Management of the plant resistance breaking strain of Tomato spotted wilt virus

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Agriculture and Natural Resources

Overview

- *Tomato spotted wilt virus*
  - Background
    - Symptom recognition/ Biology
    - Plant resistance-breaking strain
  - Varietal evaluations
  - Integrated pest management strategies

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Tomato spotted wilt virus (TSWV) Symptom Recognition

Thrips vectors TSWV

Frankliniella occidentalis (Western flower thrips)

Primary vector of TSWV in Central California

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Host Range of TSWV

Crop Hosts

- Lettuce
- Celery
- Radicchio
- Fava bean
- Tomato
- Pepper
- Eggplant
- Potato

Weed Hosts

- Prickly lettuce (*Lactuca serriola)*
- Sowthistle *(Sonchus spp.)*
- Little mallow *(Malva parvaflora)*
- Mustard *(Brassica spp.)*
- London rocket *(Sisymbrium irio)*
- Wild Radish *(Raphanus raphanistrum)*
- Pineappleweed *(Chamomilla suaveolens)*
- Rough-seeded *buttercup* (Ranunculus muricatus)
- Nightshade *(Solanum spp.)*
- Jimsonweed (*Datura stramonium)*
- Field bindweed *(Convolvulus arvensis)*

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TSWV Resistance

- SW5: Single dominant gene
- In widespread use in the Central San Joaquin Valley for ~7 years
- No documentation of resistance-breaking strains in CA prior to 2016
- Expression in SW5 varieties due to Wild type TSWV
  - There may be expression on up to 3% of plants
  - Unusual fruit symptoms in the absence of foliar symptoms may occur

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Sw-5 Resistance-breaking strain, 2016

- **First detection** mid-Apr 2016, Sw-5 fresh market tomatoes in Cantua Creek (Fresno Co.)
- May 2016, severe TSWV in Sw5 fresh market tomatoes in Firebaugh (Fresno Co.)

- July 2016, moderate TSWV in Sw-5 processing tomatoes in Huron area

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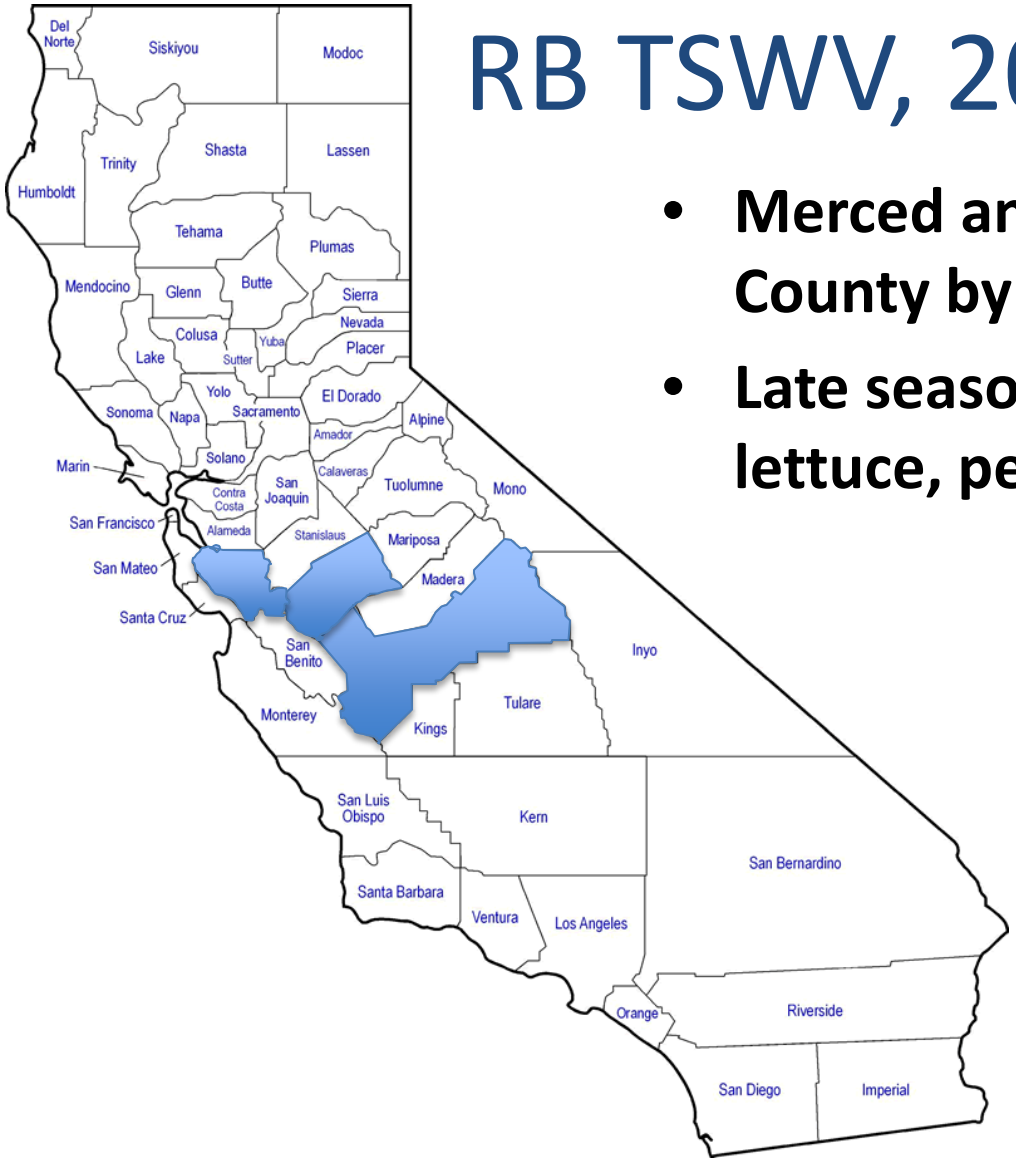
Detection of RB TSWV, 2017

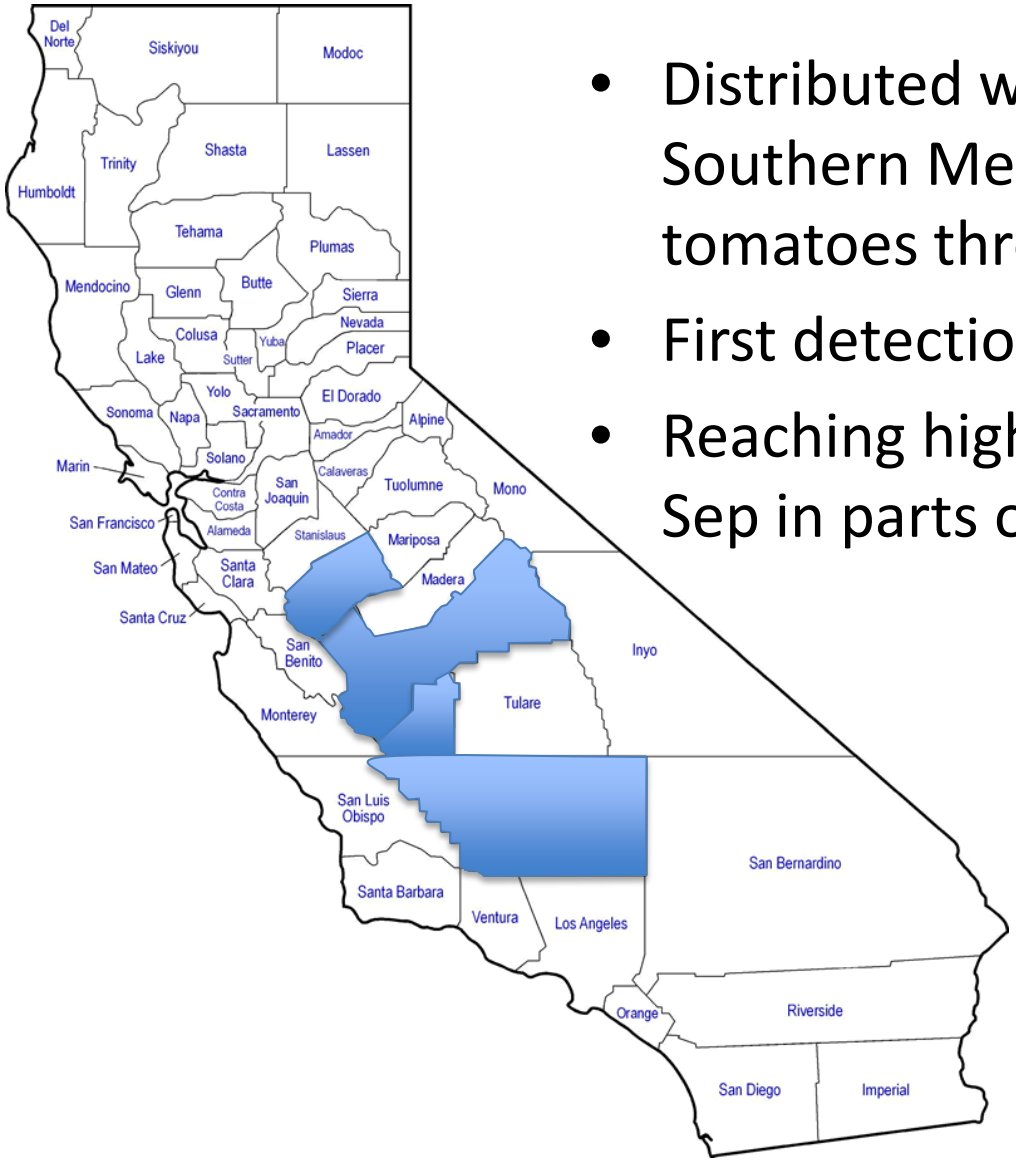
- Feb detection in sow thistle in Cantua and Huron
- April detection in processing tomatoes in Huron
- Within much of the Fresno production areas by Jun
- Substantial losses in late-season fresh market fields

Detection of RB TSWV, 2017



- **Merced and Santa Clara County by Oct**
- **Late season reports in lettuce, peppers and celery**

Detection of RB TSWV, 2018



- Distributed within Fresno and Southern Merced at low levels in tomatoes through Jul
- First detections in Kings and Kern
- Reaching high incidence in Aug-Sep in parts of Fresno County

Ag Seeds and TS&L Collaboration

Evaluation of commercial variety trial in area affected by resistance-breaking TSWV

- Company representatives provide trial maps
- UC personnel check fields for 10% incidence or more Advisors evaluate disease incidence
- In at least three trials, 3 shoots per variety in at least 6 varieties sampled and strain identified

Entries repeated over locations (6 trials)

AB 0311	H1293	HM5235	N6420
BP 13	H1428	HM58801	N6426
BP 16	H1662	HM58841	N6428
BQ273	H5508	HM58871	SV8011TM
BQ400	H5608	HM5900	SVTM1082
BQ401	HM3887	HM7885	UG 15212
BQ403	HM3888	N6366	UG 16609
DRI319	HM4885	N6416	UG 19406
H1015	HM4909		

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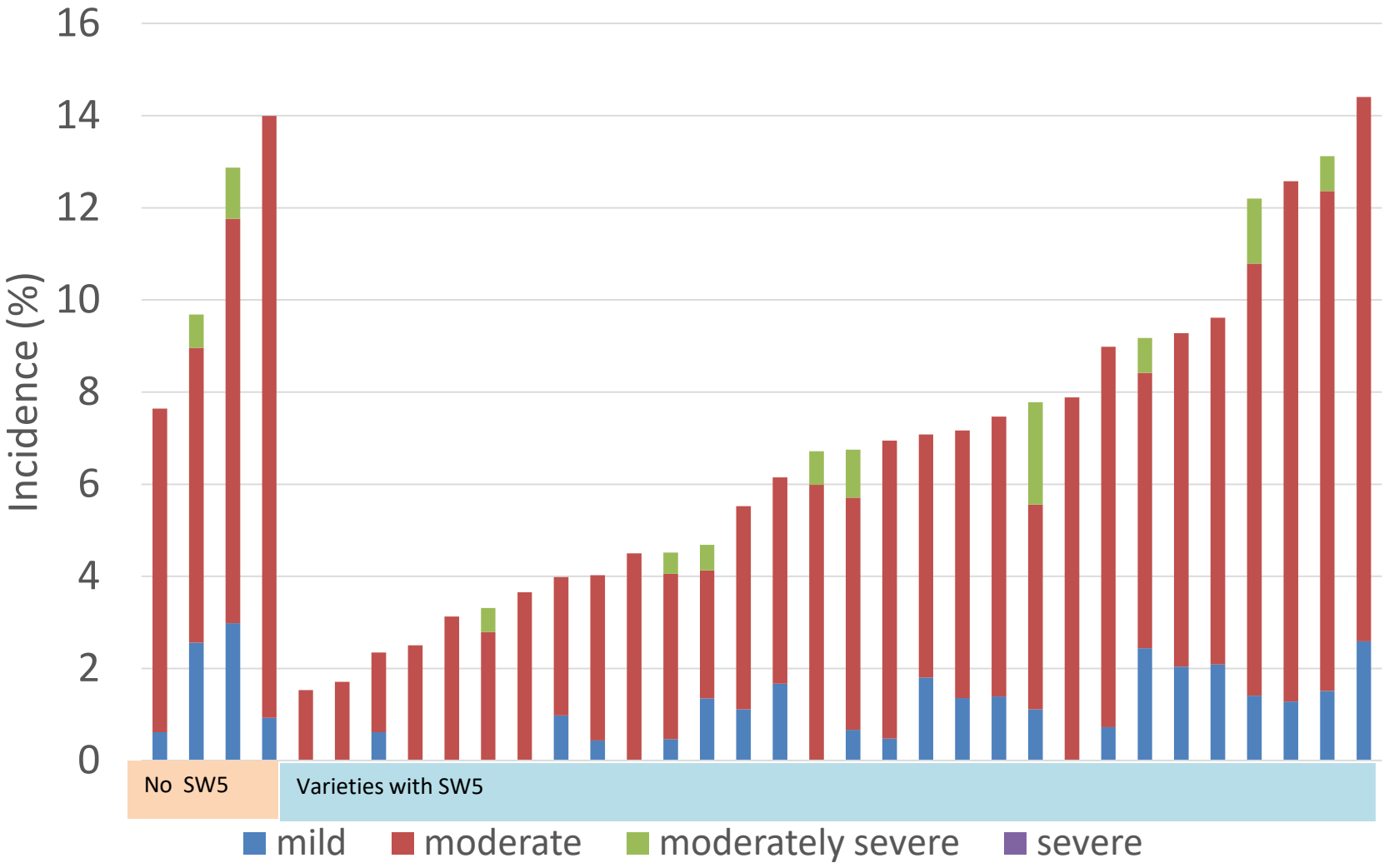
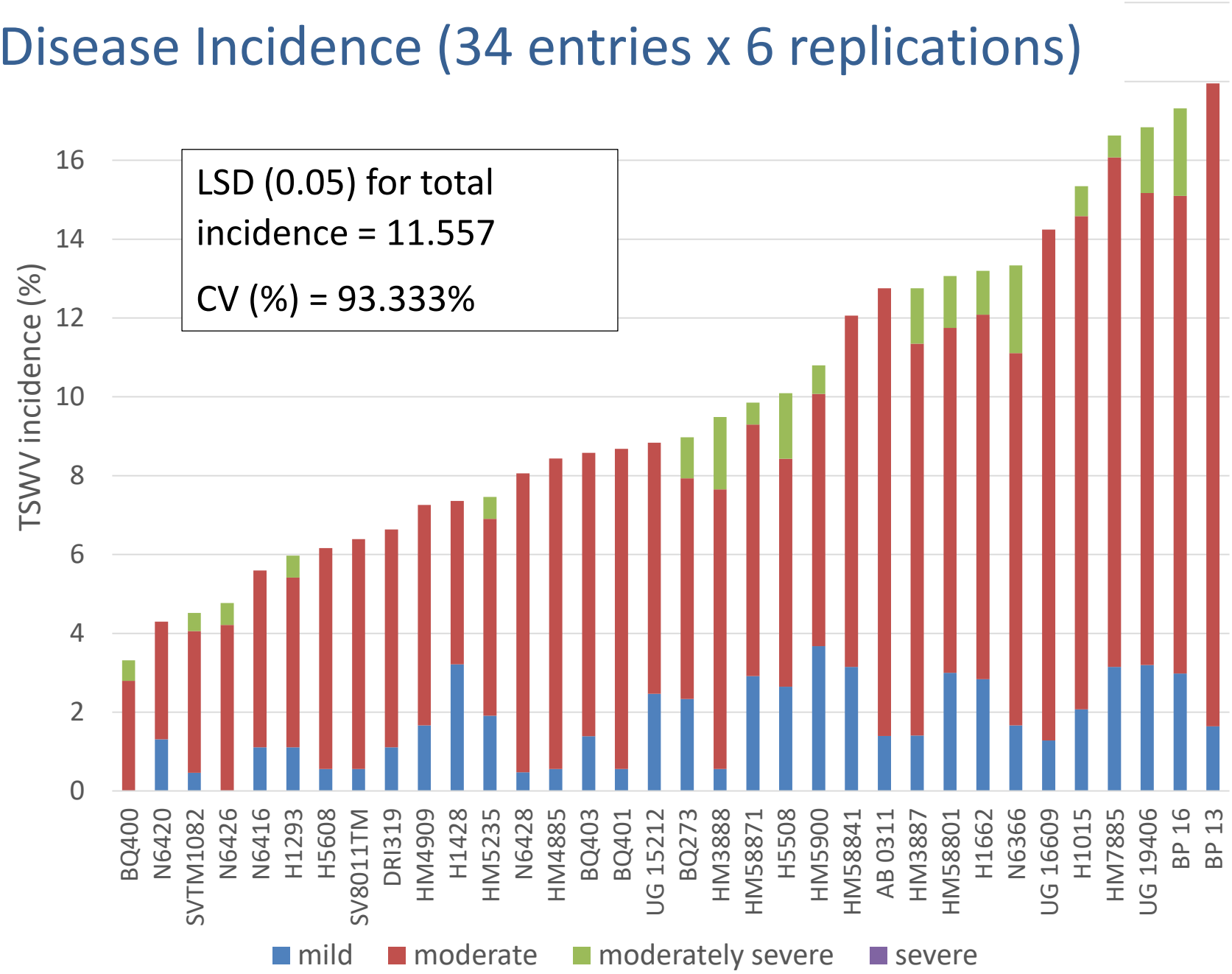
2018 Observations (34 entries x 5 replications)

Percentage TSWV (grouped by presence of Sw5)



Disease Incidence (34 entries x 6 replications)



Variety Trial: Strain Determination 2017

Variety	SW5 in variety	Strain detected
H1015	-	wt
BQ273	+	Rb
N6402	+	Rb
HM3887	+	Rb
DRI319	+	Rb
H1292	+	Rb
BP13	+	Rb

Strain identification
Sw-5 resistance breaking (Rb)
Wild type (wt)

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Variety Trial: Strain Determination 2018

Variety	SW5	Strain detected (rb or wt)		
		Five Pts	Huron	Merced
S6366	-	Rb	Rb	Rb
UG19406	-	Rb	Rb	Rb
BQ413	+	Rb	Rb	Rb
UG16609	+	Rb	Rb	Rb
HM5900	+	Rb	Rb	Rb
H1293	+	Rb	Rb	Rb
N6420	+	Rb	Rb	Rb
BOS811	+	Rb	Rb	Rb
AB311	+	Rb	Rb	Rb

Strain identification
Sw-5 resistance breaking (Rb)
Wild type (wt)

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Evidence of Persistence of Sw5-breaking TSWV in Central San Joaquin Valley

- Presence in winter weeds and lettuce
- Detection in non-Sw5 tomatoes and in crops lacking Sw5

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Evaluation of acyl sugar lines, 2018

UC West Side Field Station

Line Name	Line Description	BCTV Infection	TSWV Infection
Sun 6366	Susceptible Control, no Sw-5	LOW	HIGH
Heinz 5608	Resistant Control, +Sw-5	MODERATE	MODERATE
AS Benchmark + Sw-5	Acylsugar + Sw-5	HIGH	LOW
AL6/AS + Sw-5	QTL6 which increases acylsugar with Sw-5	LOW	LOW
AL6/AS +Sw-5 x FA2/FA7-AS7/AS	Cross, multiple QTL to increase AS amount + fatty acid QTL + Sw-5	MODERATE	LOW
AL6/AL10/AS +Sw-5	Acylsugar QTL6 and QTL10 combination that increases acylsugar production	LOW	HIGH
FA7/AS	Benchmark + FA7, no Sw-5	MODERATE	MODERATE
FA2/FA7/AS	Benchmark + FA2 & FA7, no Sw-5	MODERATE	HIGH

Trial conducted in collaboration with Diane Ullman) Marth Mischler (Cornell) and Robert Gilbertson

Field Trial at UC West Side Research and Extension Center

Preliminary Observations

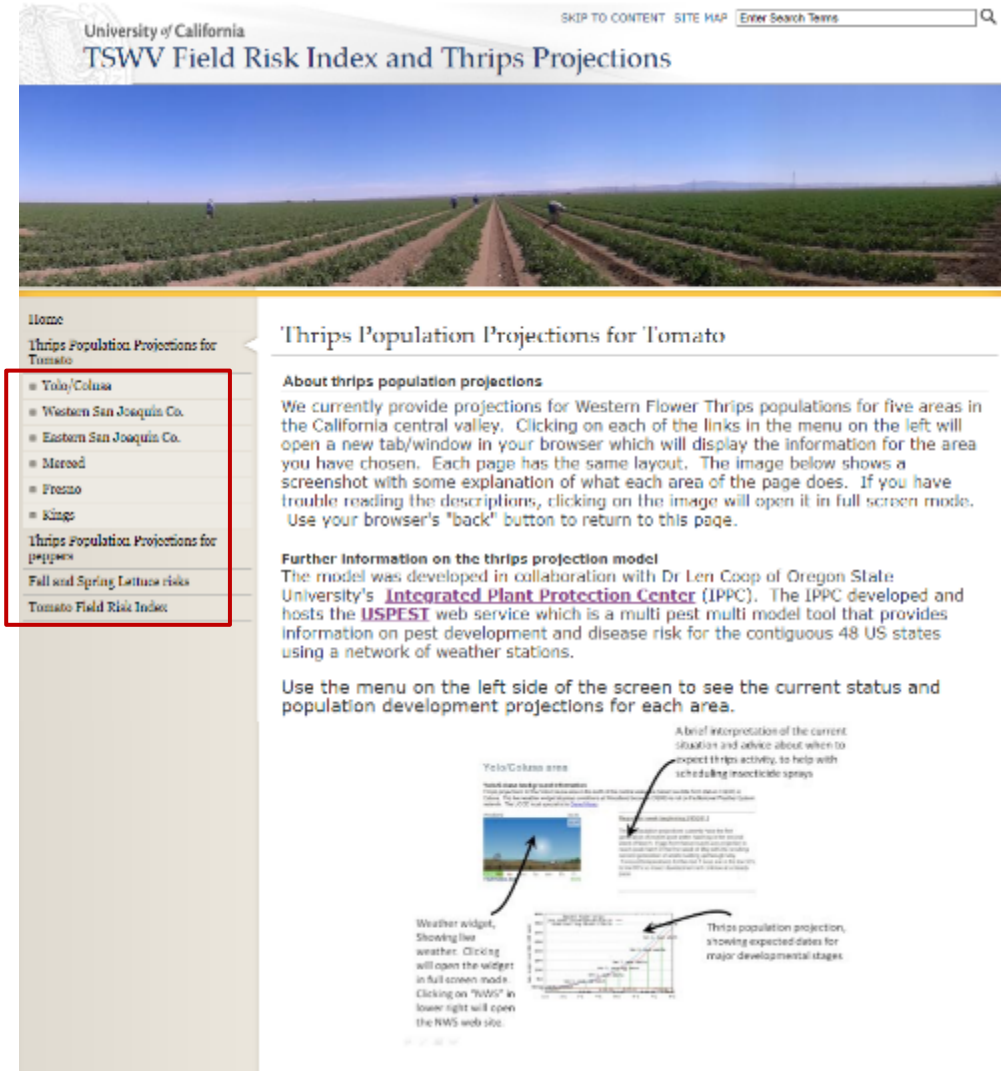
- Disease pressure was moderate to high for BCTV and TSWV
- Plants were infected by BCTV or TSWV; very few mixed infections
- Sw-5 commercial line (H5608) had moderate TSWV infection,
- Sun 6366 (no Sw-5) had high incidence
- Some evidence that acylsugars (AL6/AS) can protect Sw-5

Modified from Gilbertson UC West Side Research Extension Center presentation on 15 Aug 2018

Management of Thrips

- Radiant, Lanate and dimethoate deliver relatively consistent control
- Drip or transplant water-applied neonicotinoids have not reduced TSWV incidence in most trials
- Verimark transplant treatment reduced TSWV incidence 3/7 trials
- Thrips degree day model is available online

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.



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

TSWV Management Now

- Plant-resistance breaking TSWV is present in the Central San Joaquin Valley production area.
- Any TSWV foliar symptoms present in more than 3% of the plants should be checked for the resistance breaking strain
- Current management depends upon IPM, heavily reliant upon sanitation and site selection.
- Insecticides may reduce incidence but should not be relied upon without other approaches.

Acknowledgements

- CTRI
- Ag Seeds and TS&L

UC DAVIS

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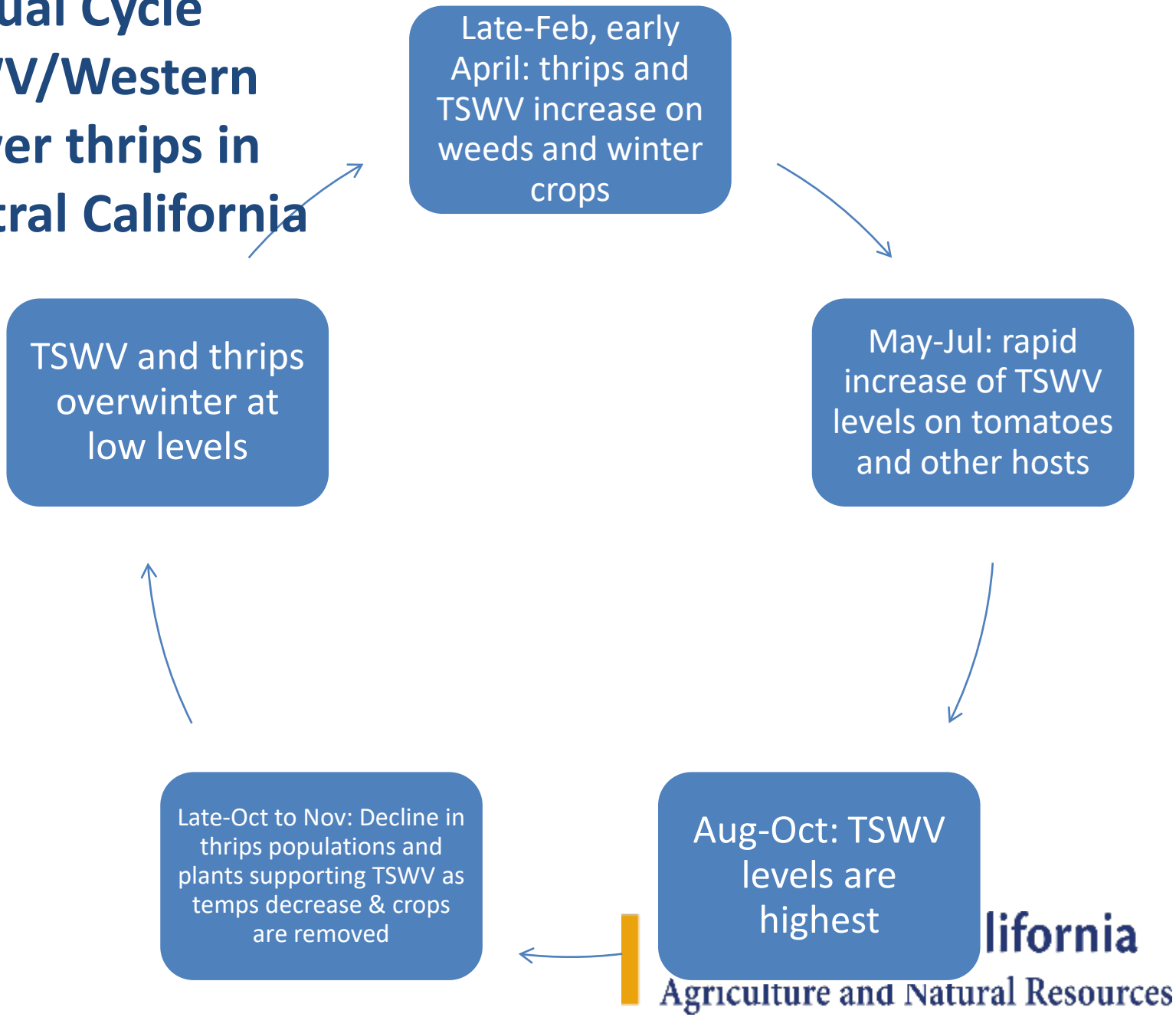
- Dr Mônica Macedo

UC Coop. Ext.

- Scott Stoddard
- Brenna Aegerter

- University of California West Side Research Center Staff
- Daniel Delgado

Annual Cycle TSWV/Western flower thrips in Central California



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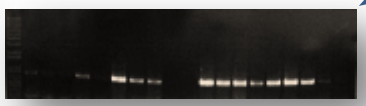
Identification of TSWV RB strain

Typical tospovirus symptoms

Test for TSWV with immunostrips

Confirm TSWV by RT-PCR



Confirm RB strain by RT-PCR of NSm gene

Amino acid (aa) sequence

MDTSKGKILLNTEGTSSFGTYESDSITESEG
YDLSARMIVDTNHHISNWKNDLFVGNGK
QNANKVIKIYPTWDSRKQYMMISRIVIWV
C

aa substitution C to Y in 118 position (C118Y) or T to N in 120 position (T120N)

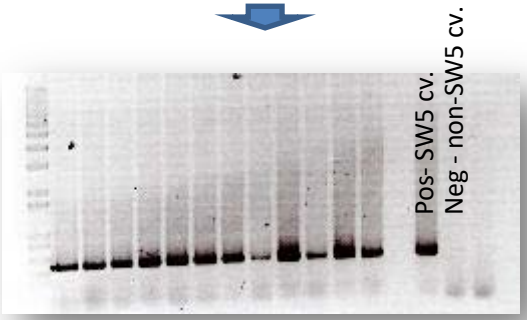
RB strain

MDTSKGKILLNTEGTSSFGTYESDSITESEG
YDLSARMIVDTNHHISNWKNDLFVGNGK
QNANKVIKICPTWDSRKQYMMISRIVIWV
C

no aa substitution in 118 or 120 position (CPT)

WT strain

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



Gilbertson UC West Side Research Extension Center presentation on 14 Dec 2017

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Difficulties in Thrips Management

- Tendency to reside in enclosed or protected locations
- Demonstrated capacity to develop resistance to insecticides
- Rapid rates of reproduction
- Percent mortality is low even with the most effective insecticides *(F. occidentalis)*

Insecticides Evaluatated in Programs

Group #	Chemical sub-group	Primary target site of action	Trade name	Active ingredient
1A	Carbamate	Acetylcholineesterase inhibitors	Lannate LV	methomyl
1B	Organophosphate	Acetylcholinesterase inhibitors	Dimethoate 4EL	dimethoate
4A	Neonicotinoid	Nicotinic acetylcholine receptor (nAChR) competitive modulators	Admire, Platinum, Venom	Imidacloprid, Thiamethoxam, Dinotefuran
5	Spinosyns	Nicotinic acetylcholine receptor allosteric activators	Radiant Entrust	spinetoram spinosad
28	Diamide	Ryanodine receptor modulators Nerve and muscle action	Cyazypyr, Exeril, Verimark	cyantraniliprole

IRAC Mode of Action Classification Scheme Jul 2017

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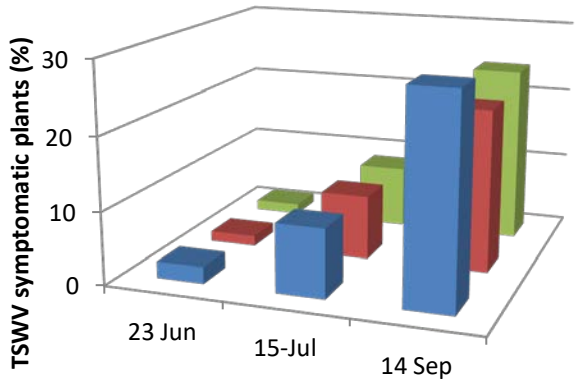
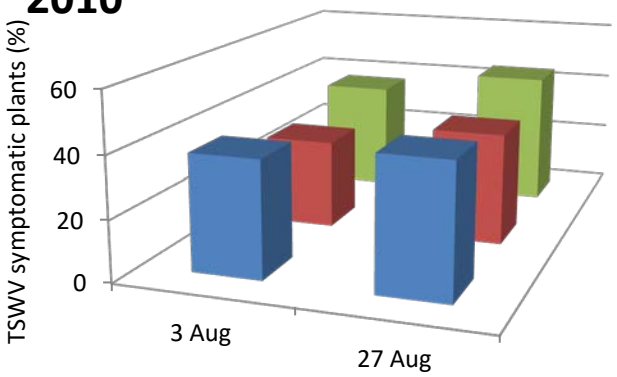
Influence of Drip-Applied Insecticides

2009



- thiamethoxam 193 g (3 Jun)
- thiamethoxam 193 g (3 Jun), dinotefuron 294 g (7 Jul)
- Untreated

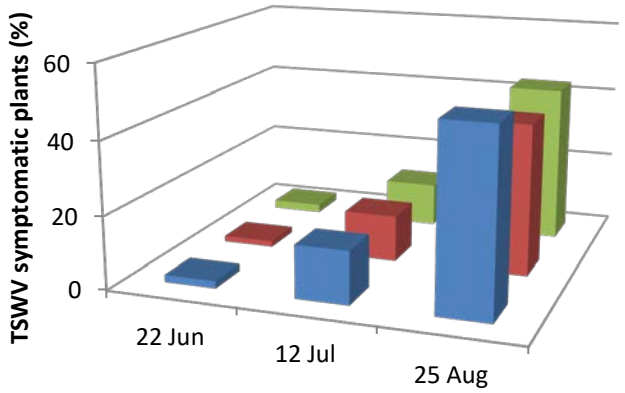
2010



- thiamethoxam 193 g (25 May), dinotefuron 294 g (30 Jun)*
- thiamethoxam 193 g (25 May), dinotefuron 294 g (30 Jun)
- Untreated

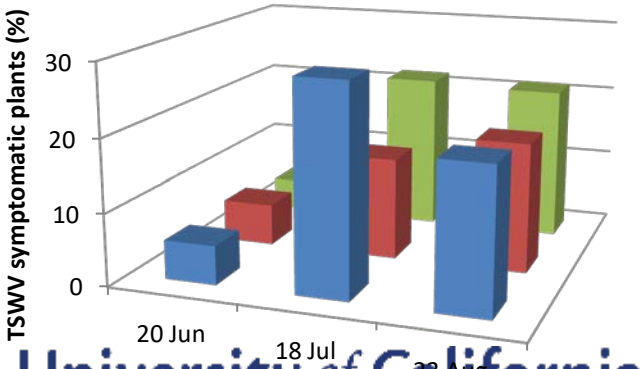
* Weekly injections of acibenzolar-s-methyl 35g/ha

2011



- thiamethoxam 193 g (22 Jun), dinotefuron 294 g (12 Jul)
- thiamethoxam 193 g (22 Jun), dinotefuron 294 g (22 Jul)
- Untreated

2012



- thiamethoxam 193 g (7 Jun), dinotefuron 294 g (27 Jun)
- thiamethoxam 193 g (7 Jun), cyantraniliprole 197 g (27 Jun)
- Untreated

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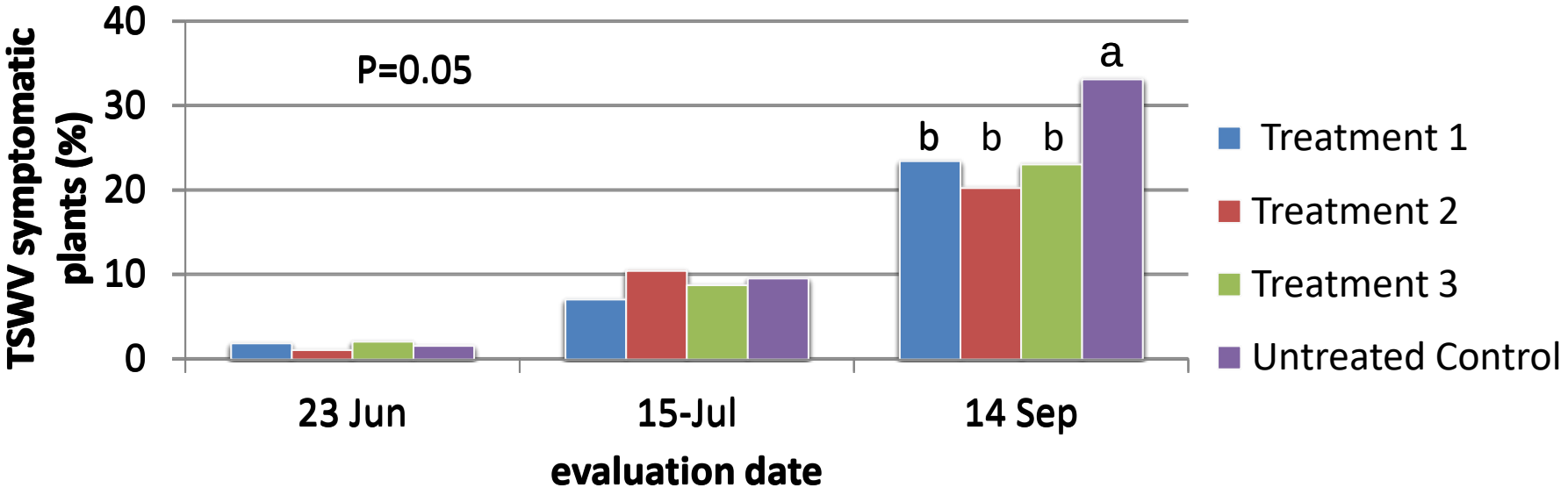
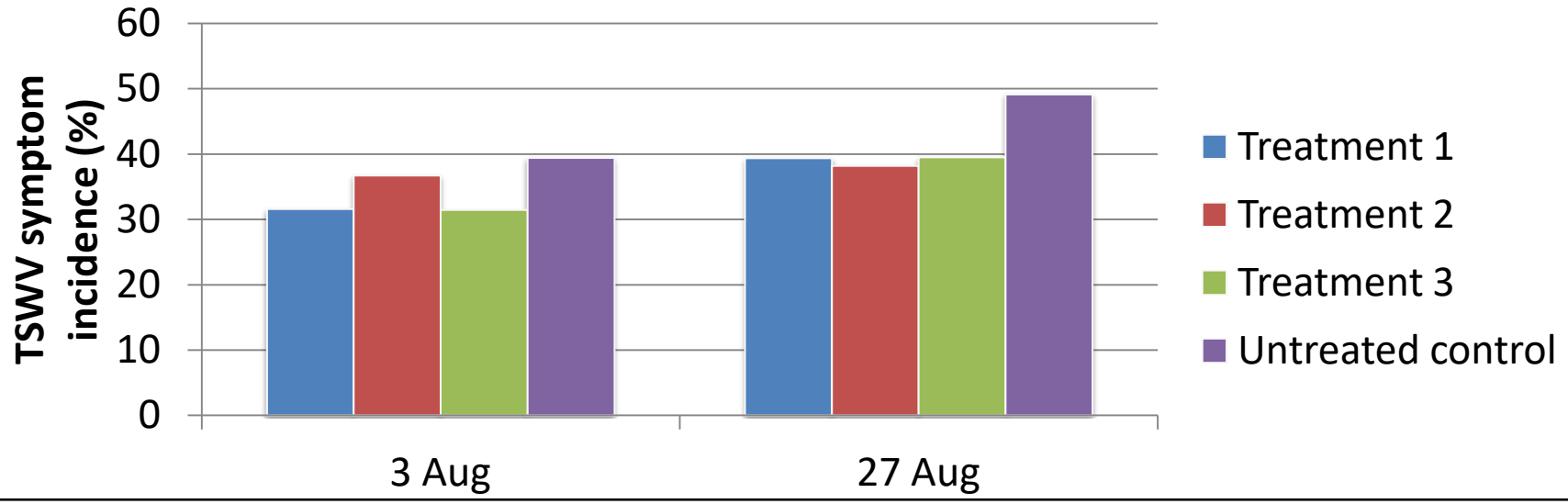
Foliar Treatment Impact on TSWV Symptomatic Plant Incidence 2009



	date of application, rate		
	17 Jun	1 Jul	15-Jul
Treatment 1	Radiant 10 fl oz	Dimethoate 4EL 1 pt	Radiant 10 fl oz
Treatment 2	Radiant 10 fl oz	Dimethoate 4EL 1 pt	
Treatment 3		Dimethoate 4EL 1 pt	Radiant 10 fl oz
Untreated control			

Foliar Treatment Impact on TSWV Symptomatic Plant Incidence 2010



	date of application, quantity ai/ha				
	drench	9 Jun	23 Jun	7 Jul	16 Jul
Treatment 1	Verimark 13.5 fl oz	Radiant 10 fl oz	Dimethoate 4EL 1 pt	Radiant 10 fl oz	Dimethoate 4EL 1 pt
Treatment 2		Radiant 10 fl oz	Dimethoate 4EL 1 pt	Radiant 10 fl oz	Dimethoate 4EL 1 pt
Treatment 3		Radiant 10 fl oz	Dimethoate 4EL 1 pt		
Untreated control					

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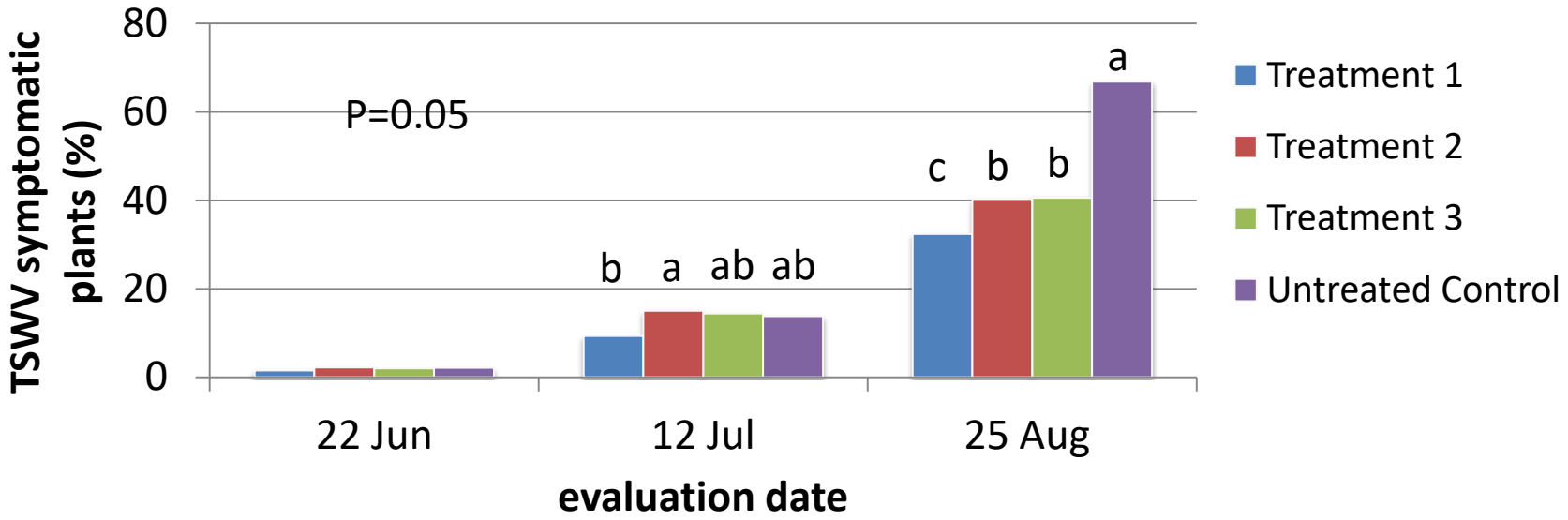
Foliar Treatment Impact on TSWV Symptomatic Plant Incidence 2011



	date of application, quantity ai/ha				
	Trans. drench	24-Jun	6-Jul	14-Jul	21-Jul
Treatment 1	Verimark 13.5 fl oz	Radiant 10 fl oz	Dimethoate 4EL 1 pt	Radiant 10 fl oz	Dimethoate 4EL 1 pt
Treatment 2		Radiant 10 fl oz	Dimethoate 4EL 1 pt	Radiant 10 fl oz	Dimethoate 4EL 1 pt
Treatment 3		Radiant 10 fl oz	Dimethoate 4EL 1 pt		
Untreated Control					

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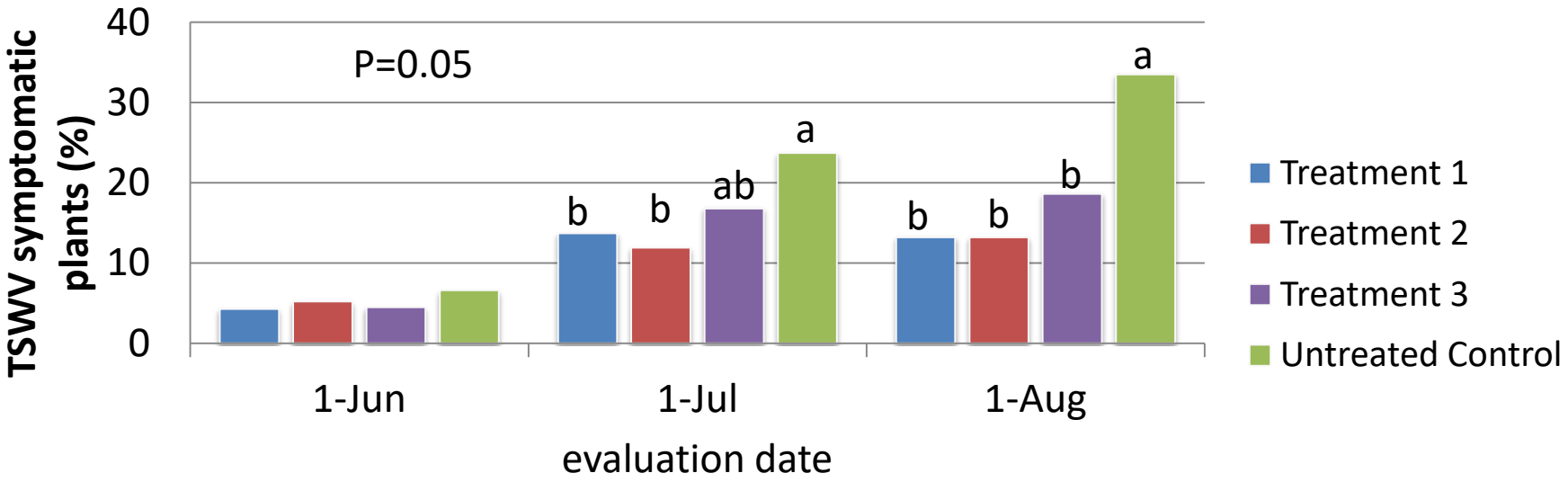
Foliar Treatment Impact on TSWV Symptomatic Plant Incidence 2012



	date of application, quantity ai/ha					
	drench	12-Jun	22-Jun	29-Jun	9-Jul	18-Jul
Treatment 1	Verimark 13.5 fl oz	Radiant 10 fl oz	Dimethoate 4EL 1 pt	Radiant 10 fl oz	Dimethoate 4EL 1 pt	Radiant 10 fl oz
Treatment 2		Radiant 10 fl oz	Dimethoate 4EL 1 pt	Radiant 10 fl oz	Dimethoate 4EL 1 pt	Radiant 10 fl oz
Treatment 3		Radiant 10 fl oz	Dimethoate 4EL 1 pt			
Untreated Control						

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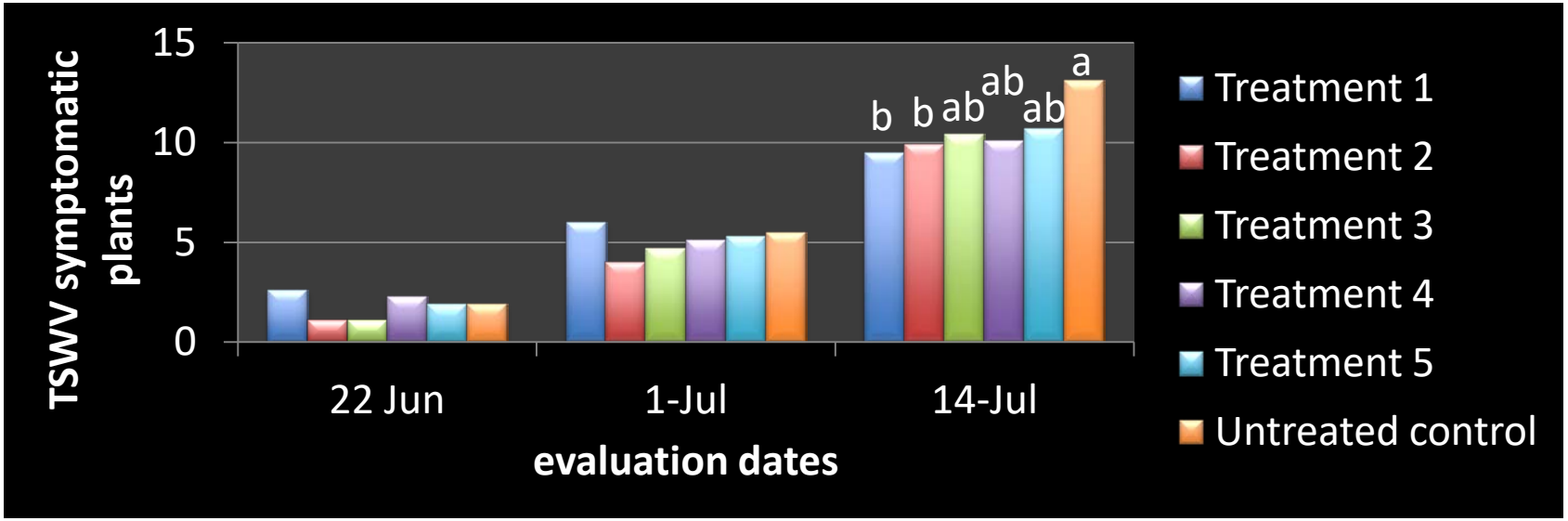
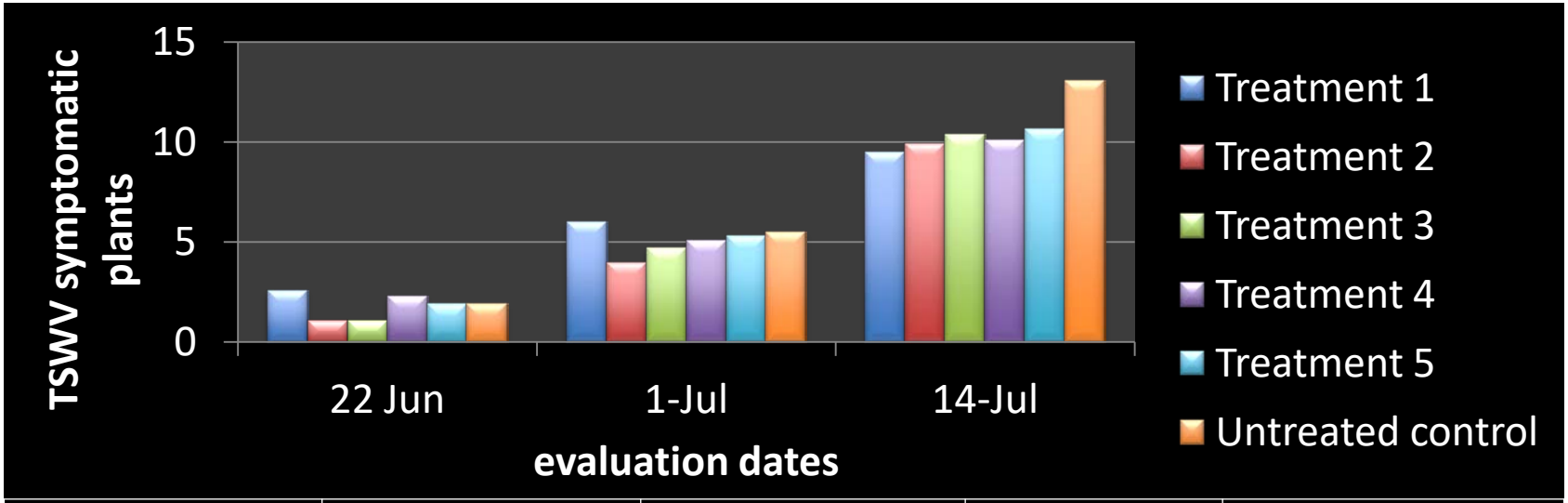
Impact of Insecticides on TSWV Symptomatic Plant Incidence, 2015



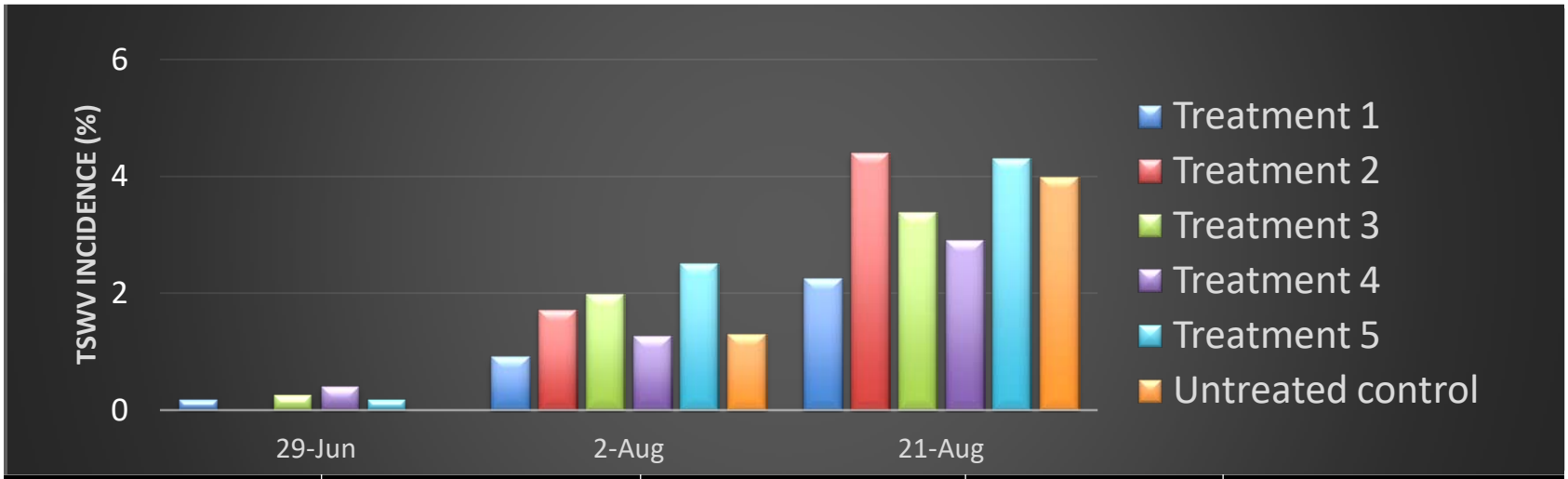
	Transplants 21 May	22 May transplant water	22 May foliar	22 June
Treatment 1	Verimark 13.5 fl oz			
Treatment 2		Admire 4.0 fl oz	Sivanto 2.0 fl oz	Admire 6.5 fl oz
Treatment 3		Admire 10.0 fl oz		
Treatment 4			Sivanto 2.0 fl oz	Admire 6.5 fl oz
Treatment 5				Admire 6.5 fl oz

Impact of Insecticides on TSWV Symptomatic Plant Incidence, 2016



	transplant trt 16 May	transplant water 17 May	10 Jun	28 Jun
Treatment 1	Verimark 13.5 fl oz			
Treatment 2		Admire Pro 4.0 fl oz	Verimark 10 fl oz drip	Verimark 10 fl oz drip
Treatment 3			Sivanto 10.5 fl oz Platinum 3.67 oz (drip)	Venom 6.0 oz drip
Treatment 4		Admire Pro 4.0 fl oz	Platinum 3.67 oz (drip	Venom 6.0 oz drip
Treatment 5	Verimark 13.5 fl oz		Platinum 3.67 oz (drip	Venom 6.0 oz drip

Impact of Insecticides on TSWV Symptomatic Plant Incidence, 2017



	transplant trt 17 May	transplant water 18 May	Foliar 1 Jun	23 Jun drip applied
Treatment 1	HGW86-885 13.5 fl oz			
Treatment 2	HGW86-906 13.5 fl oz			
Treatment 3	HGW86-885 13.5 fl oz			Platinum 11 fl oz
Treatment 4		Admire Pro 4.0 fl oz		Platinum 11 fl oz
Treatment 5		Admire Pro 4.0 fl oz SP2700 7.8 fl oz	SP2700 7.8 fl oz	Platinum 11 fl oz