Resistance breaking strains of TSWV and chemical control of insect vectors

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Tomato spotted wilt virus

- Symptom recognition/ Biology
- Plant resistance-breaking strain
- Management (including chemical control)
- Continuing research

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Tomato spotted wilt virus (TSWV) Symptom Recognition

TSWV symptoms on tomato fruit

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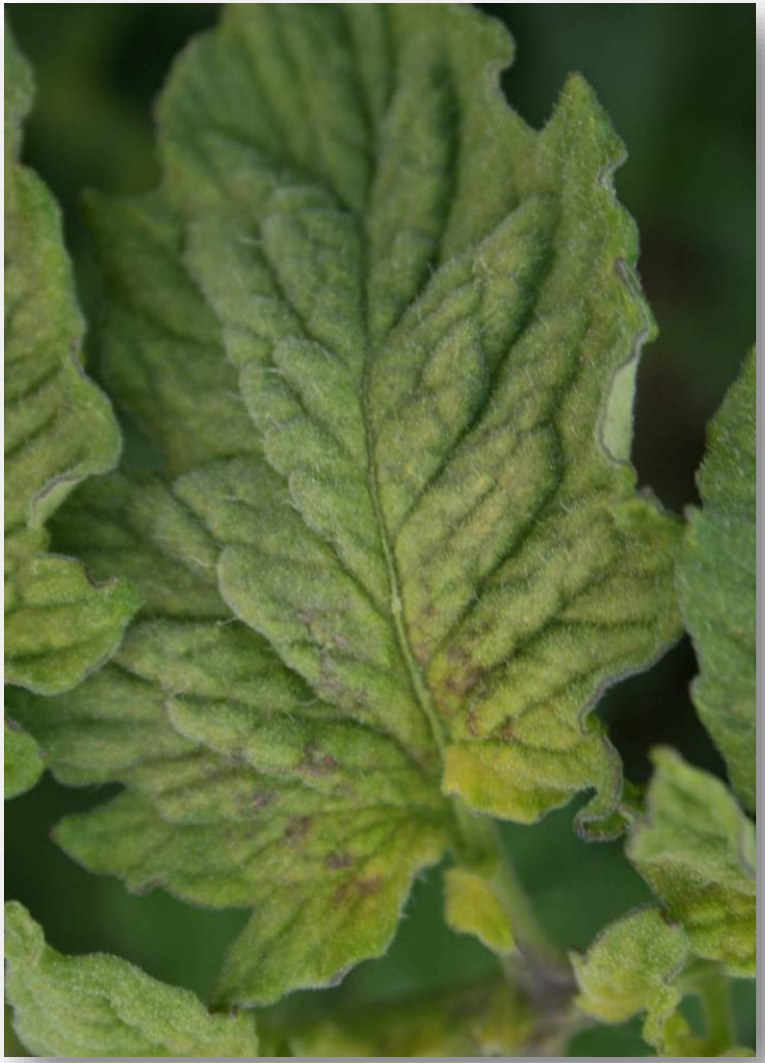
Foliar symptoms of *TSWV*



Stage of crop development at the time of infection and stage of disease development influence symptoms


Cut here
ACC 00936
SEB1, Sample extract pouch
Contains SEB1. Store at +4° C.
Contents: 3 ml
Lot No: 00039
agdia
FOR TESTING USE ONLY
SAMPLE

Thrips vectors TSWV

Frankliniella occidentalis (Western flower thrips)

Primary vector of TSWV in Central California

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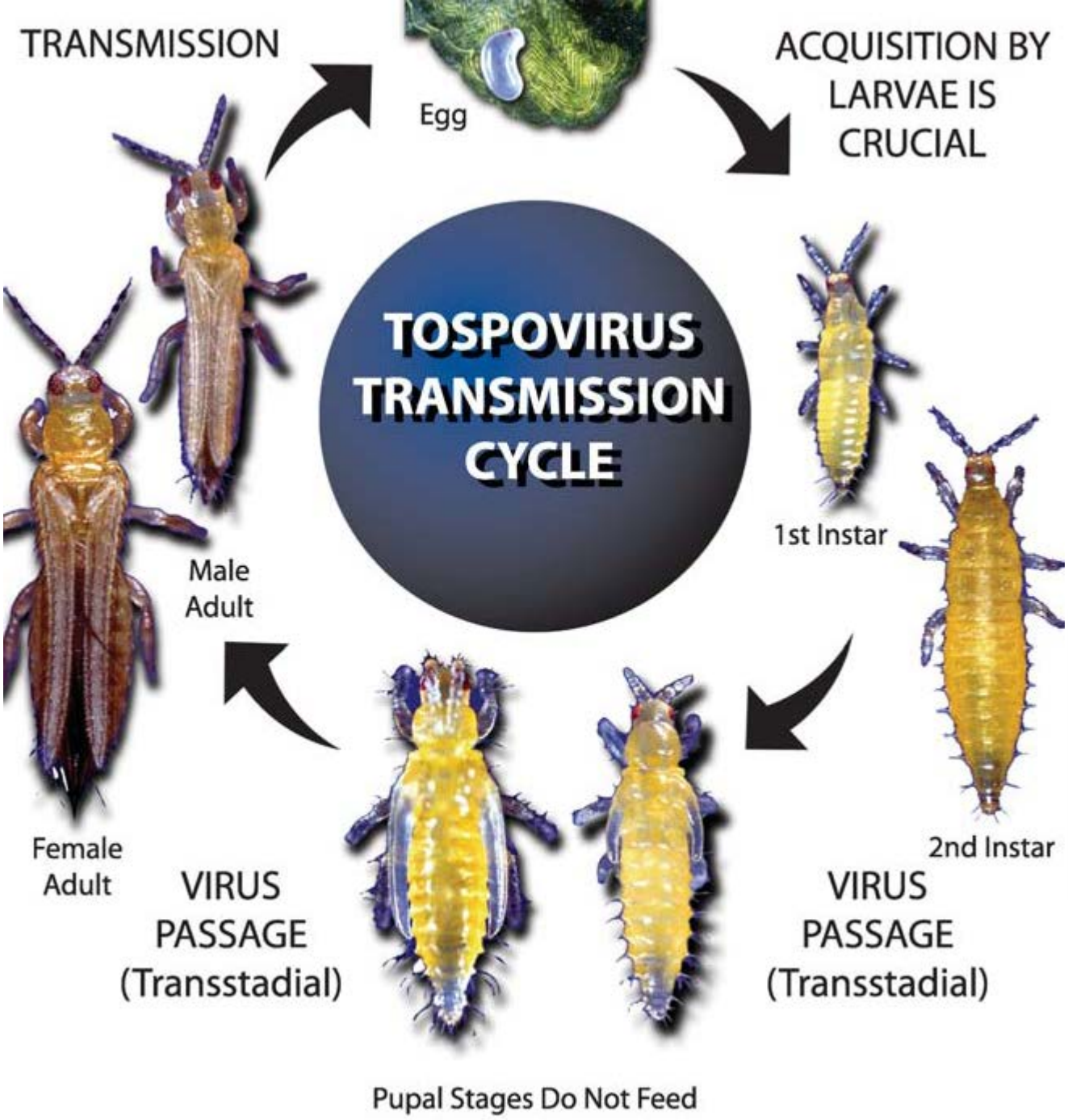

A. E.Whitfield, D. E. Ullman, and T L. German. 2005. **TOSPOVIRUS-THRIPS INTERACTIONS.** Annu. Rev. Phytopathol. 2005. 43:459–89

Host Range of TSWV

Crop Hosts

- Radicchio
- Lettuce
- Celery
- 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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Annual Cycle TSWV/Western flower thrips in Central California

- Overwintering: in a small percentage of weeds and crops & TSWV pupating thrips
- Early season: reproduction of thrips and possible virus increase of TSWV on susceptible weeds and crops
- Mid season: movement to tomatoes and rapid increase in TSWV in areas with concentrations of susceptible plants
- Late season: Highest pressure of the year

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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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Detection of Resistance-breaking TSWV strain in Fresno Co. in 2016

- **Mid-Apr 2016, severe and typical symptoms of TSWV in 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 Sw5 processing tomatoes in Huron area**

All samples were Immunostrip positive

Virology

(R. Gilbertson, O. Batuman, M. Macedo)

- RT-PCR/sequencing tests revealed only TSWV infection
- Raised the issue of the potential presence of a resistance-breaking (RB) strain
- RB strains have been reported and have been associated with specific amino acid substitutions in the viral movement protein (NSm)

López, C., Aramburu, J., Galipienso, L., Soler, S., Nuez, F. and Rubio L. (2011). Evolutionary analysis of tomato *Sw-5* resistance-breaking isolates of *Tomato spotted wilt virus.* Journal of General Virology 92: 210-215.

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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)

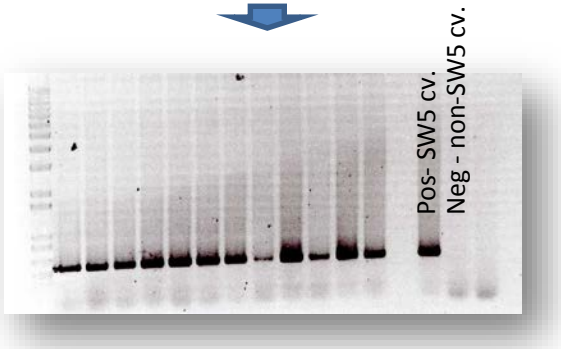
RB strain

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



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

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Detection of the RB-TSWV strain from weeds during the winter survey in 2017

WEED SAMPLES						
Scientific name	**Common name**	**Botanic family**	**Total of samples**	**TSWV +**	**CPT**	**YPT**
Amaranthus sp.	Amaranthus	Amaranthaceae	1	0	xxx	xxx
Lactuca sativa	Lettuce	Asteraceae	1	0	xxx	xxx
Lactuca sp.	Prickly lettuce	Asteraceae	2	0	xxx	xxx
Matricaria sp.	Pineapple weed	Asteraceae	5	0	xxx	xxx
Sonchus sp.	Sowthistle	Asteraceae	39	6 (15%)	2 (34%)	4 (66%)
Brassica sp.	Mustard	Brassicaceae	1	0	xxx	xxx
Beta vulgaris	Sugar beet	Chenopodiaceae	5	0	xxx	xxx
Chenopodium sp.	Chenopodium	Chenopodiaceae	3	0	xxx	xxx
Cucumis sp.	Cucumis	Cucurbitaceae	4	0	xxx	xxx
Medicago sativa	Alfafa	Fabaceae	5	0	xxx	xxx
Malva sp.	Malva	Malvaceae	2	0	xxx	xxx
Solanacearum sp.	Solanacearum	Solanaceae	1	0	xxx	xxx
TOTAL			69	6 (15%)	2 (34%)	4 (66%)

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

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Resistance Breaking *Tomato spotted wilt virus, 2017*

- Detected in Sowthistle in Jan and Feb 2017 in Huron and Cantua Creek
- Resistance breaking strains associated with weedy areas early 2017 in Fresno Co.

- By Oct., 2017 over larger area in Fresno Co., detected in Merced and Brentwood.
- By the end of 2017, the SW5-resistance breaking TSWV strain was detected in lettuce, celery and peppers.

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Winter weed survey in 5-6 Feb 2018

	Sow thistle	prickly lettuce	malva	black mustard	groundsel	pigweed	mares tail	shepard's purse	black mustard	kochia	lambs quarters
Firebaugh NW	5		4		3						
Firebaugh SW	10	3									
Firebaugh SW b	4	1									
Mendota West	5	1									
Cantua Creek	10										
Huron NW	3	3							1		
Huron NW b	1	1	3		2	1	1			1	1
Huron SE	4				2			1			

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Winter weed survey in 5-6 Feb 2018

	Sow thistle	prickly lettuce	malva	black mustard	groundsel	pigweed	mares tail	shepard's purse	black mustard	kochia	lambs quarters
Firebaugh NW	5		4		3						
Firebaugh SW	10	3									
Firebaugh SW b	4	1									
Mendota West	5	1									
Cantua Creek	10										
Huron NW	3	3							1		
Huron NW b	1	1	3		2	1	1			1	1
Huron SE	4				2			1			

All samples were symptomless.

One sow thistle sample at Mendota was positive for wild type TSWV

All other samples were negative for TSWV

Varietal Evaluation 2017

(Ag Seeds and TS&L)

- Evaluation of variety trial in area affected by resistance-breaking TSWV on 17 Jul 2017
- Tomato spotted wilt virus incidence observed among entries at **one site** were from undetectable levels to 52% of plants expressing TSWV

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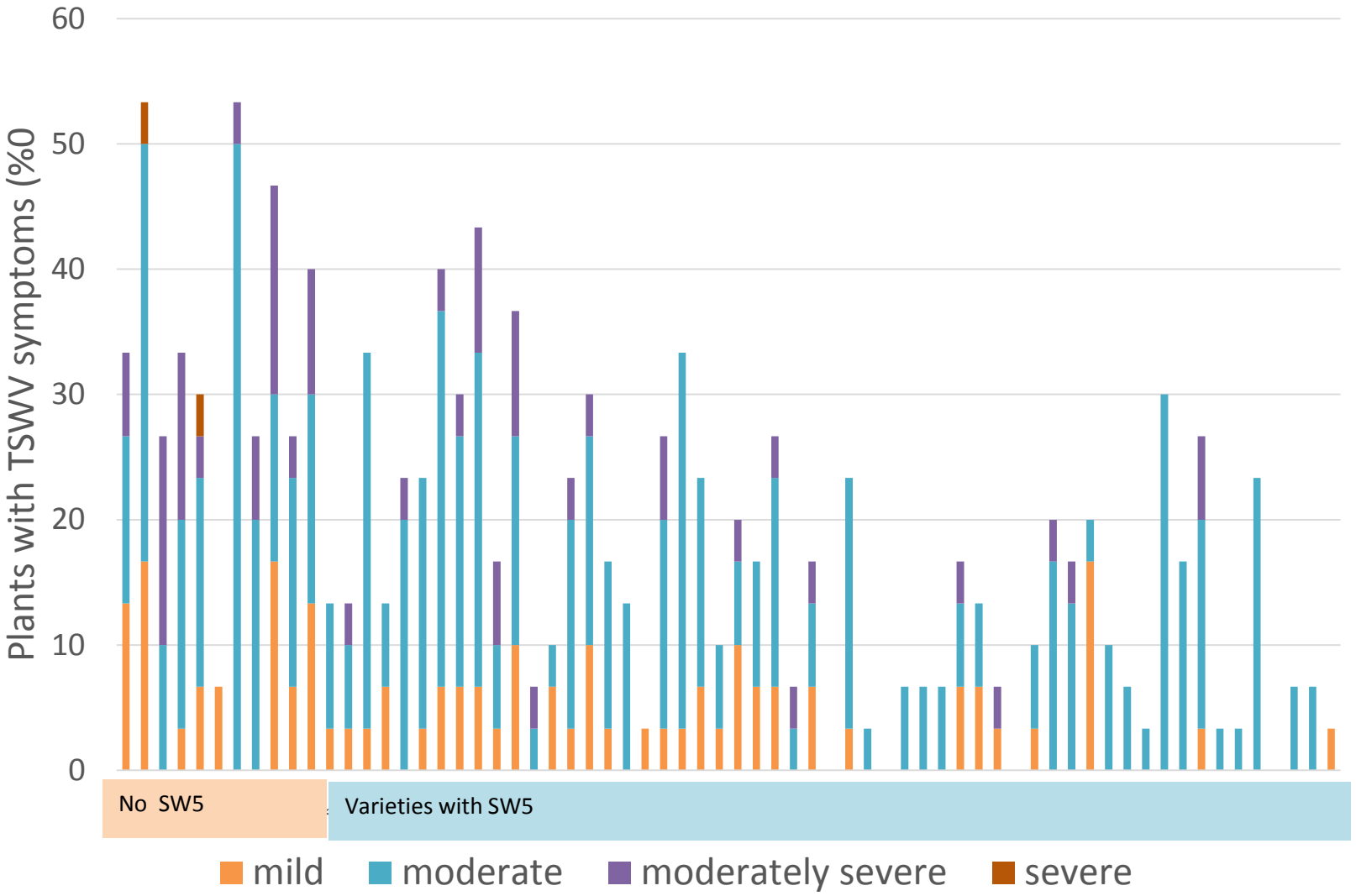
2017 Preliminary Observations (NO REPLICATION)

Percentage TSWV

(No resistance and resistance grouped)



Variety Trial: Strain Determination

Variety	SW5 in variety	Strain detected
H1015 -no SW5	-	CPT
BQ273 -SW5	+	YPT
N6402 -SW5	+	YPT
HM3887 -SW5	+	YPT
DRI319 -SW5	+	YPT
H1292 -SW5	+	YPT
BP13 -SW5	+	YPT

CPT=wild type strain
YPT= resistance-breaking strain

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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)*

- Chemical control studies will present information on specific materials
- Not all materials tested may have current registration in tomatoes
- Carefully read all current labels before writing a recommendation

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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Insecticide Program Evaluations

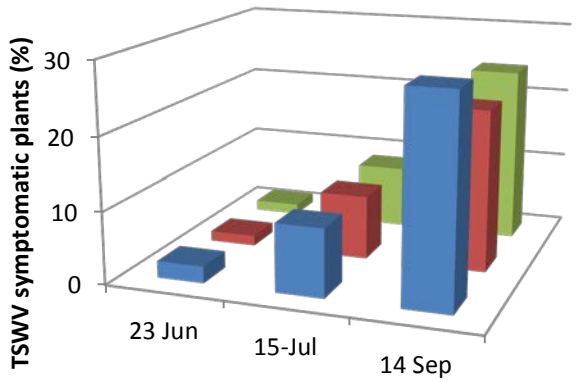
2009 -12

DRIP INJECTION (Main Plot Treatments): Platinum and/or Platinum and Venom, and an untreated control.

FOLIAR APPLICATIONS (Sub Plot Treatments): Three treatments 2 to 4 applications (cyazypyr transplant drench evaluated from 2010 to 2012) and an untreated control.

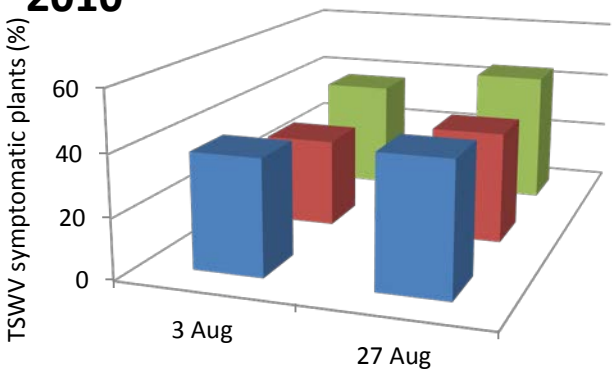
Influence of Drip-Applied Insecticides

2009



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

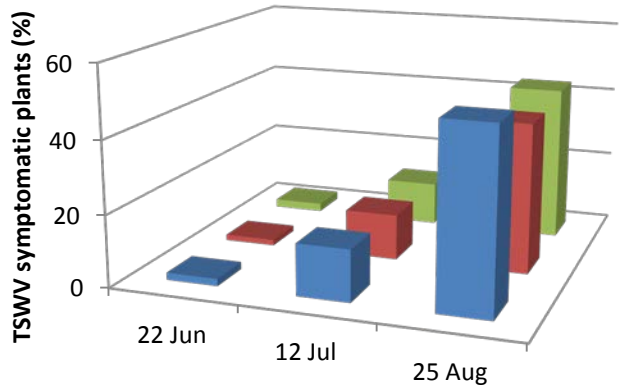
2010



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

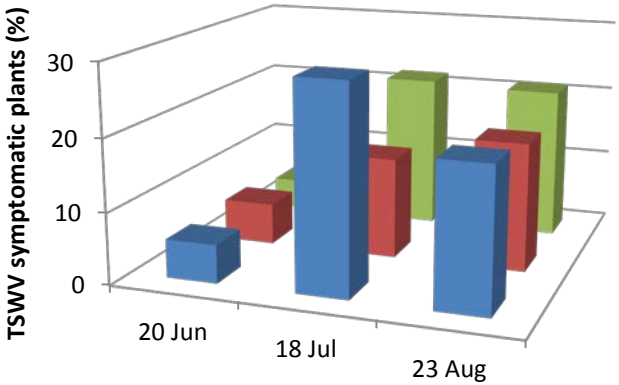
* Weekly injections of acibenzolar-s-methyl 35g/ha

2011



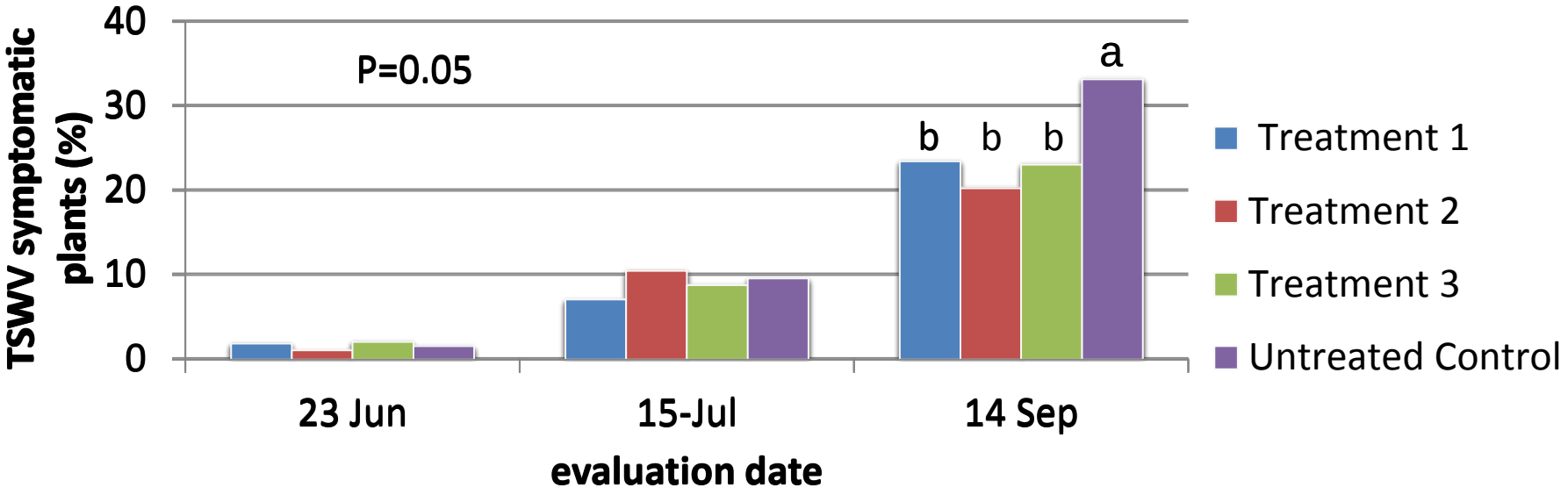
- thiamethoxam 193 g (22 Jun), dinotefuron 294 g (12 Jul)
- thiamethoxam 193 g (22 Jun), dinotefuron 294 g (22 Jul)
- Untreated

2012



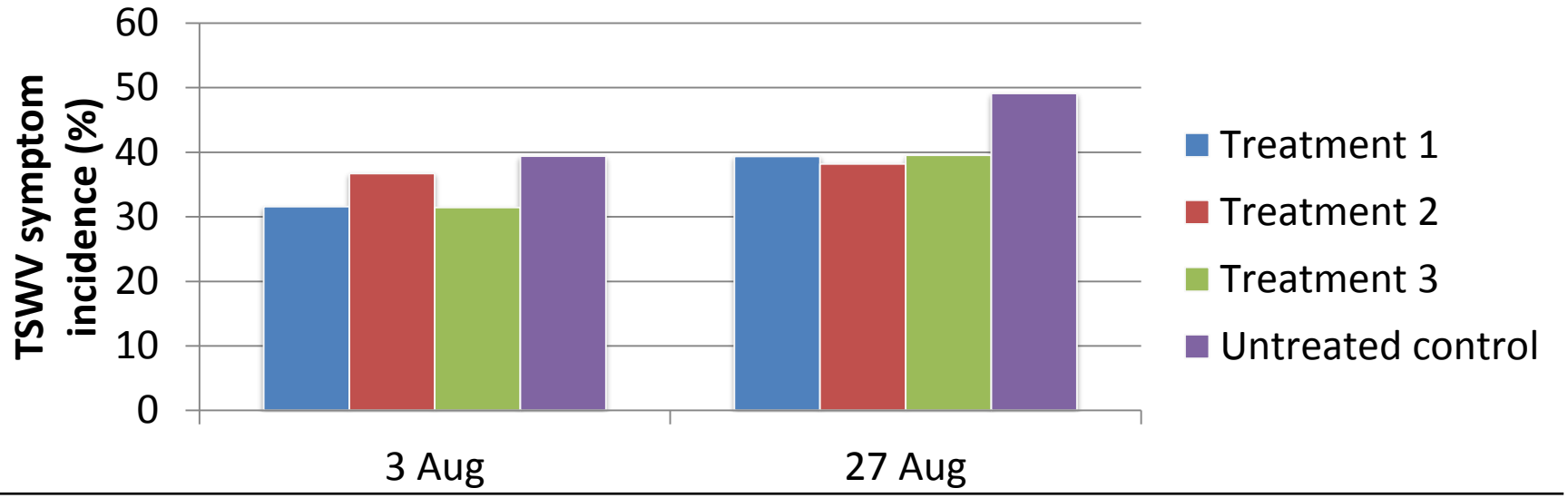
- thiamethoxam 193 g (7 Jun), dinotefuron 294 g (27 Jun)
- thiamethoxam 193 g (7 Jun), cytraniliprole 197 g (27 Jun)
- Untreated

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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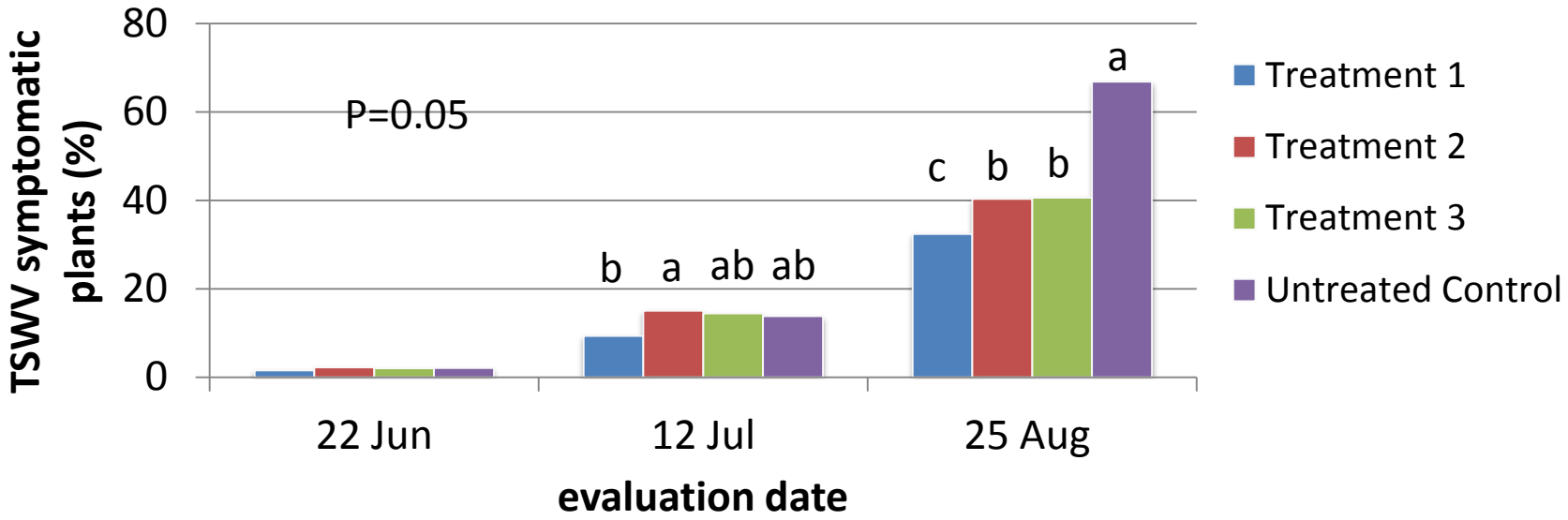
Foliar Treatment Impact on TSWV Symptomatic Plant Incidence 2011



	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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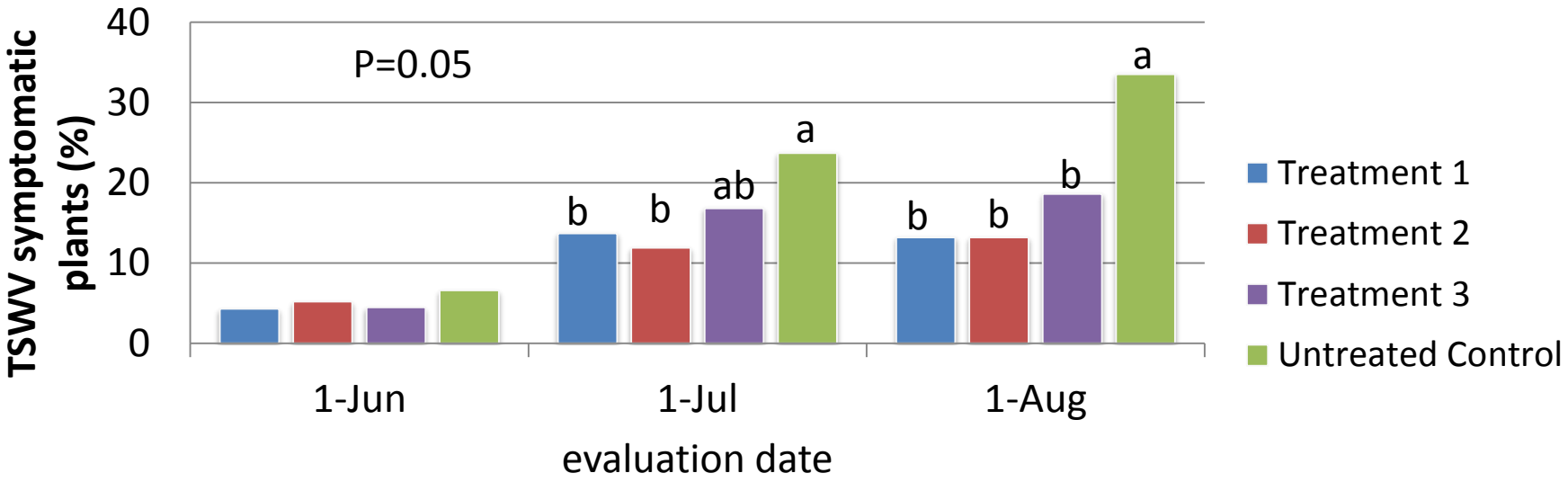
Foliar Treatment Impact on TSWV Symptomatic Plant Incidence 2012



	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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Insecticide Program Evaluations

2015 -17

- Transplant treatments with Verimark
- Transplant water with Admire Pro
- Drip applications with Admire Pro, Venom, Platinum

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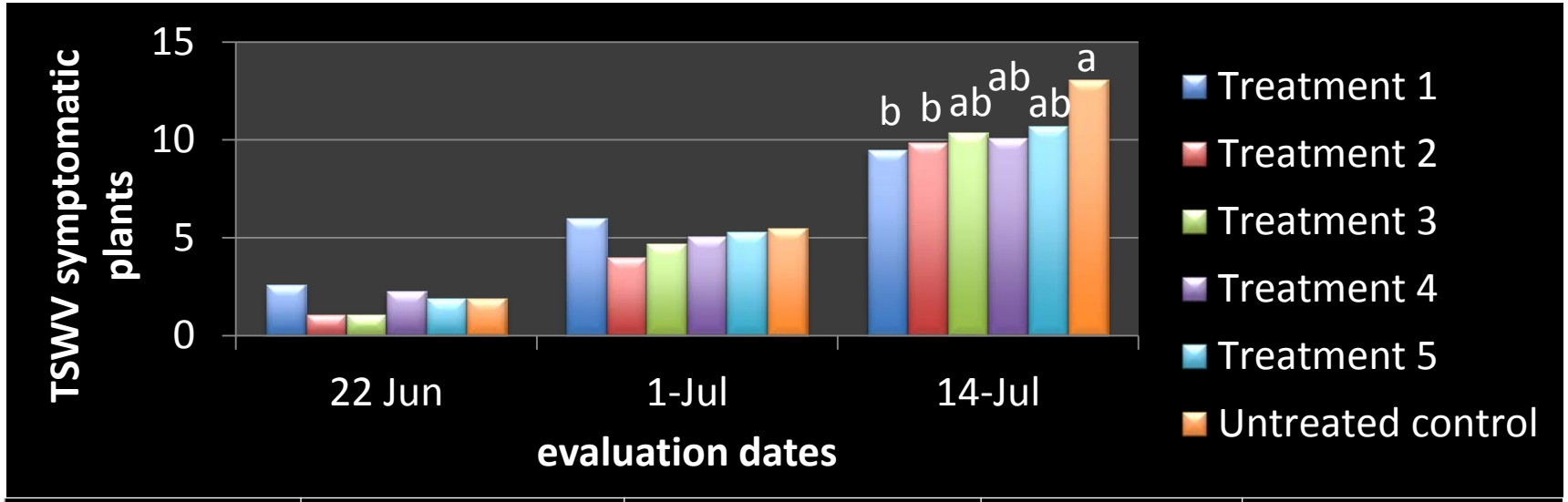
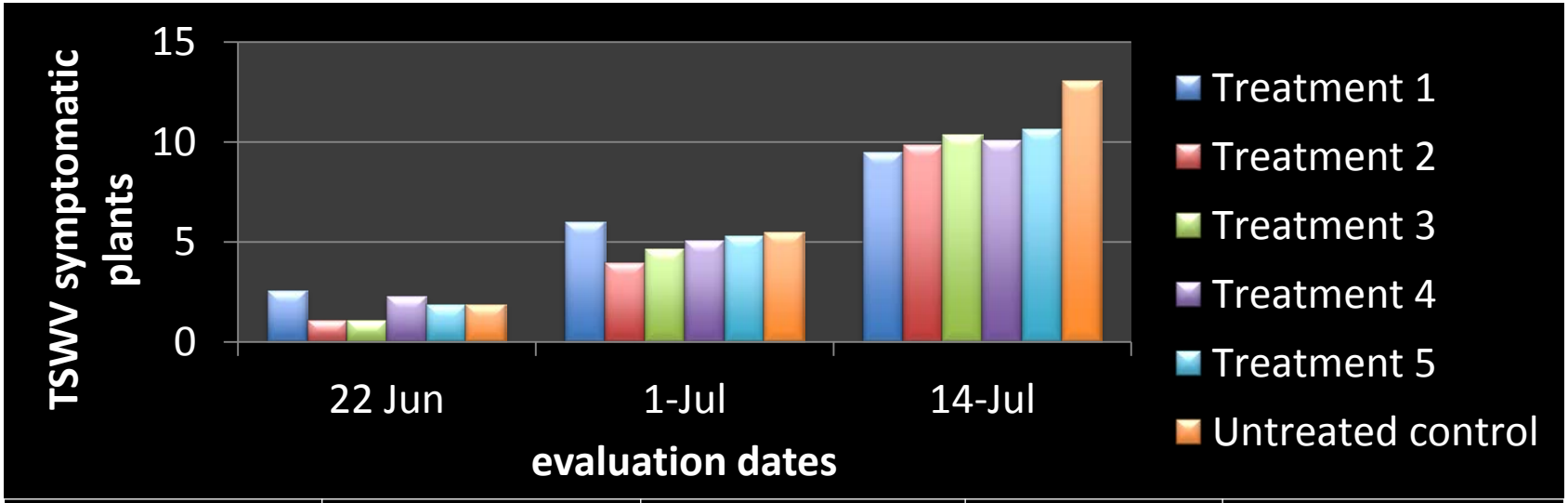
Impact of Insecticides on TSWV Symptomatic Plant Incidence, 2015



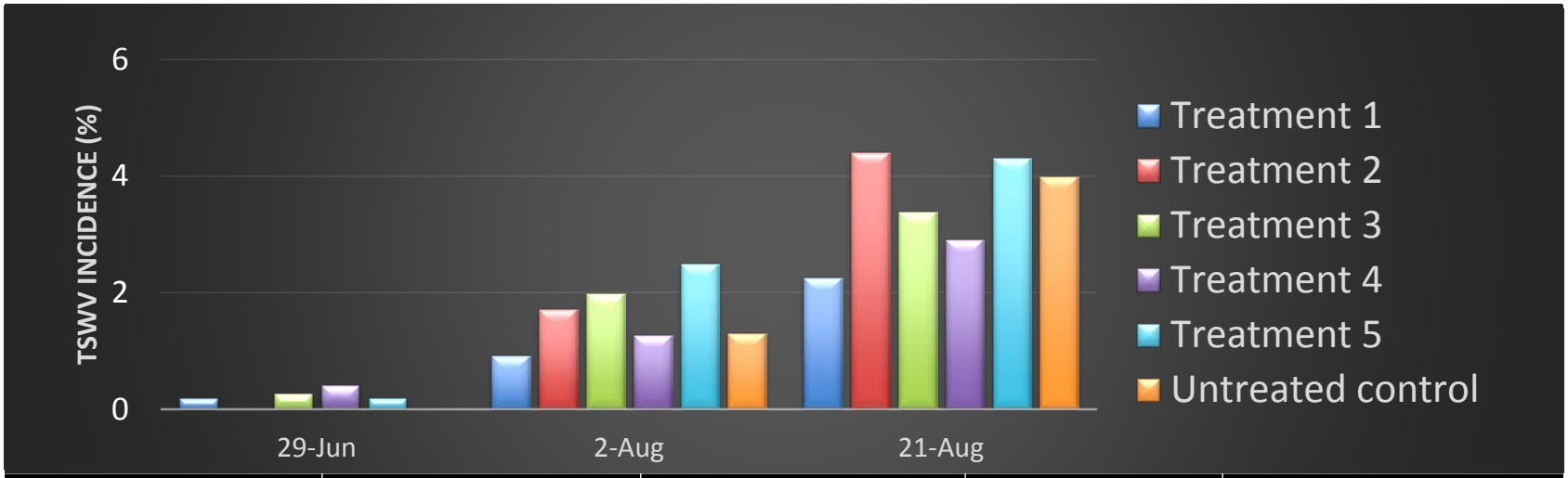
	Transplants 21 May	22 May transplant water	22 May foliar	22 June drip
Treatment 1	Verimark 13.5 fl oz			
Treatment 2		Admire 4.0 fl oz	Sivanto 2.0 fl oz	Admire 6.5 fl oz
Treatment 3		Admire 10.0 fl oz		
Treatment 4			Sivanto 2.0 fl oz	Admire 6.5 fl oz
Treatment 5				Admire 6.5 fl oz

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

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 3/6 trials

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TSWV Management

- 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, plant date and site selection to minimize risk.
- Insecticides may reduce incidence but should not be relied upon without other management approaches.

Acknowledgements

- CTRI
- Ag Seeds and TS&L

UC DAVIS

- Dr. Robert Gilbertson
- Dr. Ozgur Batuman
- Dr. Maria Rojas
- Dr Mônica Macedo

UC Coop. Ext.

- Scott Stoddard
- Brenna Agerter

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