWV outbreaks in Yolo County**

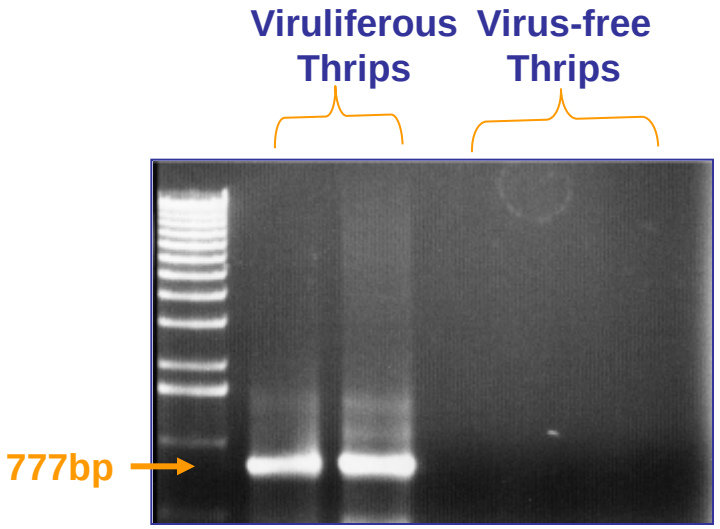
Lettuce in Fresno County

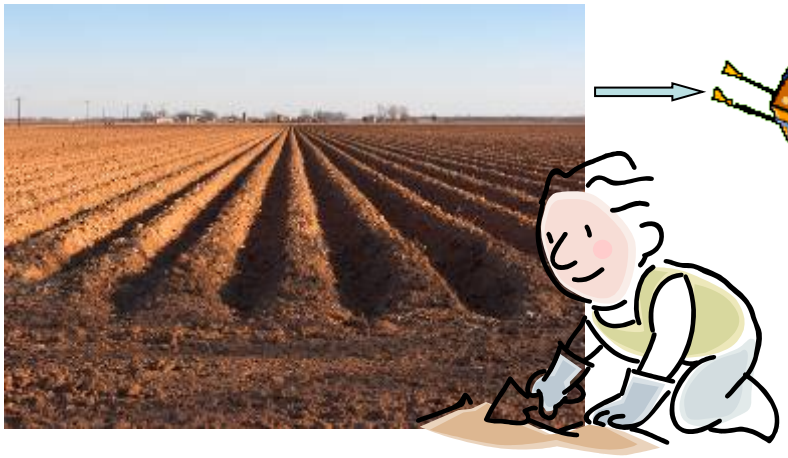
Radicchio in Merced County

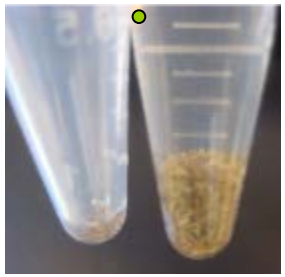

YOLO
Tomato
Fava beans
August September November October December January February March April May June July August September October November
FRESNO
Fall Lettuce
Tomato
Spring Lettuce
Fall Lettuce
August September November October December January February March April May June July August September October November
MERCED
Fall Radicchio
Tomato
Spring Radicchio
Fall Radicchio
August September November October December January February March April May June July August September October November

Are viruliferous adult thrips emerging from soil a potential TSWV inoculum source?

- **A possible source of TSWV inoculum early in the growing season is adult thrips emerging from pupae in soil**
- **In February 2011 and 2012, soil was collected from fields with crops known to have high incidences of thrips and TSWV in 2010 and 2011 and assessed for:**
  - **Emerging adult thrips**
  - **TSWV in these thrips (PCR assay and indicator plants)**



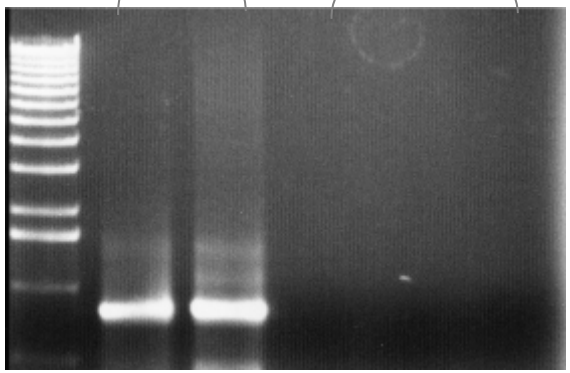




Are they carrying the virus?

Viruliferous Thrips

Virus-free Thrips



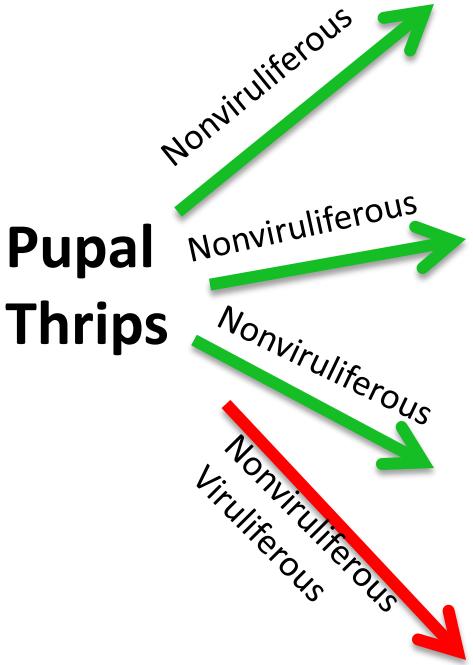
Summary of the assessment of the potential role of the soil-emerging thrips (soils from fields in 2012)

Sample #	Source of the soil samples	Collection Date	Previous/Current Crop Type	Number of captured	RT-PCR tests of thrips	RT-PCR tests of plants	Soils Discarded
	Yolo & Colusa Counties						
1	HWY 113	1-Mar	Weedy Prunus	**129**	Negative	Negative	27-Apr
2	Sutter County	1-Mar	Proc. Tomato	**12**	Negative	Negative	27-Apr
3	Yolo/Colusa County Line	1-Mar	Proc. Tomato	**26**	Negative	Negative	27-Apr
4	Yolo Rd 29	1-Mar	Fava Beans	**40**	Negative	Negative	27-Apr
	Merced County						
5	SM Sandy Mush - Merced	29-Feb	Fall Radicchio	**14**	Negative	Negative	27-Apr
6	LG La Grand Rd. -Merced	29-Feb	Late Fresh Mark. To	**2**	Negative	Negative	27-Apr
7	HT Hunt Rd. -Gustine	29-Feb	Late Fresh Mark. To	**1**	Negative	Negative	27-Apr
8	PT Paterson/Wastley	29-Feb	Weedy Almond	**9**	Negative	Negative	27-Apr
	Fresno County						
9	Gale & Butte	28-Feb	Onion	**37**	Negative	Negative	27-Apr
10	Woolf Creek	28-Feb	Proc. Tomato	**4**	Negative	Negative	27-Apr
11	North -Fairbaugh	28-Feb	Proc. Tomato	**174**	Negative	Negative	27-Apr
12	Farming D -Five Point	28-Feb	Spring lettuce	**10**	Negative	Negative	27-Apr
13	North -Fairbaugh	28-Feb	Almond	**4**	Negative	Negative	27-Apr
	Kings County						
14	John Farms	28-Feb	Proc. Tomato	**3**	Negative	Negative	27-Apr
15	Huron	28-Feb	Fall Radicchio	**149**	Negative	Negative	27-Apr
16	Plymouth	28-Feb	Weedy Almond	**13**	Negative	Negative	27-Apr
17	UC Davis Greenhouse	28-Feb	Sterile soil; (-) control	**0**	N/A	N/A	27-Apr

Overwintering of Thrips in Soil: Conclusions

- **Thrips can stay dormant in soil for long periods**
- **Adult thrips emerged from soils, indicating that thrips can overwinter in soil (probably as pupae)**
- **If the total volume of soil in these fields is considered, these populations could be important**
- **We did not find that viruliferous thrips were emerging from soil**

Overwintering assays for thrips emerging from soil under cold conditions



(I) Various soil types → Sunshine Mix was selected for following exp.

(II) Initial tests for optimal temperatures:
- 15 C for up to 4 week treatment
- 4 C for up to 1 week treatment
- 25 C as control

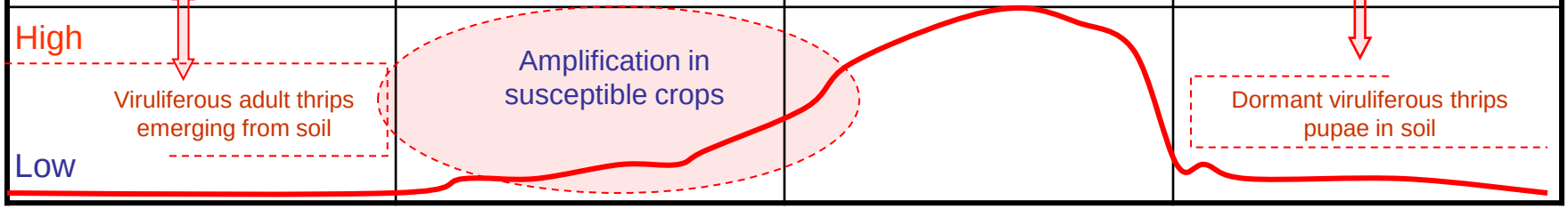
→ Emerging rates remained up to 50-60 % after these treatments

(III) Viability tests at 4 C for up to 8 weeks → ~ 6% of pupal thrips survived and emerged as adult thrips after 6 weeks of 4 C treatment

(IV) Viability comparison of viruliferous and nonviruliferous thrips at 4 C for up to 3 week treatment →
- Similar emerging rates
- Emerged adult thrips were able to transmit TSWV

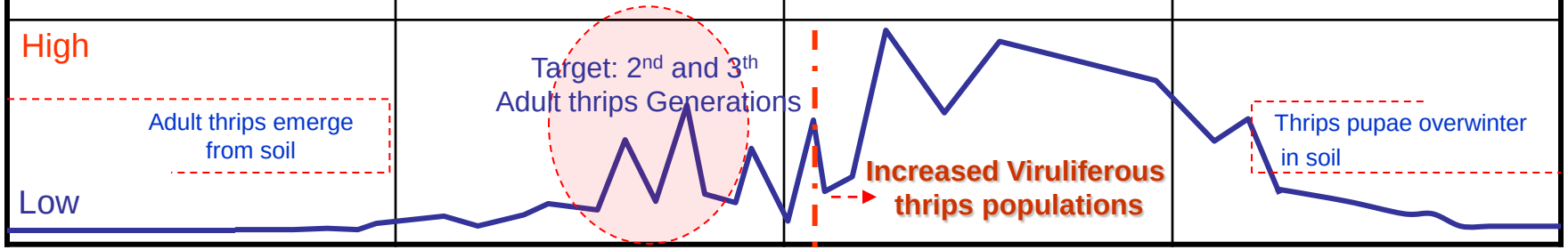
Development of TSWV in Processing Tomato Fields

Winter	Early-Mid Season	Late Season	Fall
TSWV overwinters at low levels in weeds*, bridge crops* and thrips	Infections with TSWV – low incidences, dependent on populations of viruliferous thrips	Potential for higher incidences/epidemics and economic losses in late-planted crops	Persistence in weeds, bridge crops and thrips



Western Flower Thrips Population Dynamics in the Central Valley of California

Winter: Thrips overwinter at very low levels	**Spring:** Thrips populations increase- temperature dependent	**Summer:** Peak populations	**Fall:** Populations decrease



December January February March April May June July August September October November

Development of a risk assessment index for thrips and TSWV in processing tomato fields

- **A risk index for thrips and TSWV for individual tomato fields was refined and applied to monitored fields in 2012**
- **Based upon point values assigned to factors that minimize or favor development of thrips/TSWV**
- **These factors include: variety, planting date, plant population, insecticide application, thrips populations, proximity to TSWV-susceptible crops, TSWV history in the growing area, etc.**

Tomato spotted wilt virus Risk Index for Tomatoes-2012

Tomato Variety[1]	Examples	Risk Index Points
a,b,c	stunted plt w less fruit, very severe, dead like	50
d,e,f	Res. size plt w less fruit, severe symptoms	40
g,h,i	Nor. size plt w many fruits severe symptoms	30
j,k,l	Nor. plt w many fruits some symptoms	20
m,n,o	Vigor.Plt w many fruits almost no symptom	10
p,q,r	with SW5	-35
Planting Date[2]		
Prior to February 1	First planted fields in any given region	10
February 1-29	week or two later than first planted fields	15
March 1-15	week earlier than recommended period	10
March 16- April 31	Recommended period (Majority of fields)	5
May 1-20	week or two later than majority of fields	15
May 21- June 5	tree week or more later planted from major	25
After June 5	latest planted fields in a given region	35
Plant Population[3]		
Less than 1 plant per foot	single row (7000 per acre)	35
2 to 3 plants per foot	double row (9000 per acre)	15
More than 3 plants per foot	double row but more dens (>9000 per acre)	5
Planting Method		
Direct seeded		10
Transplanted		5
Proximity to Known Bridge Crops		
adjacent	radicchio, lettuce, fava, weed/fallow field, pepper or tomato	25
less than 1 mile radius distance	(if TSWV confirmed add 20 more points)	15
1-2 mile radius distance	(if TSWV confirmed add 10 more points)	10
greater than 2 mile or None	(if TSWV confirmed add 5 more points)	5
Proximity to Thrips Source		
adjacent	wheat, pea, alfalfa or weedy patches etc.	20
less than 1 mile radius distance		15
1-2 mile radius distance		10
None		5
At-Plant Insecticide		
None		15
for other pests (+ thrips)		10
specifically for thrips		5
Weed situation/Herbicide use		
w/out herbicide but weedy	In-field ONLY weed population	15
w/out herbicide but not so weedy		10
w/out pre emergence herbicide or NO weed		5
Total Points (0-225)	**Risk of Losses Due to TSWV**	
Less than or equal to 95	**Low**	
Greater than 100 or equal to 150	**Moderate**	
Greater than 150	**High**	

Monitored Fields 2012

	Northern Counties	TSWV %	Risk Index
RO	Winters, Yolo	0	120
BF	County Line, Colusa	7	160
AO	County Line, Colusa	0	80
PR	Dixon, Solano	2	115
EG	Robin,Sutter	12	160
YL	Yolo Town,Yolo	7	165
	Merced County		
PT	Rogers Rd, Paterson	2	145
GC	Gun Club Rd, Gustine	1	150
FM	Fentem Rd, Gustine	2	135
BC	Bert Crane Rd, Merced	0	120
DF	Dickenson Ferry Rd, Merced	0	140
LG	Le Grand Rd, Merced (Fresh Market)	0.5	135
BH	Buchanan Hallow Rd, Merced (Fresh Market)	0.5	110
	Fresno County		
North	Firebough area	7	165
Oakland	Five Points area	12	155
Mt.Whitney	Five Points area	0	145
Tranquility	Tranquility area	2	150
Nees	Firebough area	14	160
Harris	Five Points area	0.5	105
	Kings County		
Tomato #1	Lassen Ave between Phelps and Jayne	2	105
Tomato #2	Laurel Ave at Avenal Cutoff	0.3	110
Tomato #3	Nevada Ave & Kent	2	110
Tomato #4	El Dorado Ave near Dorris	5	115
Tomato #5	Lassen Ave & Tornado	7	145

Legends

Less than or equal to 95
Low

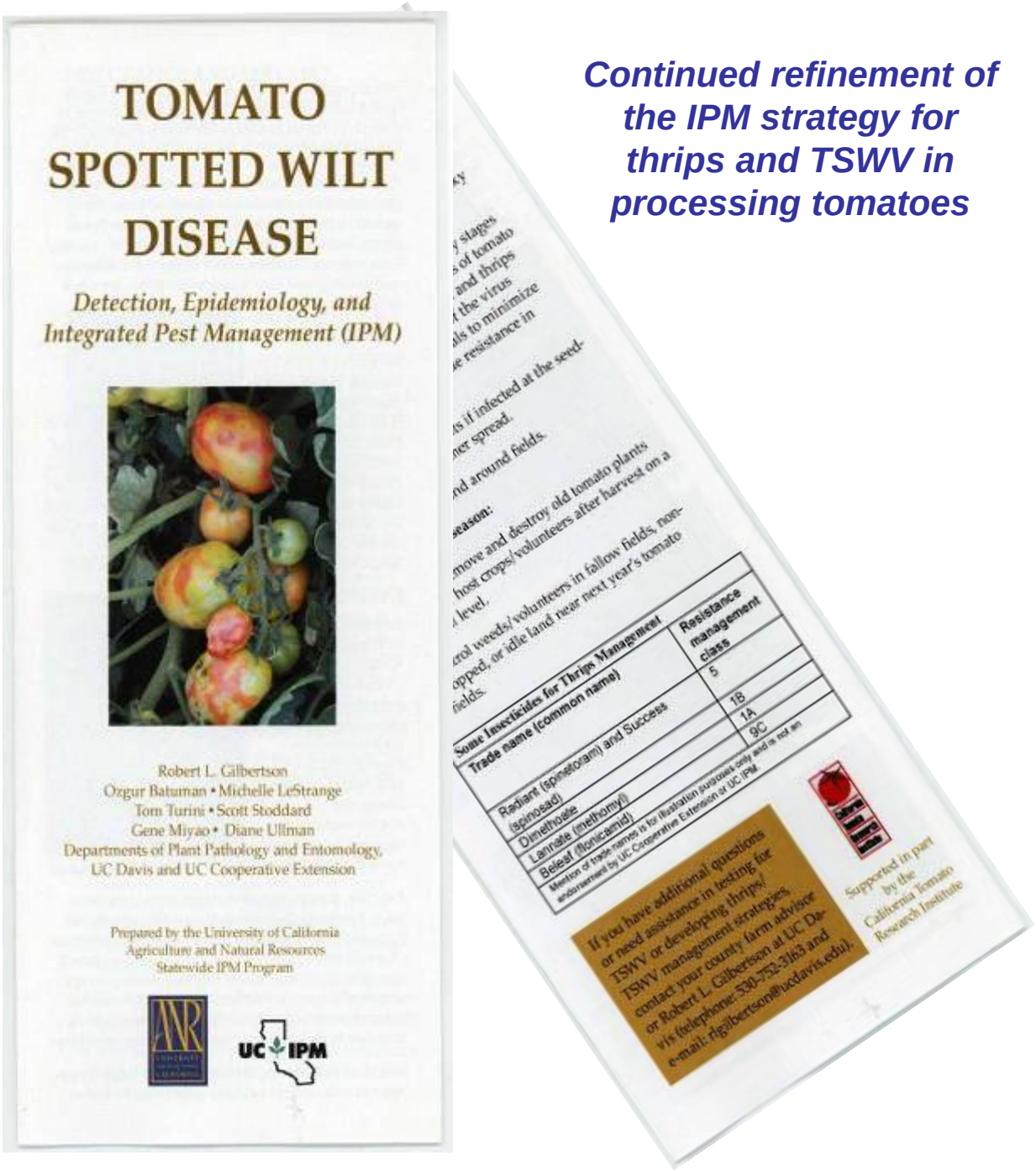
Greater than 100 or equal to 150
Moderate

Greater than 150
High

Development of a risk assessment index for thrips and TSWV in processing tomato fields

- **Expand the application of the risk index to more commercial fields in 2013**
- **Continue to refine the risk index based on the results with these fields and our further understanding of the biology of thrips and TSWV in Central California**
- **Make the risk index available to growers, PCAs and others through the CTRI, UC-IPM web site or other venues**
- **Make the use and interpretation of the risk index (and thrips degree-day model) user-friendly**

An IPM program has been developed for thrips and TSWV in processing tomatoes in California. It has been summarized in a recently prepared flyer



Continued refinement of the IPM strategy for thrips and TSWV in processing tomatoes

IPM for thrips and TSWV

- **Before planting**

-Calculate risk assessment for fields 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**

Integrated TSWV Management

- **After harvest**

  -Promptly remove and destroy plants after harvest

  -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 near next year's tomato fields

TSWV Team

Thank you!

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